# DEVELOPING A FRAMEWORK TO IMPROVE SUPPLY CHAIN EFFICIENCY OF FRUITS AND VEGETABLES SECTOR

By


**SAURAV NEGI**

SAP ID: 500065852

**SCHOOL OF BUSINESS**

**(DEPARTMENT OF TRANSPORTATION MANAGEMENT)**


Submitted

**IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY**

TO

**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**

DEHRADUN

August, 2018

**Under the Guidance of**

**Dr. Neeraj Anand**

**Professor and HoD- Transportation Management**

## ACKNOWLEDGMENT

Undertaking this PhD has been a truly life-changing experience for me, and it would not have been possible to do without the support and guidance that I received from many people. It is hard enough to name all the people that helped to get this done, but it is even harder to thank them enough. I wish to express my sincere appreciation to those who have contributed to this thesis and supported me in one way or the other during this amazing journey.

First of all, I would like to express my deep and sincere gratitude to my guide Dr. Neeraj Anand (Professor and Head-Transportation Management). His guidance and constant support have helped me in all the time of research and writing of this thesis. I was very lucky to benefit from his rich expertise and critical comments, and have motivated me to work hard because of his valuable input. Without his guidance and constant feedback, this milestone would not have been achievable.

Very special thanks to University of Petroleum and Energy Studies, UPES for giving me the opportunity to carry out my doctoral research and for their financial support.

Furthermore, I would express my appreciation to my Head, Dr. V J Byra Reddy (Director-Quality Assurance & Accreditation, UPES) for his constant encouragement. His support has contributed enormously to the success of this work. His office doors were always open to me when I needed advice and support, not only in my academic life but in also dealing with my personal difficulties.

I also appreciate the advice of the School Research Committee members for their very helpful comments and valuable suggestions, which enabled me to make necessary improvements in my work.

I owe special thanks to Dr. T Joji Rao for his valuable inputs and for always being so supportive of my work.

My sincere thanks also goes to Dr. Raju Ganesh Sunder, Dr. Tarun Dhingra, Dr. S.K Pokhriyal, Dr. Anil Kumar, Dr. P.C Bahuguna, Dr. T.B Raju, Dr. Saurabh Tiwary, Dr. Mohammad Yaqoot, Dr. Sunil Barthwal, Dr. Prasoom Dwivedi, Prof. Atri Nautiyal and Dr. K.K Pandey for always encouraging and motivating me to complete this research work.

A special thanks to my fellow colleagues and friends, Subhra Rajat Ji, Shantanu, Rahul and Aswani Madam.

I express my humble gratitude to all the farmers, wholesalers, commission agents, transporters and experts who have contributed their valuable time and efforts, during the collection of necessary data for the study.

Above all, no words are enough to thank my Daadi, Mummy, and Papa whose love encouraged me to work hard and to continue pursuing the PhD. Their moral support and encouragement have made me feel confident to fulfill my dream and to overcome every difficulty I encountered. This research would have never been realized without their prayers and persistence. My brothers, Gaurav and Sanjay, and Bhabhi have been very supportive and understanding throughout my journey so far, and I thank them for their love and support. I would also like to say a heartfelt thank you to my Father in law, Mother in law, Anshu Bhai and Ankita Di for supporting me throughout writing this thesis. Also thanks to our little champ, Atharva for making those tense moments playful and easy.

Last but not the least, a big thanks to my beloved wife ***Anjali,*** who spent sleepless nights and was always my support in the moments when there was no one to answer my queries. She has made countless sacrifices to help me get to this point.

**Thank You All…!!!**

# DECLARATION BY THE SCHOLAR

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

Saurav Negi

Date: 20 August 2018

UPES

www.upes.ac.in

# THESIS COMPLETION CERTIFICATE

This is to certify that the thesis entitled **"Developing a Framework to Improve Supply Chain Efficiency of Fruits and Vegetables Sector"** submitted by **Saurav Negi** to UPES (University of Petroleum and Energy Studies) for the award of the degree of Doctor of Philosophy (Management) is a bona fide record of the research work carried out by him under my supervision and guidance. The content of the thesis, in full or parts have not been submitted to any other Institute or University for the award of any other degree or diploma.

Guide

**Dr. Neeraj Anand**
**Professor and HoD-Transportation Management**

Date: 21st August 2018
Place: Dehradun

CORPORATE OFFICE: 210, 2nd Floor, Okhla Industrial Estate, Phase III, New Delhi - 110 020, INDIA, T +91 - 11 - 41730151-53, F +91 - 11 - 41730154
CAMPUSES:
ENERGY ACRES: Bidholi Via Prem Nagar, Dehradun - 248 007 (Uttarakhand), INDIA, T +91 - 135 - 2770137, 2776053/54/91, 2776201
F +91 - 135 - 2776090/95
KNOWLEDGE ACRES: Kandoli Via Prem Nagar, Dehradun - 248 007 (Uttarakhand), INDIA, T +91 - 8171979021/2/3, 7060111775

▪ Engineering ▪ Computer Science ▪ Design ▪ Business ▪ Law

# TABLE OF CONTENTS

# EXECUTIVE SUMMARY

In Indian economy, the role played by agricultural sector happens to be quite crucial in nature and has witnessed massive structural changes in terms of decline in share of Gross Domestic Product (GDP) from 30% in 1990-91 to 17% in 2016, thereby signifying a change from the conventional agrarian economy towards a service oriented economy.

Despite of the fact that there has been a constant decline of the share of agriculture in GDP, almost 58% of the total manpower is still engaged in agriculture sector to earn their livelihood. The massive changes introduced in agricultural sector has resulted in a scenario, which leads to a significant focus of diversification of attention towards horticulture amounting to more than 30% of the share in total agricultural output. The increased shares of horticulture in the agriculture & allied imply that they have been growing at a much faster rate than the traditional crop sector.

The Fruits and Vegetables (F&V) sector has been a driving force in stimulating a healthy growth trend in Indian agriculture. Given the rising share of high-value commodities in the total value of agricultural output and their growth potential, this segment is likely to drive agricultural growth in the years to come. It has the potential to be the world's largest food producer, which is bestowed with large base of natural resources in the world, and several factors like increasing urbanization, nuclear families, working women, disposable income and changing lifestyles are gearing up the Indian food supply chain for a better future. Organised retail and private label penetration, demand for functional food, and increased spending on health food are some of the primary drivers for the growth of this sector. Research reveals that close to 90% of food expenditure of Indian consumer is spent on fresh food with majority of the sales share constituting vegetables and fruits. As the population is increasing, the demand for such food is also increasing and to meet this increasing demand and provide food in proper quality and nutrition, the supply chain plays a very vital role in this sector and becomes even more critical because of perishability and very short shelf life. Supply Chain Management (SCM) not only helps to cut costs but also adds to maintain and improve the quality of products delivered, which are perishable.

India popularly known as F&V basket of the world. It is the second largest producer of overall F&V production in the world, after China and one of the centers of origin of F&V with the total production of 92.84 million metric tonnes of fruits and 175.19 million tonnes of vegetables till the year-end 2017.

The trend suggests that horticulture sector is anticipated to perform a crucial role in Indian economy for the forthcoming years in the domain of agricultural development. It also has tremendous potential to push the overall agriculture growth and contributes 30% of agricultural GDP.

India is among the world's largest food producer and serving the food consumer all across the globe. Despite second largest food producer in the world, the customers in India are not getting the fresh produce in proper quality, in a right time and at a right cost. India, the world’s second largest F&V producer, is also one of the biggest wasters in the world. Each year, billions of tons of fresh food items with millions of dollars' worth lost due to the inadequate supply chain. Around 30%-40% of the total production, around Rs. 2-3 lakh crore worth of F&V in India is wasted due to the inefficient supply chain. The entire supply chain is suffering from maximum inefficiencies, which are resulting in massive amount of losses and wastages and has become one of the major impediments in the growth of agricultural sector.

Therefore, there is an absolute need of further research in this domain in order to comprehend the issues in SCM in a full-fledged manner and to figure out the scope for growth and at the same time target for reduction in supply chain inefficiencies. The above business problem motivated the researcher to conduct this study. Based on this problem, an extensive literature review was carried out under nine themes, which were aimed to understand the past research conducted in the area of the supply chain of F&V sector and approaches for improving supply chain efficiency.

Various studies have been conducted on F&V supply chain in general, but there is a lack of study on supply chain efficiency specifically to F&V sector. Also, the weak links and constraints responsible for supply chain inefficiency in different stages of F&V sector and the measures to improve supply chain efficiency are not known. Further, there is a lack of a framework for improving supply chain efficiency of F&V sector in India. This research aims to fulfill this gap. The scope of the study has been narrowed down to the supply chain of selected F&V such as mango and tomato, as the highest amount of losses found in these two categories. The supply chain from farm to wholesale mandi was selected because of the maximum inefficiency between these stages. To address the gaps in the existing literature of F&V supply chain, the Research Objectives (RO) of this study are as follows:

1. To identify the most significant activities contributing to supply chain inefficiency (with respect to cost, time and quality) in different stages of the F&V supply chain with specific reference to mango and tomato.

2. To identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities in different stages of the F&V supply chain with specific reference to mango and tomato.

3. To develop a framework for improving supply chain efficiency of F&V sector with specific reference to mango and tomato.

Various theories such as Stakeholders theory, Organisational theory, Transaction Cost Economies theory, Theory of Constraints, Resource-based view theory studied to deliberate the theoretical premise for this study. After due deliberation, it has observed that Goldratt's Theory of Constraints Thinking Process is the most relevant for this study and used as a theoretical premise for this research.

A Framework has been developed to improve supply chain efficiency of F&V sector in India (specific reference to mango and tomato) using a "TOC Thinking Process" approach, which provides an answer to three critical questions, which are as follows:

*i.* Identify the constraints
*ii.* Determine the solution
*iii.* How to implement the solution

Each objective is focused on supply chain efficiency with respect to cost, time and quality. Using this deductive approach, the study first identified the activities contributing to supply chain inefficiency across the stages of F&V supply chain (starting from farm gate to the commission agent/pre-harvest contractor to local traders and then finally to wholesale market usually known as Mandi). Subsequently, the factors leading to supply chain inefficiency in the identified activities across the stages are determined. Based on the important variables under each factor, measures that need to be taken for the same have been identified through the semi-structured interview from the experts and finally, a framework has been developed to improve supply chain efficiency of F&V sector in India.

Mixed method approach has been used in this study wherein both quantitative as well as qualitative methods have been used to attain the objectives. The quantitative method has used for RO1 & RO2 and Qualitative method has been used for RO3. The questionnaires were prepared in alignment with the activities carried in different stages of F&V supply chain and the variables identified from literature review. All the questions were developed on a "five-point Likert scale." For each questionnaire, the respondents had to respond on three aspects, i.e., for cost, time, and quality. Therefore, complete 9 questionnaires (5 for fruit supply chain and 4 for vegetables supply chain) were developed for RO 1. For RO 2, total 27 questionnaires were developed (3 at each stage for cost, time and quality). For RO 3, the protocol was designed with total 27 open-ended questions. Pilot testing was conducted to make the questionnaire clearer, refined, concise and specific for the desired objective.

The sample profile used in this study consists of farmers, local traders, wholesalers, local traders at Mandi, and transporters who are involved in F&V business. These stakeholders were selected with the trust that they are familiar to operational conditions of their businesses. The researcher has adopted a multi-stage sampling along with snowball technique to collect the data from the respondents. For RO 1, the data was collected from 1180 respondents in case of fruits (360 Farmers, 230 Local Traders, 180 Wholesalers/Commission Agents, 140 Mashakhor/Local Traders, 270 Transporters) and 860 in case of vegetables supply chain (340 Farmers, 170 Local Commission Agents, 130 Wholesaler/Commission Agents, 220 Transporters) to identify the activities contributing to supply chain inefficiency with respect to cost, time and quality. For RO 2, the data was collected from 912 respondents (260 Farmers, 140 Local Traders, 160 Wholesalers/Commission Agents, 180 Mashakhor/Local Traders, 172

Transporters) in case of fruits and 600 in case of vegetables supply chain (200 Farmers, 140 Local Commission Agents, 120 Wholesaler/Commission Agents, 140 Transporters) to identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities (through RO1) across the stages of F&V supply chain.

The reliability has tested for each section of the questionnaire for cost, time, and quality to check the internal consistency of the questionnaire using Cronbach alpha test. For the entire questionnaires used in both RO 1 and RO 2 across the stages of F&V supply chain, the value of Cronbach alpha is more than 0.8 in maximum cases, which is a good measure for that assess the consistency of the entire scale.

For RO 3, based on judgmental sampling, an in-depth semi-structured interview was conducted with experts such as F&V supply chain experts, agribusiness experts, horticultural specialists, cold chain experts, supply chain experts from academia. The interview with experts helps to identify the measures for the factors leading to supply chain inefficiency and based upon those measures; a framework has developed for improving supply chain efficiency of F&V sector. The questions were designed based on the knowledge attained from the RO 2. A pilot study was conducted with F&V supply chain experts to decide whether the questions are could be easily grasped by the respondents. This exercise was conducted in order to test the validity and reliability of the questions inducted in the interview schedule. The sample size used for this objective was decided on the basis of data saturation and unavailability of participants.

The data collected for RO1 and RO 2 was fed into the SPSS: Statistical Package for the Social Sciences (version 21) for further analysis. The tools used in this study to attain the objectives are ranking method for RO1; to identify the activities contributing to supply chain inefficiency (RO1) and factor analysis for RO2; to identify the factors leading to supply chain inefficiency (RO2). For RO3, the responses taken from the interview were recorded, transcribed and codes were generated. From transcribed conversation and codes, measures were taken out, as suggested by the experts. Finally, considering the output, suitable framework was developed.

The findings of RO1 shows that Sorting, Grading & Packaging and Tying, Plucking & Collection, Handling, Loading & Stacking of goods, Unloading of Crates/Cartons/Wooden Box from Trucks at Mandi Level, Storing & Ripening, and Transportation (During transit) from Farm to Wholesale Mandi are some of the activities contributing to supply chain inefficiency in Fruits sector with specific reference to mango. Carriage of Crates to the Collection Area/Collection Centre, Unloading of Tomato and Loading to the buyer's Crate, Storing of Fresh Produce at Mandi area, and Transportation (During transit) of Tomatoes from Farm to Wholesale Mandi are some of the activities contributing to supply chain inefficiency in tomato.

Factor analysis (3 at each stage-for cost, time and quality) were carried out for RO 2, to identify the factors leading to supply chain inefficiency for cost, time and quality in different stages of F&V supply chain. It was found that Resources, Operational Charges, Infrastructure, Labour's Knowledge, Operational issues, Imprudence, Labour Availability, Quality Control System, Standardisation, Connectivity, Labour, Ambience, Preservation, Labour Charges, Information, Techniques, Market Uncertainty, Rates & Charges, Transit Ease, Verification & Frisking, Geography, Operational & Labour Charges, Technical Resources and Resources/Transport Facilities are the factors leading to supply chain inefficiency in F&V supply chain with specific reference to mango and tomato.

Based on these findings, measures have been identified and the framework has developed for F&V supply chain. The framework shows that Infrastructural development, Human resource development, Operations management, Availability of Resources, Use of technology, Accurate planning, Supply chain integration, Temperature control, Pest Control management, Process mechanization, Effective communication among supply chain partners, and Government/Institutional support are some of the critical elements of the framework, which , if taken care properly will improve the supply chain efficiency of F&V sector in India.

The findings show that Government support is extremely required at each stage to develop the efficient supply chain of F&V sector that will improve the scenario of the agricultural sector and give better returns to the agriculturalists, which would enable them to maximise and develop food economy of India.

The finding of this research has contributed to the literature on Goldratt's Theory of Constraints Thinking Process for the supply chain of F&V sector in the Indian scenario. The present research has identified the core constraints responsible for inefficient supply chain in F&V sector and developed a framework to improve the present scenario and reduce the losses and wastages. This would be largely beneficial specifically for the farmers, traders, users and for Indian economy in general. As most of the prior literature on TOC Thinking Process focused on the manufacturing and service sector for improving the business performance, lack of study found for F&V Supply chain. This study used the approach of TOC Thinking process to improve the supply chain efficiency of F&V sector in India, thus filling the gap in the literature of "Theory of Constraints Thinking Process".

This study also has some of its own limitations, which provide opportunities for further research. The study is limited to the supply chain of F&V with specific reference to mango and tomato from farm stage to wholesale stage. Uttar Pradesh to Azadpur Mandi, Delhi, India in case of mango and Himachal Pradesh & Uttarakhand to Azadpur Mandi, Delhi, India in case of tomato was considered. As the measures given in this study are central to only the most important variable under each identified factors for supply chain inefficiency of mango and tomato concerning cost, time, and quality, the measures for other reasons may also be looked out in the future study.

The present study, unique in its nature has made a systematic attempt to develop a framework for improving supply chain efficiency of F&V sector in India. The framework will benefit the stakeholders involved in the process of decision making like Farmers, Local Traders, State Government, Department of food processing industries, Policymakers, Transportation and logistics companies, Cold Chain Solution Providers, Private agri-business companies, APMC, and Wholesalers in planning & executing their operations accordingly. This framework will also be helpful in improving the income of the farmers, which may also contribute towards realizing the target of doubling the farmer's income in overcoming years.

## ABBREVIATIONS

| | | |
|---|---|---|
| 1 | AAA | American Automobile Association |
| 2 | ADB | Asian Development Bank |
| 3 | APEDA | Agricultural & Processed Food Products Export Development Authority |
| 4 | APMC | Agricultural Produce Market Committee |
| 5 | ASSOCHAM | Associated Chambers of Commerce |
| 6 | CIPHET | Central Institute of Post-Harvest Engineering & Technology |
| 7 | CISH | Central Institute for Subtropical Horticulture |
| 8 | CMB | Common Method Bias |
| 9 | CONCOR | Container Corporation of India Ltd |
| 10 | CSR | Corporate Social Responsibility |
| 11 | DEA | Data Envelopment Analysis |
| 12 | EFA | Exploratory Factor Analysis |
| 13 | EPI | Environmental Performance Index |
| 14 | F&V | Fruits and Vegetables |
| 15 | FAO | Food and Agriculture Organisation |
| 16 | FCI | Food Corporation of India |
| 17 | FFS | Farmer Field School |
| 18 | FICCI | Federation of Indian Chambers of Commerce & Industry |
| 19 | FIFO | First in First out |
| 20 | FSCM | Fresh Produce Supply Chain Management |
| 21 | GDP | Gross Domestic Product |
| 22 | GLPI | Green Logistics Performance Index |
| 23 | GST | Goods & Service Tax |
| 24 | HIC | Horticulture Information Centre |
| 25 | HLS | Handling, Loading and Stacking |
| 26 | HMNEH | Horticulture Mission for North East and the Himalayan States |
| 27 | HP | Himachal Pradesh |
| 28 | HWT | Hot Water Treatment |
| 29 | ICT | Information and Communications Technology |
| 30 | IDEC | Indirect Direct Evaporative Cooling |
| 31 | ICT | Information and Communication Technology |
| 32 | IT | Information Technology |
| 33 | JIT | Just in Time |
| 34 | KMO | Kaiser Meyer Olkin |
| 35 | KPI | Key Performance Indicator |
| 36 | LPI | Logistics Performance Index |
| 37 | LT | Local Traders |
| 38 | MHE | Material Handling Equipment |
| 39 | MoAFW | Ministry of Agriculture & Farmers' Welfare |

| | | |
|---|---|---|
| 40 | MOFPI | Ministry of Food Processing Industries |
| 41 | MoR | Minister of Railways of India |
| 42 | MOSPI | Ministry of Statistics and Program Implementation |
| 43 | MoT | Ministry of Transport |
| 44 | MSME | Ministry of Micro, Small and Medium Enterprises |
| 45 | MSP | Minimum Support Price |
| 46 | NABARD | National Bank for Agriculture and Rural Development |
| 47 | NAM | National Agriculture Market |
| 48 | NCCD | National Centre for Cold Chain Development |
| 49 | NGO | Non-governmental organisation |
| 50 | NIFTEM | National Institute of Food Technology Entrepreneurship and Management |
| 51 | NHB | National Horticulture Board |
| 52 | NIC | National Informatics Centre |
| 53 | NOC | No-Objection Certificate |
| 54 | NSDC | National Skill Development Corporation |
| 55 | NSIC | National Small Industries Corporation |
| 56 | PCA | Principal Component Analysis |
| 57 | PPP | Public–Private Partnership |
| 58 | RFID | Radio Frequency Identification Device |
| 59 | RO | Research Objective |
| 60 | RRBs | Regional Rural Banks |
| 61 | SC | Supply Chain |
| 62 | SCM | Supply Chain Management |
| 63 | SCOR | Supply Chain Operations Reference |
| 64 | SIDBI | Small Industries Development Bank of India |
| 65 | SPSS | Statistical Package for the Social Sciences |
| 66 | TOC | Theory of Constraints |
| 67 | TQM | Total Quality Management |
| 68 | UfSC | Unloading from Seller's Crate |
| 69 | UfT | Unloading from Truck |
| 70 | UK | Uttarakhand |
| 71 | UP | Uttar Pradesh |
| 72 | USA | United States of America |
| 73 | WEF | World Economic Forum |

# LIST OF FIGURES

**Chapter 6**



**Chapter 7**

# LIST OF TABLES

# 1. INTRODUCTION

*India is an agriculture dominating country and known as the food bowl of the world. Fruits and Vegetables (F&V) sector plays a vital role and has been a driving force in stimulating a healthy growth trend in Indian agriculture. It also plays a unique role in India's economy by improving the income of the rural people. This chapter presents the status and significance of F&V sector in India followed by the post-harvest losses scenario in F&V sector, which is one of the key impediments in the growth of Indian economy. Further, this chapter discusses the issue of the inefficient supply chain in F&V sector. Thus, establishes a need for the efficient supply chain.*

## 1.1. Background: Fruits and Vegetables Sector-Status and Importance

In Indian economy, the role played by agricultural sector happens to be quite crucial in nature and has witnessed massive structural changes in terms of decline in share of Gross Domestic Product (GDP) from 30% in 1990-91 to 17% in 2016, thereby signifying a change from the conventional agrarian economy towards a service oriented economy. However, the agriculture sector still employs more than half of the total workforce and one of the primary source of livelihood for about 58% of India's population (IBEF, 2018). Despite a steady decline of its share in the GDP, agriculture is still the most significant economic sector and a significant piece of the overall socio-economic development of India (GoI, 2017; ASSOCHAM, 2013).

Structural change in the composition of agriculture and allied sector in India is leading to a diversification of agriculture into the horticulture, livestock and fisheries sector. According to the study of ASSOCHAM, the share of horticulture output has significantly enhanced from 16% in 1990-91 to 20% in the year 2009-10 (at 2004-2005 prices) as shown in Figure 1.1. Moreover, the share of traditional crop likes cereals, pulses, and oilseeds have declined in the same period.

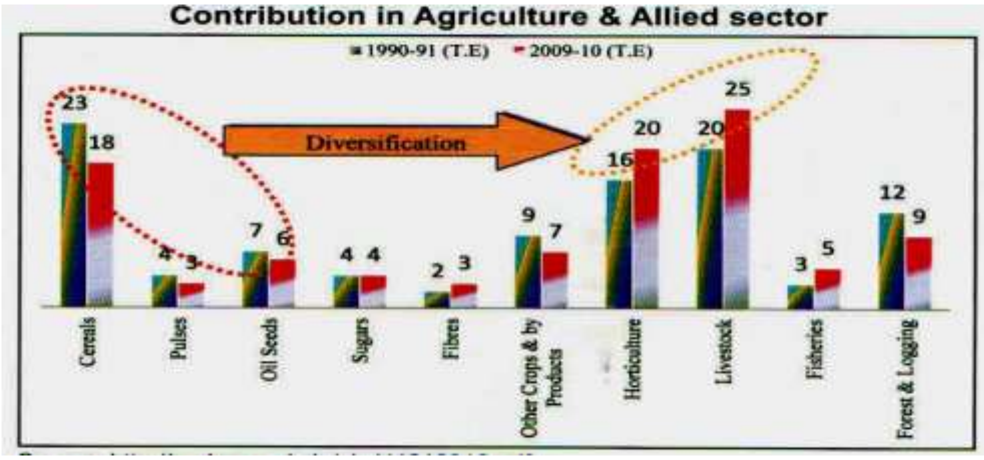



**Figure 1.1: Contribution of different agriculture segments in Agriculture & Allied Sector**

*Source: ASSOCHAM Report (2013)*

The growth in horticulture sector is evident from the Figure 1.2, which exhibits that over a period of 14 years (2001-02 to 2014-15) the horticulture production has shot up by 84%. The gross produce of horticulture in India touched 284 million tonnes in 2014-15, far ahead of total food grain production of 253 million tonnes. Production of F&V overtook India's food grain production by a whopping 31 million tonnes in 2014-15.

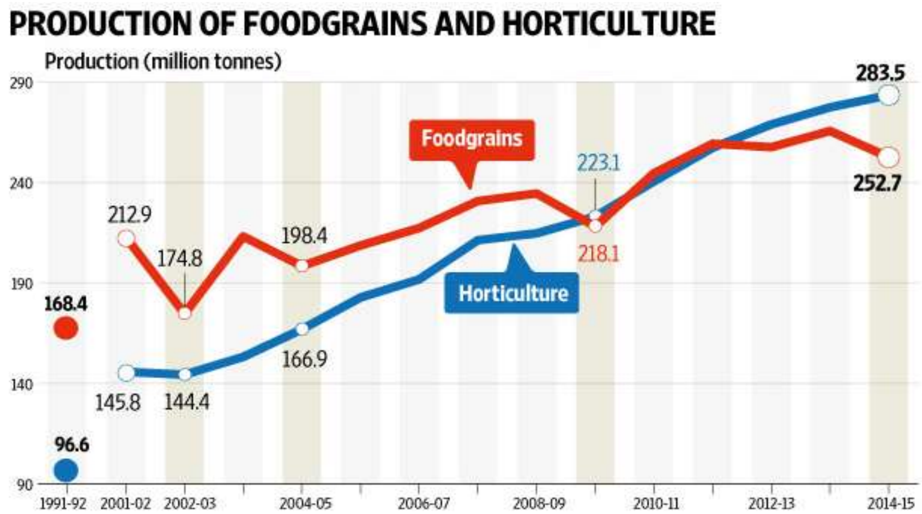



**Figure 1.2: Horticulture and Food grain production in India (1991-2015)**

*Source: Horticulture Statistics at a Glance, 2015*

The movement of farmers towards horticulture sector can be attributed to the fact that there has been a tremendous increase in the demand for fresh F&V in organised markets, is a true sign of prosperity in horticulture sector (Mallapur, 2015). Government of India data reveals that there has been a sharp decline in the consumption patterns of rice and wheat of around 1-2%, both by rural and urban population in India, whereas a significant increase of around 2-3% has been witnessed annually towards the demand for F&V (Govil, 2013).

The increased shares of horticulture in the agriculture & allied imply that they have been growing at a much faster rate than the traditional crop sector. The percentage share of horticulture output in agriculture is more than 33% (GoI, 2016a). Before a couple of decades, the scenario was entirely different, where the horticultural crop production was considerably low. Since the area covered by horticultural crops has increased significantly to 24.94 million ha in 2016-17, as compared to the area of 15.14 million ha in the year 2001-02, there has been a massive growth in the horticulture production, which rose from 145.78 million tonnes to 295.35 million tonnes as shown in Figure 1.3. Thus, there has been a robust growth observed in the area (40%) and production (78%) of horticulture crops during the year 2001-02 to 2016-17 (NHB, 2017). The total land available for horticulture production has been doubled up during the past 20 years.

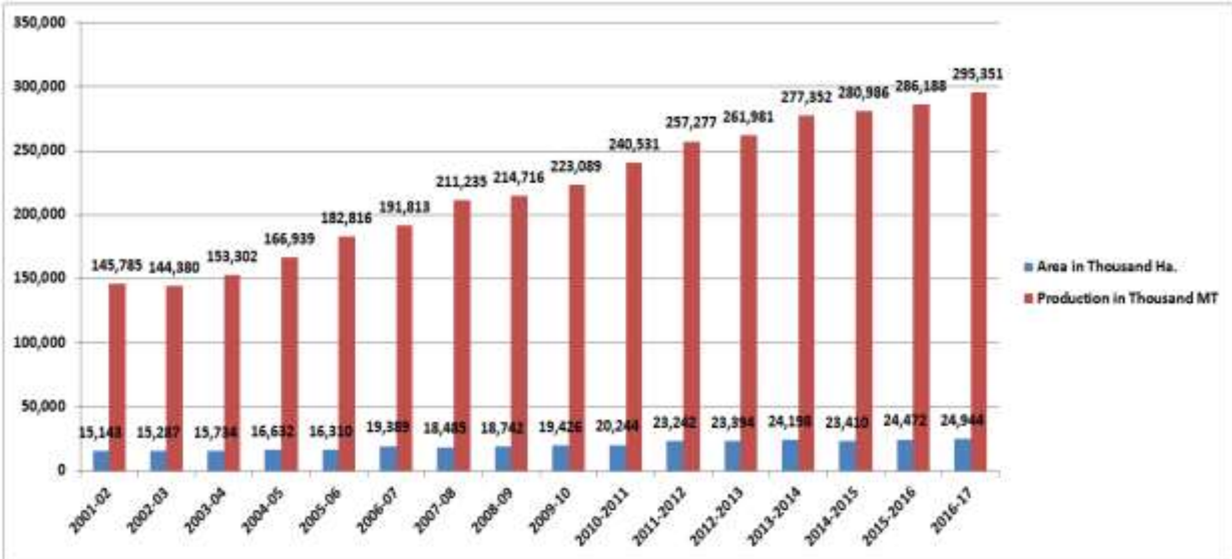



**Figure 1.3: Area and Production Growth Trends for Horticulture Crops**

*Source: National Horticulture Board, 2017*

The trend suggests that horticulture sector is going to be a major player in contributing to the development of Indian agriculture in times to come. It also has tremendous potential to push the overall agriculture growth and contributes 30% of agricultural GDP (Kallega et al., 2015; Choudhary, 2013).

The production of horticulture constitutes F&V, spices, rubber, coffee and tea in which the contribution of vegetables is 60% while fruits contribute 30% and plantation crops cover the remaining 10%. (NHB, 2017). India has bestowed with a wide range of climate and physio-geographical conditions, which is most suitable for growing various kinds of horticultural crops. This has placed India among the leading countries in horticulture production just behind China. In horticulture sector, F&V together constitute about 91% of the total horticultural production in India (NHB, 2017); thus, the study primarily focuses upon these two categories only.

The F&V sector has been a driving force in stimulating a healthy growth trend in Indian agriculture. Given the rising share of high-value commodities in the total value of agricultural output and their growth potential, this segment is likely to drive agricultural growth in the years to come (Negi and Anand, 2016). It plays a unique role in India's economy by improving the income of the rural people. Cultivation of these crops is Labour intensive, and as such, they generate many employment opportunities for the rural population. F&V sector is perhaps the most profitable venture of all farming activities as it provides ample employment opportunities and scope to raise the income of the farming community. It has full potential to be categorised as a substitute cash crop for growers and has tremendous potential to push the overall agriculture growth. India has bestowed with a wide range of climate and physio-geographical conditions, which is most suitable for growing various kinds of F&V, and has placed India among the leading countries in F&V production just behind China. Apart from providing security in terms of livelihood and nutrition and helping individuals in a massive manner to tackle poverty, it also helps in generation of employment. The creation of ample employment opportunities in the non-farming sector along with the ability to sustain numerous agro industries is a major characteristic feature of this sector.

### 1.1.1 Trends in Fruits and Vegetables Production & Present Status

During 2014-15, India's contribution to the world production of F&V was 13.6% and 14% respectively (NHB, 2017). China’s share was highest in both F&V with 21% in world’s fruit production, followed by India (13.6%), Brazil (5.9%), and USA (4.1%) and 49% in world's vegetables production followed by India (14%), USA

(3%), and Turkey (2%). The world production and its percentage share in F&V are shown in Table 1.1 and Figure 1.4 & Figure 1.5.

**Table 1.1: World production and percent share in 2014-15**

| FRUITS | | | VEGETABLE | | |
|---|---|---|---|---|---|
| **Country** | **Production** | **Share** | **Country** | **Production** | **Share** |
| China | 137066750 | 20.9% | China | 573935000 | 49% |
| ***India*** | ***88977134*** | ***13.6%*** | ***India*** | ***162896911*** | ***14%*** |
| Brazil | 38368678 | 5.9% | USA | 35947720 | 3% |
| USA | 26548859 | 4.1% | Turkey | 27818918 | 2% |
| Indonesia | 17744411 | 2.7% | Iran | 23485675 | 2% |
| Philippines | 16370976 | 2.5% | Egypt | 19825388 | 2% |
| Mexico | 15917806 | 2.4% | Russian Federation | 16084372 | 1% |
| Turkey | 14974561 | 2.3% | Mexico | 13599497 | 1% |
| Spain | 13996447 | 2.1% | Spain | 12531000 | 1% |
| Italy | 13889219 | 2.1% | Italy | 12297645 | 1% |
| OTHERS | 270594597 | 41.3% | OTHERS | 261467661 | 23% |

*Source: Indian Horticulture Database, NHB, 2017*

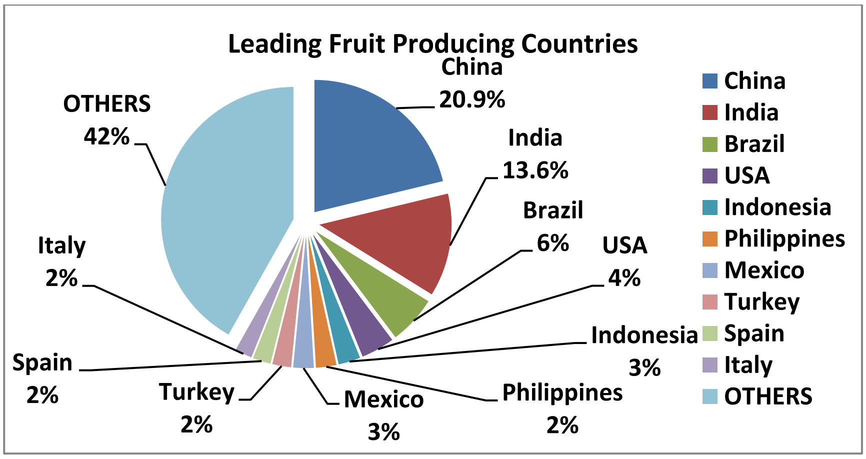



**Figure 1.4: Percentage shares of leading fruit producing countries**

*Source: National Horticulture Board, 2017*

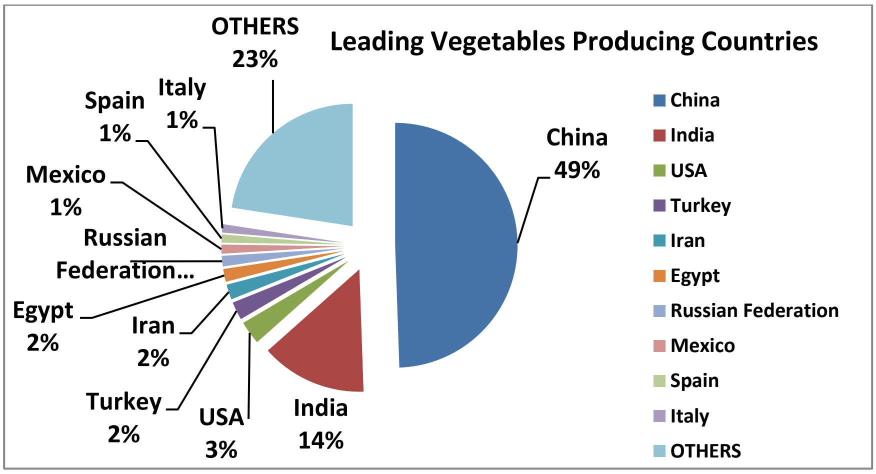



**Figure 1.5: Percentage shares of leading vegetables producing countries**

*Source: National Horticulture Board, 2017*

India is the largest and second largest producer of many F&V such as Mango, Guava, Banana, Papaya, Okra, Potato, Onion, Tomato, and Cabbage. The share of this fresh produce in world production has shown in Table 1.2 and Table 1.3.

**Table 1.2: Largest Producer of F&V with a share in World Production**

| S. No. | Fruit & Vegetables | Share in World Production |
|---|---|---|
| 1 | Mango & Guava | 45.11% |
| 2 | Banana | 27.81% |
| 3 | Papaya | 43.74% |
| 4 | Okra | 72.90% |

*Source: National Horticulture Board, 2017*

**Table 1.3: Second Largest Producer of F&V with a share in World Production**

| S. No. | Fruit & Vegetables | Share in World Production |
|---|---|---|
| 1 | Brinjal | 27.23% |
| 2 | Cabbage | 12.79% |
| 3 | Cauliflower & Broccoli | 37.53% |
| 4 | Onion | 22.57% |
| 5 | Potato | 11.04% |
| 6 | Tomato | 11.05% |

*Source: National Horticulture Board, 2017*

India is the second largest food producer in the world, after China and one of the centers of origin of F&V with the total production of 92.84 million metric tonnes of fruits and 175.19 million metric tonnes of vegetables till the year 2017 (NHB, 2017). The production of F&V in India has been shown in Figure 1.6 from the year 2001-2017, which has increased from 43.001 million metric tonnes to 92.84 million metric tonnes in fruits and 88.62 million metric tonnes to 175.19 million metric tonnes in vegetable.

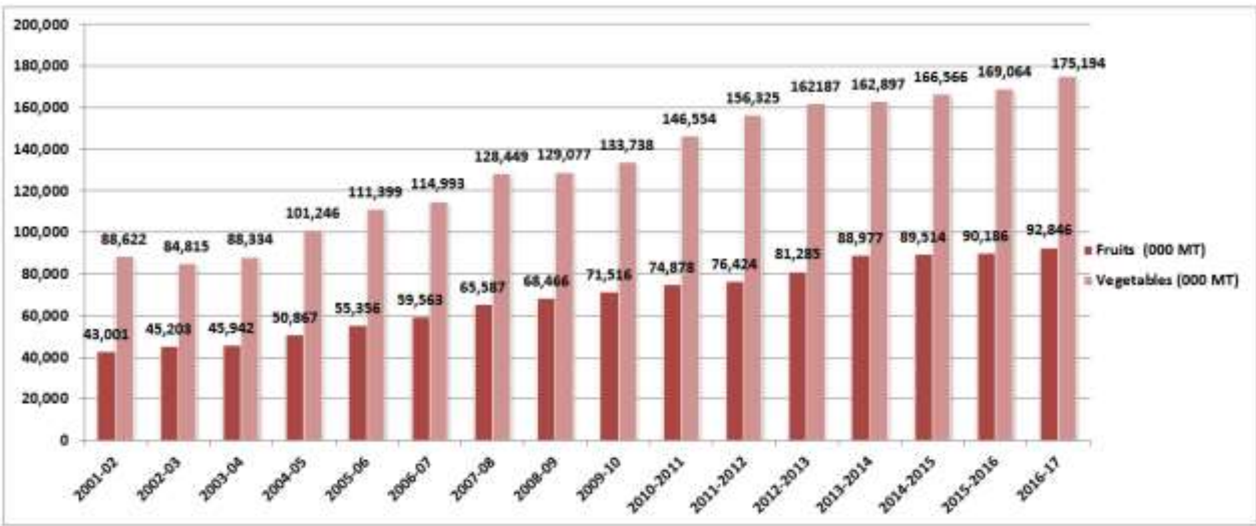



**Figure 1.6: Fruits and Vegetables Production in India**

*Source: National Horticulture Board, 2017*

A large variety of F&V are grown in India such as banana, mango, apple, papaya, sapota, citrus, pineapple, grapes, guava in fruits and potato, tomato, onion, brinjal in vegetable. Among fruits, banana and mango accounted for more than half (52%) of total fruit production with 29.16 million tonnes of banana and 19.68 million tonnes of mango during 2016-17 as shown in Figure 1.7.

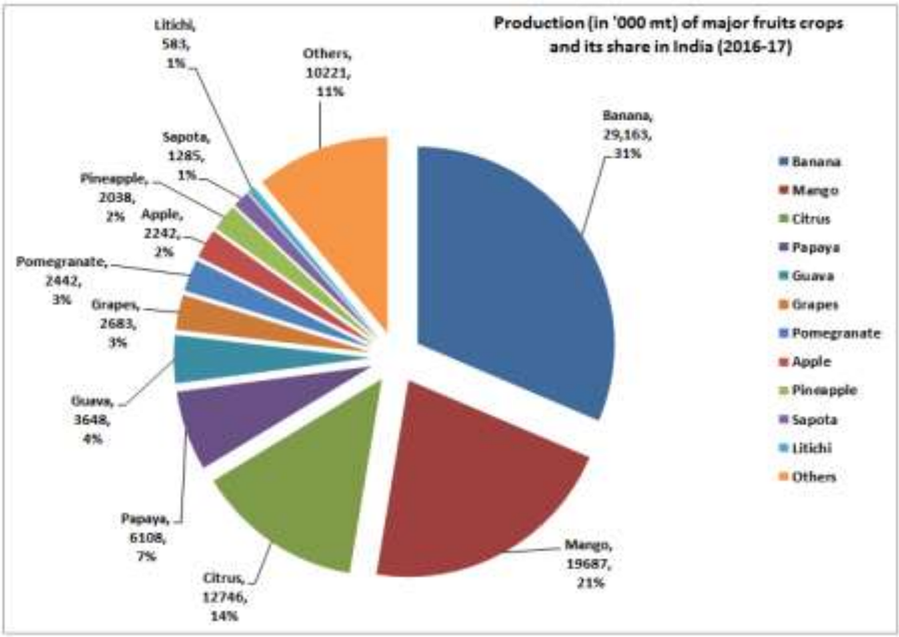



**Figure 1.7: Major Fruit Production in India**

*Source: National Horticulture Board, 2017*

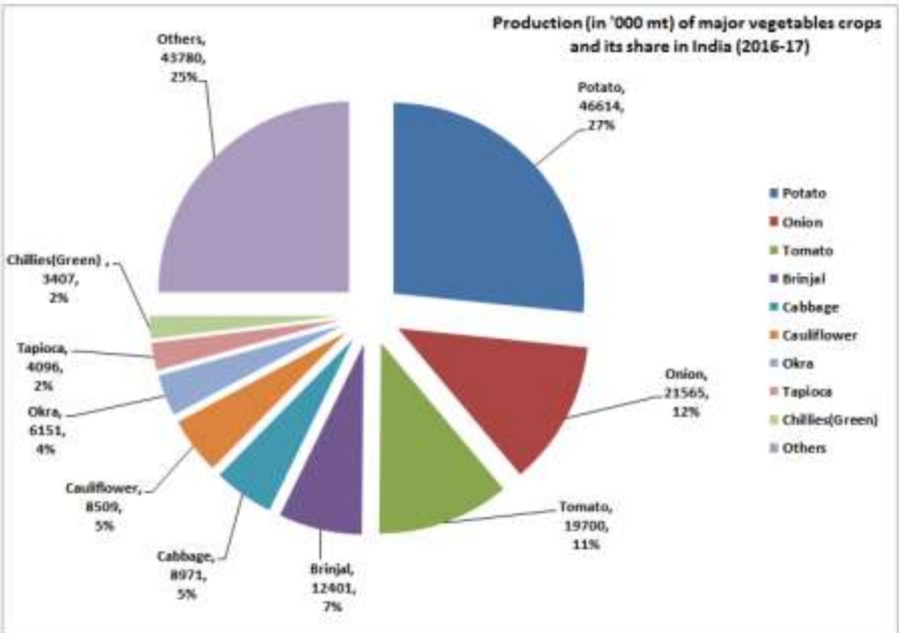



**Figure 1.8: Major Vegetables Production in India**

*Source: National Horticulture Board, 2017*

Among vegetable, potato comprised about one-fourth of the total vegetables production with 27%, onion comprises 12%, and tomato comprised 11% of the total vegetables production in India as shown in Figure 1.8.

F&V is also the rich source of vitamins, minerals, proteins, and carbohydrates, which are essential in human nutrition. Hence, these are referred to as protective foods and assumed great importance for the nutritional security of the people. As the population is increasing, the demand for such food is also increasing.

### 1.1.2 State wise comparison

Concerning fruits production (as shown in Figure 1.9), state of Andhra Pradesh has the maximum share of 13% with the total production of 12.09 million tonnes. Maharashtra follows this with 10.37 million tonnes (11.18%), Uttar Pradesh with 10.35 million tonnes (11.15%), Gujarat with 8.48 million tonnes (9%), Karnataka with 7.42 million tonnes (8%), Tamilnadu with 6.07 million tonnes (7%), Madhya Pradesh with 5.93 million tonnes (6%), Bihar with 4.27 million tonnes (5%), West Bengal with 3.70 million tonnes (3.99%), Telangana with 3.53 million tonnes (3.81%), Kerala with 2.46 million tonnes (2.66%) , and rest of the states in India with 18.10 million tonnes of production (19.50%).

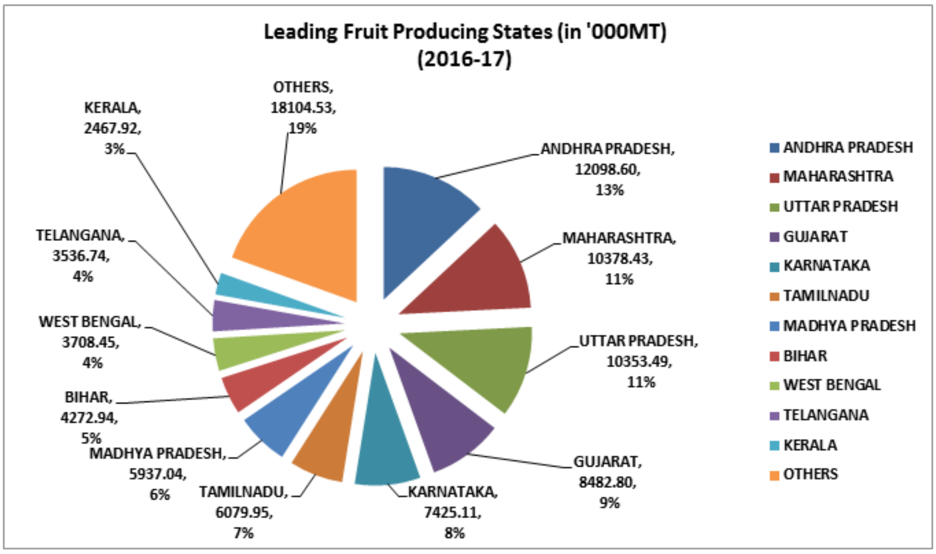



**Figure 1.9: Leading Fruits Producing States in India**

*Source: National Horticulture Board, 2017*

Concerning vegetables production, (as shown in Figure 1.10) state of Uttar Pradesh has the maximum production of 26.40 million tonnes with the share of 15% of the total production. West Bengal follows this with 25.50 million tonnes (14%), Madhya Pradesh with 16.66 million tonnes (9%), Bihar with 14.22 million tonnes (8%), Gujarat with 13.40 million tonnes (8%), Maharashtra with 10.36 million tonnes (6%), Odisha with 8.76 million tonnes (5%), Karnataka with 8.20 million tonnes (5%), Haryana with 6.96 million tonnes (4%), Chhattisgarh with 6.70 million tonnes (4%), Tamilnadu with 6.30 million tonnes (4%), Andhra Pradesh with 5.35 million tonnes (3%), and 26.34 million tonnes (15%) by rest of the states in India34 million tonnes (15%).

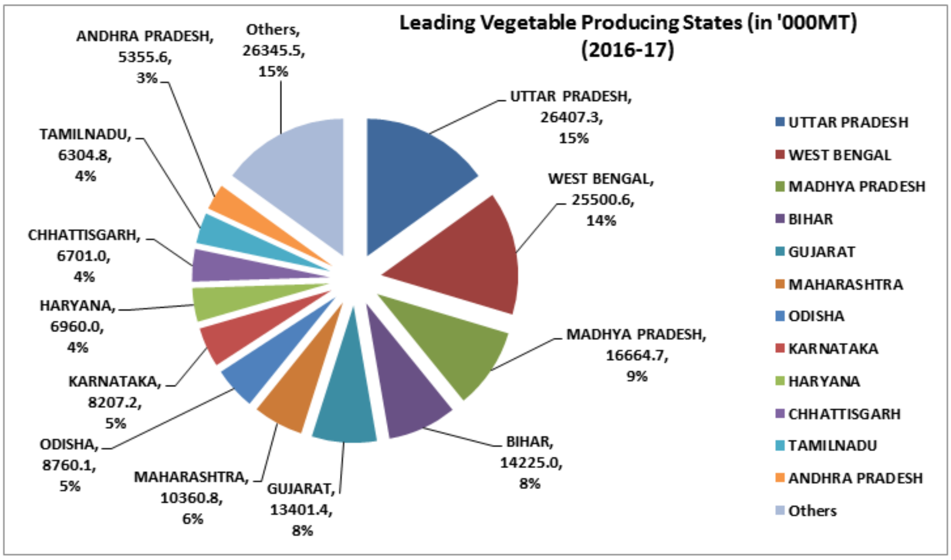



**Figure 1.10: Leading Vegetables Producing States in India**

*Source: National Horticulture Board, 2017*

India has the potential to be the world's largest food producer that is bestowed with large base of natural resources and several factors like disposable income, nuclear families & working women, and increasing urbanization are preparing supply chain of food in India for a healthy future. Organised retailing, functional food demand, higher expenditure on healthy food are the major drivers for significant development of F&V sector (Rathore et al., 2010). As per the estimates of Euromonitor International, approximately 90% consumers in India effectively spend on fresh categories of food with majority of the share consisting of F&V (Sinha & Thomas, 2012). As the population is increasing, the demand for F&V is also increasing; therefore, to meet such demand and provide food in proper nutrition and quality, the supply chain plays a very vital role in F&V sector and becomes even more critical because of perishability and very short shelf life.

India is among the world's largest food producer serving the food consumer all across the globe. Despite second largest food producer in the world, the customers in India are not getting the fresh produce in proper quality, right time and at a right cost. India, the world’s second largest F&V producer, is also one of the biggest wasters in the world (ASSOCHAM, 2013).

### 1.2. The extent of losses and wastage in the supply chain of the F&V sector

Each year, billions of tons of fresh food items with millions of dollars are lost due to poor supply chain system in developing market (International Trade Administration, 2013). As per the list of World Economic Forum (WEF), ***food crises is the fourth top global risks of highest concern for the next ten years*** (World Economic Forum, 2016). Globally, billions of dollar spent on improving agricultural processes to create higher food production, but the fact is that nearly half of all food produced never reaches to the consumer’s plate (World Economic Forum, 2013), resulting to global losses of more than $750 billion annually in the food sector (FAO, 2013). From various studies on post-harvest losses in India, it is evident that the amount of food wasted in a year in India is equivalent to annual food consumption in some countries like UK (Rathore, Sharma, & Saxena, 2010) and the total production of Great Britain (Khan, 2005). The challenge of feeding India's billion-plus people is not really about agriculture production but getting the proper food to the individuals. The average production of F&V in India is sufficient to meet the recommended dietary allowances for a balanced diet. However, there are large interstate differences in the availability of F&V (Rao Narsinga, 2013). Many are available only in particular seasons of the year, and lots of fresh produce gets wastage before reaching to consumer's hand.

Post-harvest losses in the supply chain of F&V are one of the determinants of the food problem in most developing countries (Babalola et al., 2008; Ojo, 1991). In developing countries, losses incurred in the process of post-harvest amount between 1-50%, or even greater at times (Buyukbay et al., 2011; Kader, 2005). However, wastage of food is not suitable for two main reasons: firstly, there may be a quality loss regarding energy protein and other nutrients; and secondly, there may be an economic loss concerning the value of food. The primary concern for F&V supply chain management is the post-harvest wastage. F&V are highly perishable commodities, and according to a study by ASSOCHAM (2013), in India, about 30% of F&V are not fit for the purpose of consumption because of post-harvest losses.

As per the estimates of Ministry of Food Processing Industries (MoFPI), in the year 2016, the losses resulting from post-harvest operations in agricultural production of India amounted to a staggering figure of Rs. 92,651 crores. The loss is nearly thrice as that of the Indian agriculture budget, that has witnessed a growth of 44% from Rs 24,909 crore in the budget of 2015-16 to Rs 35,984 crore in 2016-17 (Moloney, 2016). According to Central Institute of Post-Harvest Engineering and Technology (CIPHET), Punjab, approximately 16% of F&V (Rs 40,811 crores) were lost. The losses vary from 4.65% to 5.99% in case of cereals and 4.58% to 15.88% in case of F&V (Table 1.4). It was also reported that F&V have high losses and wastage in farm-level operations.

**Table 1.4: CIPHET estimated losses of major produces**

| Commodity/Crop | Loss (in Rs. crore) | Loss (%) |
|---|---|---|
| **Fruits & Vegetable** | **40811** | **4.58-15.88** |
| Cereals | 20698 | 4.65-5.99 |
| Pulses | 3877 | 6.36-8.41 |
| Oilseeds | 8278 | 3.08-9.96 |
| Milk | 4409 | 0.92 |
| Egg | 1320 | 7.19 |
| Inland Fish | 3766 | 5.23 |
| Marine Fish | 4315 | 10.52 |
| Meat | 1235 | 2.71 |
| Poultry Meat | 3942 | 6.74 |
| Total | 92,651 | |

*Source: GoI, 2016b*

According to ASSOCHAM (2013), every year, around Rs. 2.13 lakh crore worth of F&V is wasted among major producing states in India as shown in Table 1.5. The losses are found higher in the state of West Bengal valued Rs. 13, 657 Crore, followed by Gujarat, Bihar, Uttar Pradesh, Maharashtra, Tamilnadu, Karnataka, Andhra Pradesh, and Madhya Pradesh.

**Table 1.5: Fruits and Vegetables Losses among the major producing state**

| State | Total Loss (Rs. Crore) |
|---|---|
| West Bengal | 13657 |
| Gujarat | 11398 |
| Bihar | 10744 |
| Uttar Pradesh | 10312 |
| Maharashtra | 10100 |

| | |
|---|---|
| Tamil Nadu | 8170 |
| Karnataka | 7415 |
| Andhra Pradesh | 5633 |
| Madhya Pradesh | 5332 |
| *Others* | *129791* |
| **All India** | **212552** |

*Source: ASSOCHAM India, 2013*

A research study conducted by CIPHET (2010) in India found that losses in selected pulses, cereals and oilseeds amounted to 4.3-6.1%, 3.9-6%, and 2.8-10.1% respectively. Marine fisheries witnessed 2.9% loss on an average whereas, the losses incurred in inland fisheries amounted to approximately 6.9%. In meat and poultry sector, the losses incurred were 2.3% and 3.7% respectively, whereas, in dairy sector, the loss stood at 0.8%. Among all the agriculture produce, the highest losses were found in F&V, which was in the range of 5.8-18% (CIPHET, 2010) as shown in Table 1.6.

**Table 1.6: Losses percentage in major produces**

| Crop | Cumulative wastage (%) |
|---|---|
| Milk | (0.80%) |
| Meat | (2.30%) |
| Oilseeds | (2.8-10.1%) |
| Fisheries (Marine) | (2.90%) |
| Poultry | (3.70%) |
| Cereals | (3.9-6%) |
| Pulses | (4.3-6.1%) |
| **Fruits & Vegetable** | **(5.8-18%)** |
| Fisheries (Inland) | (6.90%) |

*Source: Post-harvest losses study by CIPHET, 2010*

According to CIPHET, the total post-harvest losses in major agricultural produces at the national level was Rs 44,143 crore per annum. It was found that most of the wastage incurred in F&V (5.8-18%), comprising value of Rs 7,437 crore in fruits and Rs 5,872 crore in vegetables (GOI, 2012). The maximum amount of losses was found in Mango (Rs. 3,298 Crore) as shown in Table 1.7.

In F&V losses, Sinha (2011) also found the maximum amount of losses in Mango and Tomato, both having 39% of losses (as shown in Table 1.8). Bhushan (2013) also found that nearly 15% of India’s Mango production goes waste.

**Table 1.7: CIPHET Percentage of estimated losses**

| S. No. | Crop / commodity | *Production (million MT) | *Price Rs/MT | Losses estimated (%) | Estimate of economic value of the losses (₹ in crores) |
|---|---|---|---|---|---|
| (i) | **Cereals** | **211.61** | **51,676.5** | | **12,593** |
| (ii) | **Pulses** | **11.974** | **1,27,229.7** | **4.3 – 6.1** | **1,735** |
| (iii) | **Oilseeds** | **31.66** | **1,25,367.3** | **2.8 – 10.1** | **5,107** |
| (iv) | **Fruits** | | | | |
| 1 | Apple | 1.622 | 47,771.6 | | 953 |
| 2 | Banana | 20.858 | 9,262.5 | | 1,275 |
| 3 | Citrus | 7.097 | 18,774.6 | | 839 |
| 4 | Grapes | 1.668 | 31,364.2 | | 434 |
| 5 | Guava | 1.856 | 12,194.5 | | 407 |
| 6 | Mango | 13.501 | 19,232.2 | | 3,298 |
| 7 | Papaya | 2.405 | 8,833.3 | | 157 |
| 8 | Sapota | 1.191 | 10,727.5 | | 74 |
| | **Total** | **50.198** | **1,58,160.4** | **5.8 – 18** | **7,437** |

*Source: Post-harvest losses study by CIPHET, 2010*

**Table 1.8: Fruits and Vegetables losses**

| Fruits & Vegetables | Percentage of Losses |
|---|---|
| Mango | 39% |
| Tomato | 39% |
| Onion | 25% |
| Banana | 18% |
| Litchi | 22% |
| Potato | 24% |
| Papaya | 10% |
| Guava | 15% |
| Cauliflower | 18% |
| Brinjal | 14% |

*Source: Sinha, Times of India, 2011*

Chadha and Pareek (1993) also assessed the amount of losses in F&V sector and found the highest amount of losses in Mango among all the fruits contributing to 17-37% as shown in Table 1.9.

**Table 1.9: Post-harvest losses in major fruit & vegetables crops**

| Post-harvest losses (% of production) | Name of fruit & vegetable |
|---|---|
| 23-30% | Grapes |
| 17-37% | Mango |
| 10-25% | Apple |
| 12-14% | Banana |
| 8-31% | Citrus (orange) |
| 5-20% | Pineapple |

| | |
|---|---|
| 3-15% | Guava |
| 15-30% | Onion |
| 15-20% | Potato |
| 10-20% | Tomato |
| 10-15% | Cauliflower |
| 10-13% | Brinjal |
| 7-15% | Cabbage |
| 7-12% | Beans and peas |
| 1-3% | Garlic |

*Source: Chadha and Pareek (1993)*

Table 1.10 highlighted the losses and wastages situation in the supply chain of F&V, based on the past studies.

**Table 1.10: Post-harvest losses scenario in fruits and vegetable**

| Authors/Source | Losses and Wastage Issue |
|---|---|
| GoI (2016b) | According to an analysis by the CIPHET, 16% of F&V, which worth Rs 40,811 crores were lost. |
| ASSOCHAM (2013) | As per the assessment of ASSOCHAM, India in 2013, the farmers have to forgo Rs. 2.13 lakh crore every year because of supply chain losses in F&V. |
| MOSPI (2012); Mishra & Sinha (2010) Verma & Singh (2004) | About 20 -30-40% of all foods produced in India (Rs. 500 b) gets wasted annually. |
| MOSPI (2012) | From the origin (farm) to the consumption (consumer), the F&V passes through six-seven different channel of distributions, and in each stage, there is a loss of 5-7%. |
| Gustavsson et al. (2011) | One-third of the total food production that is meant for human consumption gets wasted every year. |
| Narula (2011) | In F&V supply chain, the massive loss in the quality and quantity of fresh produce resulting to the value loss of 40%. |
| CIPHET (2010) | The study by CIPHET has estimated harvest and post-harvest losses of primary agricultural produce at a national level, which was of the order of Rs 44,143 crore per annum at 2009 wholesale prices. It was also found that most of the wastage is happening in F&V of about 5.8-18% worth value of Rs 7,437 crore in fruits and Rs 5,872 crore in vegetables. |
| Rathore, Sharma, & Saxena (2010) | From various studies on post-harvest losses in India, it is evident that the amount of food wasted in a year in India (around 35% to 40% of the total production) is equivalent to annual food consumption in UK. |
| | It has been predicted that the Indian food production figure is going to be twofold in ten years down the lane, but the losses after harvesting amounting 35-40% of the total production per annum (valued Rs. 58,000 crores) is a serious concern.. |
| Gauraha & Thakur (2008); Singh et al. (2008) | Supply chain losses in the perishable food product are the key impediment to the development of agriculture sector in India. |
| Babalola, Megbope & Agbola (2008); Ojo (1991) | In most developing nation, the main reason behind food problems is post-harvest losses. |
| Dagar (2007) | 25-40% of fresh farm produce that worth Rs 50,400 crore ($12 billion) deteriorate every single year prior it reaches to the final consumers. |
| Viswanadham (2007) | Farm produce valued at Rs 70,000 million (US$1,400 m) is wasted every year. |
| Jain (2007) | The post-harvest losses are of Rs. 29214 Cr. in Perishable (F&V) produce. |
| Jha (2007) | Rs. 58,000 Crore worth fruits, vegetables, and cereal grain wasted each year in India, which is sufficient to feed 27% of the below poverty line population and amounts to more than a third of total food production. |
| Kader (2005) | Worldwide about one-third of all F&V produced are never consumed by humans. |

| | |
|---|---|
| Subrahmanyam (1986) | The losses results to lack of availability of fresh food products and extensive monetary affect, which in turn, also escalates marketing costs and products distributing cost. |
| NationalAcademyofSources (1978) | Estimates of postharvest losses in developing countries vary significantly from 1 to 50% or even higher. |

In past few years, the prices of F&V have soared, and lack of affordability has become one of the significant factors that limit adequate consumption of F&V, especially in poorer households. Lack of usage and management issues in supply chains massively contributes to quality loss of F&V resulting in declining profits and other business opportunities (Halder & Pati, 2011). Jha (2007) presented the Food Facts in India, where, the author highlighted that Rs. 58,000 crores worth fruits, vegetable, and cereal grain are wasted each year in India, which is sufficient to feed 27% of the below poverty line population and amounts to more than a third of total food production.

Inefficient supply chain results in price instability, poor remuneration to the farmers, higher supply chain cost, rural poverty causing frustrations among farmers and eventually leading them to commit suicides (Rathore, Sharma, & Saxena, 2010). This in course of time makes the consumers to pay a hefty price. Due to the inefficient supply chain, the extent of loss in F&V is about Rs. 10,000 crores to Rs. 12,000 crores per annum and the loss of quantity ranges from 10% and 80% in some of the most perishable F&V (Mittal, 2007). Because of such losses and poor remuneration, it becomes extremely difficult on the part of the farmers to give back the debts, which they had incurred on buying pesticides, seeds, farm equipments and fertilizers for which the suicide rates among farmers are high, which constitutes almost two precious lives each day (Maheshwar and Chanakwa, 2007). In parliament, it has been acknowledged that 1,00,000 farmers have given away their lives during the decade from 1993-2003. Further, on an average, 16,000 farmers per year are said to have died since then (Maheshwar and Chanakwa, 2007). Various studies have shown the extent of losses in F&V supply chain and highlighted it as one of the primary issues in Indian economy. The past studies on losses and wastages are discussed in detail in the literature review chapter.

Agriculture is one of the most essential and thrust areas of the economy of India. Many researchers have found inefficiency as the major problem in the supply chain of perishable food produce leading to supply chain losses and wastages as shown in Table 1.11. It has been found that these losses are higher in the developing countries like India.

**Table 1.11: Inefficient supply chain in fruits and vegetable-An Issue**

| Author | Inefficient Supply Chain in F&V Sector |
|---|---|
| Degun (2014) | As per the estimates of World Economic Forum (WEF), approx. 95% of losses and wastage in food occurs due to supply chain inefficiency. |
| | WEF's report stated that inefficiency in supply chain results to huge losses in food each year, which amount to 1.3 billion tons. |
| Simon (2014) | Total one-third production of food in India is waste before it reaches to the consumer due to inefficient supply chains. |
| Bhardwaj et al. (2011) | Traditional F&V supply chain is prone to various sources of inefficiencies, which are contributing to losses. |
| Veena et al. (2011) | Due to the inefficient supply chain, the price received by farmers is only about 24% to 58% of the consumer price. |
| Mishra & Sinha (2010) | Inefficient supply chain is the most serious problem faced by agricultural industry in India. Due to the which, the extent of losses in fruit and vegetables is about Rs. 10,000 crores to Rs. 12,000 crore per annum and the loss of quantity ranges from 10% and 80% in some of the most perishable F&V |
| Rathore et al. (2010) | Lack of efficient supply chain results to high wastage for the organisations. |
| Singh, Sikka, & Singh (2009) | Mandi (market) system has many inefficiencies, which results in huge amount of losses. In case of vegetables supply chain it is approximately 40%. |
| Viswanadham (2007) | The present supply chain in F&V sector is still in a very pathetic state and fraught with maximum inefficiency resulting in massive losses as much as nearly 30% and less remuneration for the farmers. |
| Mittal (2007) | Supply chain inefficiency in F&V sector resulting in huge amount of losses and wastages, due to which there is a lack of availability of better quality food.<br>Due to the inefficient supply chain, the extent of loss of F&V is about Rs. 10,000 crores to Rs. 12,000 crore per annum and the loss of quantity ranges from 10% and 80% in some of the most perishable F&Vs. |

There is an absolute requirement of research in the area not only to understand the challenges in supply chain management fully, but also to identify the opportunities for improvement and to reduce several inefficiencies in the supply chains (Bhardwaj & Palaparthy, 2008). F&V are highly perishable and because of the high level of wastage and inefficiency in this sector, efficient supply chain after the farm gate to the final consumer has become an absolute necessity. Hence, there is an urgent need to develop intelligent supply chains to curb losses and increase the shelf life of F&V ensuring safety and desired quality (Rathore *et al.*, 2010). The extent of wastage can only be reduced by proper and efficient supply chain (Shukla & Jharkharia, 2013).

In Indian agriculture, the potential problems hindering growth are the issues related to supply chain losses in the perishable food products. Hence, the supply chain efficiency is a necessary pre requisite in F&V sector, facilitating increase in profits for the supply chain participants and would further minimise the wastage and losses. Moreover, it will minimise the chances of quality deterioration of F&V and increases the value significantly by ensuring a reliable delivery within the right time and right quality by ensuring minimum prices for the customers.

The objective of this thesis is to address the supply chain inefficiency in perishable F&V. Therefore, researcher defines these as perishable food products to differentiate these from other F&V in which the shelf life is long such as Jackfruits, Coconut, Watermelon, and Pumpkin. Figure 1.11 exhibits complete differentiation to develop an understanding of the various perishable food products.

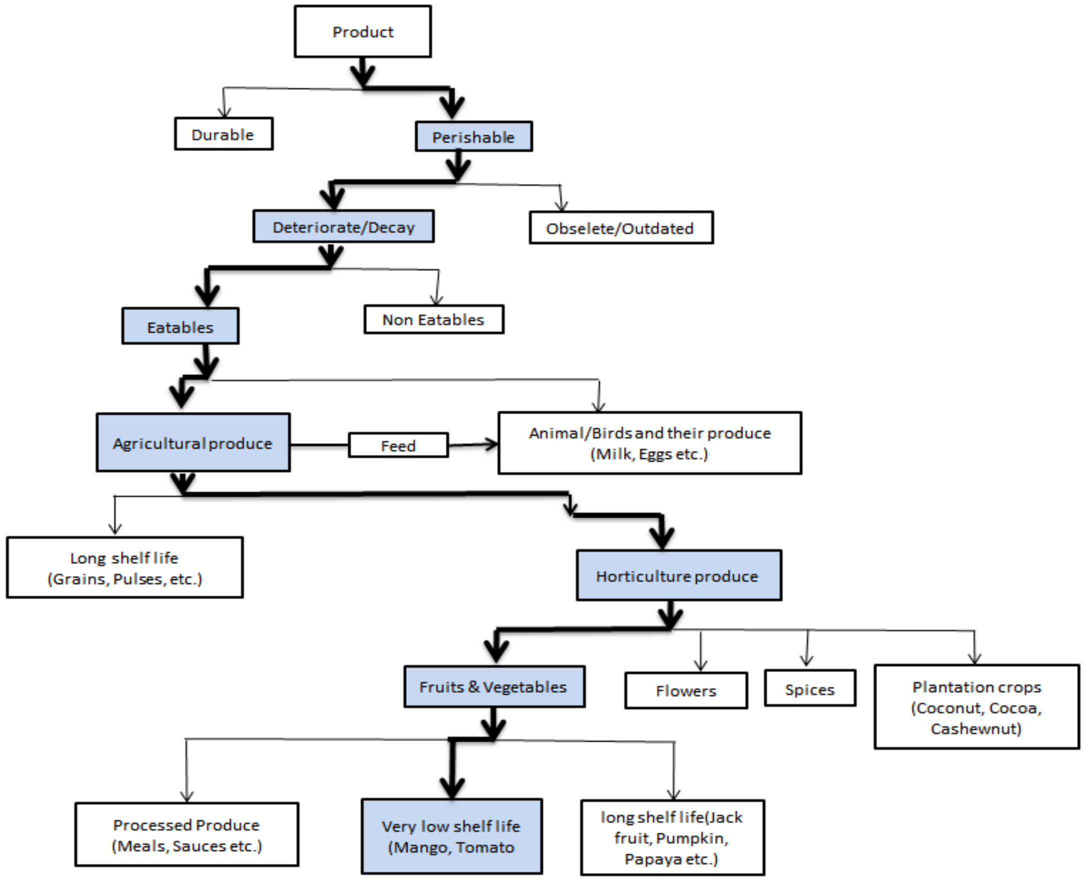



**Figure 1.11: Product Differentiations**

*Source: Adapted & Modified from Jharkharia and Shukla (2013)*

## 1.3. Rationale of the Study

Supply chain of F&V sector in India is suffering from maximum inefficiencies that are leading to huge amount of losses and wastage in F&V. India, the world's second largest F&V producer, is one of the biggest wasters in the world, which is a high matter of concern for the nation. Each year, billions of tons of fresh food items with millions of dollars' worth are lost due to poor supply chain system. Therefore, a need arises for research in the domain of F&V in order to understand the issues and challenges in supply chain and moreover, to determine the scope for improvement and simultaneously dealing with supply chain inefficiency. F&V are highly perishable in nature and because of the high level of wastage due to inefficiency in this sector; efficient supply chain from the farm gate to the final consumer has become an absolute necessity. Hence, there is an urgent need to develop an intelligent supply chain to curb losses, increase the shelf life of F&V, and ensure safety and desired quality. This thesis focuses on identifying the activities contributing to supply chain inefficiencies across the stages of F&V supply chain starting from farm gate to the commission agent/pre-harvest contractor to local traders and then finally to wholesale market usually known as Mandi, and the factors leading to supply chain inefficiency in the identified activities across the stages. Based on these identified activities and factors, a framework has been developed for improving supply chain efficiency of F&V sector in India.

## 1.4. Business Problem

Inefficient Supply Chain is resulting into immense loss of quantity and quality of F&V, decreasing shelf life and loss in terms of revenue to the various stakeholders of perishable F&V sector in India.

## 1.5. Research Questions

To address the gaps in the existing literature of F&V supply chain, some important research questions are considered in this research, as follows:

- What are the most significant activities contributing to supply chain inefficiency in different stages of fruits and vegetables supply chain with specific reference to mango and tomato?

- What are the factors leading to supply chain inefficiency in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato?
- How to develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato?

### 1.6. Objectives of the Study

Given these questions, the objectives of this research are:

- To identify the most significant activities contributing to supply chain inefficiency (*with respect to cost, time and quality)* in different stages of fruits and vegetables supply chain with specific reference to mango and tomato.
- To identify the factors leading to supply chain inefficiency *(with respect to cost, time and quality)* in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato.
- To develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato.

### 1.7. Scope of the Study

The scope of the study is limited to supply chain of F&V with specific reference to mango and tomato, as the highest amount of losses in F&V were found in these two categories. The supply chain from farm to wholesale mandi was selected because maximum inefficiency has been found between these stages. For Mango, state of Uttar Pradesh (UP) was selected as the origin point (farm), as it has the highest production of mango in India. For Tomato, Himachal Pradesh, and Uttarakhand was selected as the origin point (farm), as it has the high potential to serve the needs during offseason and the livelihood of the people in these states is largely dependent on the agriculture. For destination point/wholesale level, Azadpur Mandi was selected. Azadpur wholesale mandi is the Asia’s largest mandi and world’s second largest mandi, which has the highest amount of arrival among any wholesale mandi across the country.

## 1.8. Summary

| | |
|---|---|
| **Business Problem** | Inefficient Supply Chain is resulting into immense loss of quantity and quality of F&V, decreasing shelf life and loss in terms of revenue to the various stakeholders of perishable F&V sector in India. |
| **Research Gap** | Though various studies are available on Supply Chain Efficiency of agri and other products, hardly any study could be found suggesting a framework for improving supply chain efficiency at various stages of Fruits and Vegetables sector. |
| **Research Problem** | Although in the existing literature various studies have been conducted on F&V supply chain, in general, there is a lack of study on supply chain efficiency specifically to F&V sector. Also, the weak links and constraints responsible for supply chain inefficiency in different stages of F&V sector and the measures to improve supply chain efficiency are not known. Further, there is a lack of a framework for improving supply chain efficiency of F&V sector (specifically mango and tomato) in India. |
| **Research Questions** | • What are the most significant activities contributing to supply chain inefficiency in different stages of fruits and vegetables supply chain with specific reference to mango and tomato?<br>• What are the factors leading to supply chain inefficiency in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato?<br>• How to develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato? |
| **Research Objectives** | • To identify the most significant activities contributing to supply chain inefficiency (with respect to cost, time and quality) in different stages of fruits and vegetables supply chain with specific reference to mango and tomato<br>• To identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato.<br>• To develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato. |

## 1.9. Structure of the Thesis

The work presented in this thesis has been arranged in the following seven chapters:

Chapter 1: Introduction & Background

Chapter 2: Supply Chain Management of Fruits and Vegetable

Chapter 3: Literature Review

Chapter 4: Research Methodology

Chapter 5: Data Analysis and Findings

Chapter 6: Framework to Improve Supply Chain Efficiency of Fruits and Vegetables Sector

Chapter 7: Conclusion and Recommendation

# 2. SUPPLY CHAIN MANAGEMENT OF FRUITS AND VEGETABLES

*Supply chain plays a vital role in F&V sector and becomes even more critical because of perishability and very short shelf life. This chapter discusses the concept of the supply chain in general, its objectives and principles, and then the supply chain of F&V sector. It also throws light on different players involved in the supply chain of F&V Sector. Further, this chapter describes the various supply chain models operating in F&V sector in the Indian scenario.*

## 2.1. Introduction to Supply Chain Management (SCM)

Citing a proper definition of SCM, authors have placed higher emphasis on the importance of the chain players, considering the fact that customers is the most important element of the chain. Various definitions also focus on the both side movement of goods and services including funds and information from the point of origin to the point of consumption to achieve twin goals of profitability and sustainability in competitive market. This chapter highlights the critical features of few paradigms of SCM as various scholars and practitioners have described it.

Monczka et al. (2002) described that "today's organisations must manage both the upstream firms – suppliers providing direct and indirect inputs- and downstream firms or the distributive network delivering and offering after-market service to customers". Based on this, the authors have offered a broad definition of SCM, which is as follows:

"The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage (extraction), through to end users, as well as the associated information flows. Material and information flow both up and down the supply chain. The supply chain includes systems management, operations and assembly, purchasing, production scheduling, order processing, inventory management, transportation, warehousing, and customer service. Supply chain are essentially a series of linked suppliers and customers; every customer is, in turn, a supplier to the next downstream organisation until the finished product reaches the ultimate end user".

SCM is the amalgamation of the above-mentioned activities through better supply chain associations to garner sustainability in terms of competitive advantage.

SCM has a significant consequence on larger strategies of the organisations, specifically those related with sourcing and purchasing (Monczka et al. 2002), integrating manifold organisations as chain members. Monczka et al. (2002) have classified the members into three distinct types –internal operations, inbound suppliers and outbound customers. Couple of significant internal operations of an organisation are production scheduling and processing of orders. Scheduling of production goes as per the drafted schedules and production plans while processing of order includes interaction with the customers in a full-fledged manner- right from the start, which requires receiving the orders to post sale services. Inbound suppliers regulate the delivery of materials ensuring right time, quality and cost to the manufacturers. The goods in order to reach to the final consumers has to pass through distribution channel including various intermediate players. The role of logistics manager is to ensure the smooth management of distribution of goods and its transportation in the supply chain.

Monczka et al. (2002) highlighted the fact that there is interflow (both upward and downward) of goods, funds and information among the supply chain partners. Hence, managing the relationship between the partners is important, which provides competitive edge to the companies. Below mentioned are some of the advantages of supply chain to the organisations.

- Reduction in operational cost;
- Better delivery of goods;
- Enhanced Quality;
- Less cycle time;
- Convenient access to technology (Both product and process); and
- Less product development cycle times

Ross (2000) has stated that there is existence of multiple difficulties in providing a proper definition of SCM considering the fact that the concept includes a variety of usage and hence the possibility of defining it in manifold ways looms large. The author has visualized SCM as a vibrant, inclusive, growth oriented, and competition oriented method that is fostered by volatilities of market, which includes vulnerability to globalization, unpredictability and continuous change. Ross (2000) has concluded the SCM with following definition:

"SCM is a continuously evolving management philosophy that seeks to unify the collective productive competencies and recourses of the business functions found both within the enterprise and outside the firm’s allied business partners located along intersecting supply channels into a highly competitive, customer-enriching supply system focused on developing innovative solutions and synchronizing the flow of the marketplace products, services, and information to create unique, individualized sources of customer value."

Ross (1998) has stated the significance of consumers and has put forward an argument that the strategies of SCM should cater to the needs of the customers. SCM plays a very important role in both upwards and downwards flow of information of demand from the customers and fulfilling that demand through distribution of goods ensuring efficiency in cost and proper management of time. The modern day market is driven by the pull product approach as compared to that of the traditional push demand approaches. Hence, this is essential for proper SCM because in the modern era, customers are more inclined towards customized product. The reduction in costs and significant increase in sales due to SCM is recognised by several academicians and supply chain experts. In addition to that, Hoover et al. (2001) has stated that organisations following efficient practices with respect to SCM have significantly reduced cost as compared to their competitors, with a higher margin of profit and significantly lower prices.

Burt et al. (2003) stated that all the members belonging to the supply chain should focus on the following aspects of adding value into SCM:

- Cost-SCM needs to place emphasis on cost management bringing down the total cost in the chain.

- Quality- SCM should focus on Total Quality Management (TQM) to ensure that the products that enter into the market is of better quality.
- Time- SCM aims to deliver the goods and services to the customer on timely basis thereby reducing the lead time.
- Continuous supply- SCM helps to monitor the market trends, which augments to maintain the supplier relationship.
- Technology- In order to achieve competitive edge, SCM needs to put in order the technology externally and internally.

### 2.1.1. Definitions of SCM

Supply chain management (SCM) may be defined as:

[. . .] "a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimise system-wide costs while satisfying service level requirements" (Simchi-Levi et al., 2008).

"Supply Chain is a set of entities that collectively manufacture a product and sells it to an endpoint" (Stern et al., 2001). "Supply chain is the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hand of the ultimate customer" (Christopher, 1998). According to (Jones & Riley, 1985), "A supply chain consists of multiple parties/firms, both upstream (i.e., supply) and downstream (i.e., distribution), and the final consumer. It is the planning and control of the flow of total material from suppliers to manufacturers to distributors and finally to the end users". Ballou (2004) says, "Supply chain refers to all those activities associated with the transformation and flow of goods and services, including their attendant information flows, from the sources of raw materials to end users". "Supply chain management involves many independent organisations and develops through intra- and inter-organisational integration and coordination encompassing the initial stage to the end user. It includes a two-way flow of materials, services and information, and the related managerial and operational tasks. It aims at providing high value to customers with appropriate resource utilisation and building competitive advantage" (Cooper *et al.*, 1997a). The crucial factors involved in supply chain are competitive edge and integration, values of the customer and coordination among the partners in the chain. Competitive advantages to any firms come through enhancement of productivity and value. The advantage of productivity accrues by achieving the better results with minimum resource utilisation compare to others. Value emanates by providing customized products or services, reliability, and responsiveness, which require innovation and resources (Christopher, 1998). Integration and Coordination come through partnership in the supply chain, which requires strong interactions among the partners over time, with sharing of information, risks, and rewards (Ellram & Krause, 1994). Cooper et al. (1997a) stated that SCM is the planning and controlling of goods, flow of information and logistics activities internally and externally. A supply chain consists of varied links including the raw-material suppliers, manufacturers, distributors, retailers and finally the consumers as depicted in Figure 2.1. The supply chain includes operations engaged in conversion of raw-material into finished products. It involves not only the suppliers and manufactures/producers rather it includes a set of middlemen such as wholesalers, retailers, warehouse keepers, transporters and ultimately the consumers.

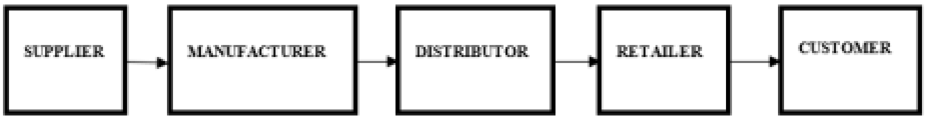



**Figure 2.1: An Illustration of Supply chain**

In literature, scholars have presented various perspectives in looking at the SCM, and for this reason, no universal definition of SCM exists (Croom et al., 2000). Various definitions of SCM are available in literature, which has been discussed in Table 2.1. Although the various definitions exhibits a variety of meanings, they happen to share a singular theme, i.e. operations management across various organisations. Moreover, there is universal rationality of SCM, organisations will gather business advantages (New, 1996).

**Table 2.1: Definitions of Supply Chain Management**

| Authors, year | Definition |
|---|---|
| Simchi-Levi et al. (2008) | "SCM is a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses, and stores so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, to minimise system-wide costs while satisfying service level requirements." |

| | |
|---|---|
| Koch (2006) | "SCM is the combination of art and science that goes into improving the way the company delivers products to customers." |
| Arunachalam (2003) | "SCM is concerned with planning and coordinating the activities of organisations across the supply chain, from raw material procurement to finished goods delivery." |
| Ayers (2001) | "SCM is the design, maintenance, and the operation of supply chain processes for the satisfaction of end users." |
| Hanfield and Nichols (1999) | "The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage (extraction), through to the end user, as well as associated information flows. Material and information flow both up and down the supply chain. SCM is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage." |
| Christopher (1998) | "The supply chain is the management of a network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hand of the ultimate customer." |
| Lambert, Cooper, and Pagh (1998) | "As the integration of fundamental business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders." |
| Cooper et al. (1997a) | "An integrating philosophy to manage the total flow of a distribution channel for ultimate customer." |
| Lee & NG (1997) | "The management of a network of entities that starts with the suppliers' supplier and end with the customers' customers for the production and delivery of goods and services." |
| International Center for Competitive Excellence (1994) | "SCM is the integration of business processes from end-user through original suppliers that provides products services and information that add value for customers." |
| Harland (1994) | "SCM is defined as the management of the flow of goods and services to end consumer to satisfy their requirements." |
| Berry, Towill, and Wadsley (1994) | "SCM aims at building trust, exchanging information on market needs, developing new products, and reducing the supplier base to a particular original equipment manufacturer (OEM) to release management resources for developing meaningful, long-term relationships." |
| Ellram (1991) | "An integrative approach to dealing with the planning and control of the materials flow from suppliers to end user." |
| Stevens (1989) | "A system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together through the feed forward flow of materials and the feedback flow of information." |
| Jones & Rilley (1985) | "SCM techniques deal with the planning and control of total materials flow from suppliers through end-users." |
| Oliver & Webber (1982) | "SCM covers the flow of goods from supplier through manufacturing and distribution chains to end user." |

## 2.2. Objectives of SCM

It can comprehend that with the variations in business environment, organisations have taken steps to form strategic alliances with supply chain partners, with the objective of declining unpredictability and increasing hold of channels with respect to distribution and supply of goods. Such associations together help organisations to upgrade the performance (financial and operational) of every network partner through minimising total cost in the supply chain and inventories by an increase in sharing the real-time information. Therefore, it is extremely crucial to realize the central purpose of SCM.

***The fundamental objective is to "add value."***

The aim of SCM is to enhance the overall value generation. Value is the difference between the costs of particular item incurred by the customer, and the effort laid down by the supply chain to satisfy the demand of the customer. In simple term, SCM is primarily meant for satisfying the customer's requirement and in the entire process ensuring profit for them (Chopra, Meindl, and Kalra, 2010).

Furthermore, according to Cooper et al. (1997b), "SCM is designed to face the market challenges and helps the firm to eliminate non-value adding activities". The fundamental objective of SCM is to enhance the productivity and competency of organisations (Hsiao, 2006). It is also essential to minimise the allied costs incurred, to improve the flexibility and that will increase the competency and performance of SCM. It has been acknowledged that efficient and effective SCM can enhance customer value and reduce operating cost. Value has a strong relation with the profitability of supply chain, and an efficient and effective supply chain optimizes performance in delivering customer requirements and reducing costs while ensuring resources optimization. Some of the primary objectives of SCM are as follows:

- *Cost Minimisation*
- *Profit Maximisation*
- *Customer Fulfilment*
- *Reliability*
- *Shorter Lead Time in delivery*
- *Fast Cash Cycle*
- *Business Development*
- *Economical Delivery*
- *Faster delivery*
- *Right quality*
- *Less Inventory*

For increasing competitiveness with respect to organisations, SCM is regarded as the best operational strategy (Gunasekaran & Kobu, 2007; Winser, 2003). Therefore, today the organisations on realizing the importance and impact of managing SCM have started paying attention to the continuous improvement to fulfill the desired aims of SCM in the process of achieving advantages of an effective and efficient supply chain. Scholarly studies conducted previously, have found tangible gains garnered through efficient and effectively managed SCM (Harrington, 1999; Alber and Walker, 1997; Cooper et al., 1997b; Higginson and Alam, 1997; Giunipero and Brand, 1996; Cooper and Ellram, 1993). Some of the benefits of well-managed supply chain are as follows:

- Closer relationship with chain members
- Cost reduction
- Inventory reduction
- Productivity improvement
- Cycle time reduction
- Reliable delivery responsiveness to changes
- Customer service level improvement
- Profit margin improvement

**2.3. Seven Goals/ Principles of SCM**

Since the chapter has discussed the definition and meaning of SCM, this section mentioned the seven significant requirements for prosperous SCM. The 7 R's (R means Right) of SCM are as follows:

1. *Right Product*
2. *Right Time*
3. *Right Condition*
4. *Right Quantity*
5. *Right Place*

6. *Right Cost*

7. *Right Customer*

## 2.4. Supply Chain of Fruits and Vegetables (F&V)

Over the years, the definitions have changed and broadened the scope of SCM, but, these definitions are still limited to manufactured products and services with little attention paid to agriculture (Shukla and Jharkharia, 2013). F&V constitutes a significant part of the world economy and is the raw material for many industries. Among the agricultural produce, perishable food produce like F&V has got the least attention. The SCM of F&V constitutes the processes from production to delivery of the agro-fresh produce, i.e., from the farmer to the customer. SCM of F&V is complex as compared to other SCMs due to the perishable nature of the produce, high fluctuations in demand and prices, increasing consumer concerns for food safety & quality (Vorst & Beulens, 2002), and dependence on climate conditions (Salin, 1998). Some definitions of fresh supply chain and agriculture supply chain are shown in Table 2.2, which would give an idea in a nutshell.

**Table 2.2: Definitions of Food Supply Chain/Agri Supply Chain**

| Author(s) | Definition |
|---|---|
| Canfora (2016) | "Agricultural supply chain (ASC) is the goal of attaining sustainable agriculture, through the reduction of transportation costs and consequently of CO2 emissions." |
| Kusumastuti et al. (2016) | "ASC is supply chains of products of agricultural origin." |
| European Commission (2015) | "Food supply chain (FSC) stated as the direct exchange of food from the farmer to the consumer, or the different stages of activities such as the processing of raw agricultural commodities as well as the checking of consumer safety standards and packing or transport activities, which add value to food products before they sold." |
| Yared et al. (2014) | "FSC is a sequence of operations that is concerned about the perishable nature of the produce, high fluctuations in demand and prices, increasing consumer concerns for food safety and dependence on climate conditions." |
| Tsolakis et al. (2014) | "Agri-food supply chains (AFSC) is a set of activities in a farm-to-fork sequence including farming (i.e., land cultivation and production of crops), processing/production, testing, packaging, warehousing, transportation, distribution, and marketing." |
| Parwez (2014) | "ASC starts from the input to the consumer, requires integration to achieve the objective of an efficient and effective supply chain mechanism." |
| Bosona and Gebresenbet (2013) | "FSC stated as a mechanism that adequately provides information of consumers, a variety of the food attributes, country of origin, animal welfare, and genetic engineering related issues." |
| Shukla and Jharkharia (2013) | "FSC defined as the processes from the production to consumption of fresh produce (fruits, flowers, and vegetables)." |
| Bukeviciute et al. (2009) | "FSC defined as a wide diversity of products and companies, which operate in different markets and sell a variety of food products." |

From a farm gate to the consumers, the horticulture products passes through six-seven different distribution channels (Viswanadham, 2007). F&V produced in the farmer’s field reaches the end consumer through a chain of intermediaries. These intermediaries carry out various functions, such as movement of goods, transfer of ownership of goods, quality & quantity preservation, vendor’s payment, maintenance and final delivery to the customer (Halder & Pati, 2011). An illustration of the supply chain of F&V is depicted in Figure 2.2.

## 2.5. Stakeholders in the Supply Chain of F&V Sector in India

There are several players involved in fulfilling the needs of the consumer in the SCM of F&V. These players are farmers, local traders, agents (commission agents), transporter, auctioneers, wholesalers, processors, a traditional retailer of all type of formats-family run 'mom and pop' stores, roadside shops, pavement shops and cart vendors apart from farmers and customers. Farmers are the cultivators of produce and source of supply. They are small by landholding and yield volume of the crop, and highly fragmented across geographical areas.

Agents, auctioneers, and wholesalers are traders in this supply chain. Agent and auctioneers are the first level of middlemen in this supply chain and transfer commodity from producers to wholesalers. Numbers of transfers of ownership as well as transshipments of F&V depend upon the number of agents present in between farmers and wholesalers. An agent operates from shops of small space, works for one or more wholesalers and usually deals with a particular range of F&V. The traditional retailers buy F&V from wholesalers and sell directly to customers. The families-run 'mom and pop' type stores sell staple products including F&V.

Farmers may sell the product directly to the consumers or traders or food processors, without or after storage of the fresh produce; cold storage units; food processing entities; packaging units; wholesalers or distributors; retail chains or other forms of retailers; hotels, restaurants, caterers; and consumers. The consumers may get the fresh produce from the farmers directly or through a combination of the different players in the supply chain.

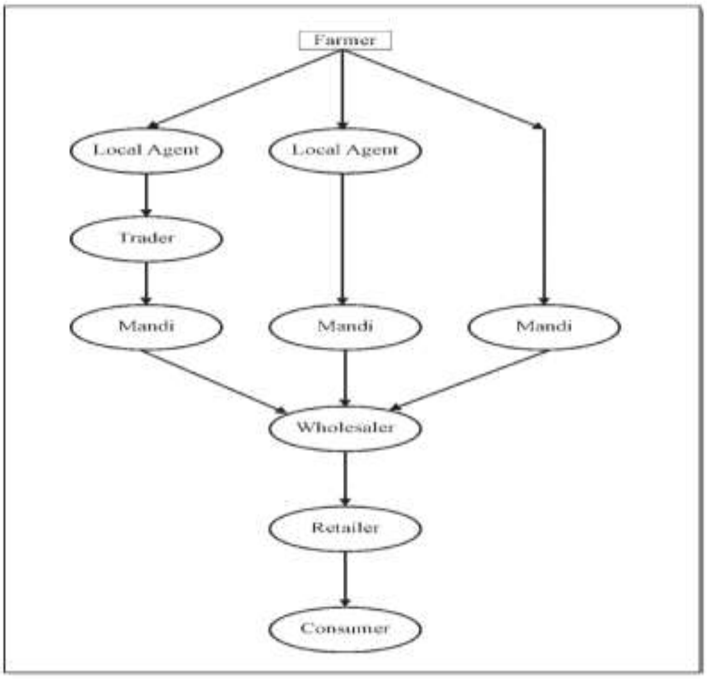



**Figure 2.2: Supply Chain for Fruits &Vegetables sector in India**

*Source: Modi et al., 2009*

The commission agents and local traders perform the function of aggregators. On behalf of big traders, they procure the fresh produce from the small growers. Some big farmers used to sell their produce directly to the local Mandis (marketplace). Usually, farmers prefer to sell their produce to local agents or trader rather than selling directly in Mandi. Sidhu *et al.* (2010) in his study found that more than 90% of the produce disposes through commission agents/wholesalers and a small proportion sells through retailers and directly to consumers. All the links from farmers to end user of the commodity constitute supply chain of the F&V sector in India.

The supply chain may pass through all the stages referred above or only through some of them. Some farmers may sell their produce on the farm itself to the intermediaries. Some may sell to the trader through local commission agent. Some big farmers with large land size holding may sell directly to the mandi. Some may keep a small part of the produce for consumption and sell the rest. These approaches provide a low return to the farmer. If the produced is stored and sold according to the favourable marketing condition, then the return will be higher. However, the farmers do not store any produce because of lack of storage facility. Processing of

F&V will add value to it. Only primary processing is done by the farmers, which include the processes such as manual sorting and grading, packaging. Generally, food items are processed by the firm involved in the business of export and processing of food items.

### 2.5.1. Cold Chain

A cold chain protects a wide variety of food products from deteriorating in the whole supply chain by providing the temperature-controlled facility. It is a logistic system that provides a series of controlled temperature storage and transport conditions from the point of origin to the point of consumption, i.e., from farm to fork. It saves fresh produce from degradation, humidity, improper expose to temperature and keeps them fresh, frozen, and chilled (Saurav and Potti 2016; Bishara, 2006). Fresh foods, like fruits, dairy items, vegetables, meat and poultry, and confectionary items requires continuous and uninterrupted temperature controlled atmosphere known as cold chain due to their perishable nature. By controlling proper temperature throughout the chain can improve the shelf life of the products for days, weeks and even for months (for some products) and minimise the chances of losses. The basic concept of cold chain is depicted in Figure 2.3.


**Figure 2.3: A Cold Chain**

*Source: Sapra and Joshi (2011)*

The fundamental difference between the supply chain of non-perishable items and the temperature controlled supply chain, i.e., cold chain is the possibility of degradation in quality and value of the product, which start from the farms to the customer (Joshi et al., 2009). Table 2.3 shows the primary difference between supply chain of non-perishables and cold chain. The cold chain starts at farm stage and covers up to the consumer stage in a temperature controlled practices and behavior.

**Table 2.3: Difference between supply chain of non-perishables and cold chain**

| Supply Chain of Non-Perishable | Cold Chain |
|---|---|
| Includes temperature-insensitive products like nuts, bolts, and equipment. | Includes temperature-sensitive items like plant and animal-based product. |
| Produce information regarding the transaction (order, shipment, payment) and location | The cold chain includes condition and time along with transaction and location. |
| Stops as the product reach the customer. | Includes customer practices related to temperature sensitivity. |
| No degradation in value while in transport. | Continuous degradation in value right from the producer till final consumption. |
| Different products can be loaded based on the space available. | The different temperature required for different products, e.g., milk is to be kept at 48C to 108C, whereas ice cream requires- 18 degree Celsius. |
| Less transportation cost as ordinary trucks, vehicles are used. | Refrigerated vehicles are mandatory for transportation. |
| Can bear being stuck in traffic jam. | Require keeping the refrigeration system in a running state, which devours more cost. |

*Source: Joshi et al. (2009)*

Cold chain infrastructure generally consists of grading, sorting, packing, storage, processing, and transportation facilities. A typical cold chain infrastructure is shown in Figure 2.4. It contains precooling system at farms to keep the produce fresh and refrigerated vehicles & containers for the effective and efficient movement of F&V from the point of origin (i.e., Farm) to the point of consumption (i.e., Fork). It also requires cold storage facilities to store the fresh produce in a temperature controlled warehouse to maintain the quality of F&V, so the quality cannot be deteriorated.

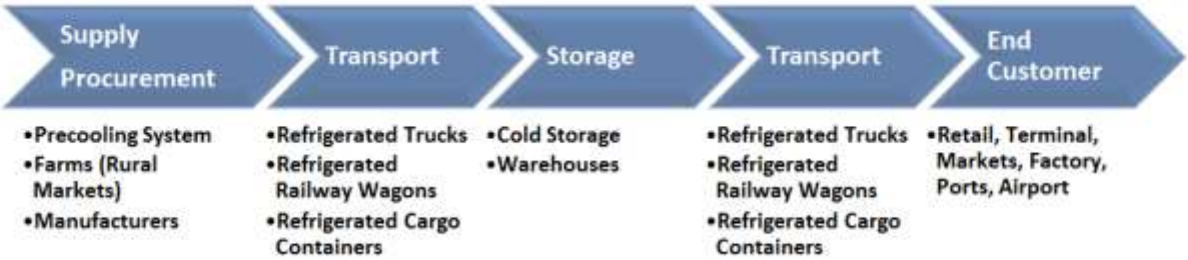



**Figure 2.4: The Cold Supply Chain Infrastructure**

*Source: Sapra & Joshi (2011)*

The reasons for excelling in proper implementation of cold chain requires constant observation of temperature throughout the supply chain and has suitable measures and action plans in place, to reduce the cost, improving the reliability of the product, enhancement in customer satisfaction and reduction of wastage & returns of the expired stock (Sapra & Joshi, 2011). Table 2.4 shows the status of cold chain in India.

**Table 2.4: Overview of the status of Cold Chain in India**

| | |
|---|---|
| 1 | As per the data available as on 31st July 2015, there were 7,129 numbers of cold storages having a cumulative capacity of 32.86 MMT. |
| 2 | U.P. state has highest numbers of cold storage followed by the state of Gujarat, Punjab, Maharashtra, and West Bengal. |
| 3 | Most of the cold storage is standalone regular cold storage. The capacity of state of the art CA/MA chambers is tiny. |
| 4 | 96 % of the cold storage is in the hands of Private Sector; more than 75 percent of the capacity is utilized only for potato, and only about 23 percent are under the multi-commodity category. |
| 5 | Much of this multi-purpose cold storage capacity is located in the states of Karnataka, Maharashtra, West Bengal, Tamil Nadu, and in the National Capital Region (NCR). |
| 6 | The push to build up storage capacity through cold chains has not been successful in vegetables and limited for fruits, meat, and Fish. |
| 7 | The available cold storages are not linked to the Farm and market through controlled temperature (Reefer vans) transportation. |

*Source: NCCD (2015a)*

### 2.5.2. Challenges in Cold Chain

Despite the enormous opportunities, the cold chain industry is at a nascent stage with various challenges as discussed below.

India stores only two percent of its horticulture products in temperature-controlled conditions, while China stores 15% and Europe and North America stores 85% of their products in such conditions. Adequate cold storage facilities are available for just about 10% of India's horticulture production. Of the total annual production, 30-40 percent gets wasted before consumption. During the peak production period, the gap between the demand and supply of cold storage capacity is approx. 25 million tonnes (ONICRA, 2012). Although cold storage capacity of over 30 million tonnes has created in the country, the concept of cold-chain is still in its infancy in India. Because India is producing about 265 million tonnes of F&V every year, the development of cold-chain networks assumes high priority. Owing to the tremendous pressure on improving supply chain and reducing losses during produce handling and movement, the need for creation of a cold chain network is crucial for perishable food commodities.

The cold chain sector involved in the business of F&V have ample opportunities as India is the largest and second largest producer of many F&V such as Mango, Guava, Banana, Papaya, Okra, Potato, Onion, Tomato, Cabbage in world production (NHB, 2017).

Regionally, the existing cold storage capacity is concentrated concerning both number and capacity in the northern region. Uttar Pradesh and West Bengal contain over 65% of the cold storage units in the country and the rest are spread across India. The Region Wise Number and Capacity of Cold Storages in India are shown in Table 2.5.

**Table 2.5: Region-wise Number and Capacity of Cold Storages in India (2015)**

| | **Central** | **East/North East** | **North** | **South** | **West** | **All India** |
|---|---|---|---|---|---|---|
| **Number** | 470 (6.5%) | 1051 (14.7%) | 3419 (47.9%) | 980 (13.7%) | 1209 (16.9%) | 7129 (100%) |
| **Capacity (Million MT)** | 1.73 (5.3%) | 8.11 (24.6%) | 17.31 (52.6%) | 2.57 (7.8%) | 3.09 (9.4%) | 32.81 (100%) |

*Source: NCCD (2015b)*

The existing cold storage facilities are available only in the wholesale market or nearer to that market. The local market or regional market does not have the cold storage facility where the farmer sells the major fresh produce. Cold storage in India has largely adopted for long-term storage of potatoes, onions and high-value crops like apples, grapes, and flowers. 75% of the cold storage capacity is used to store potatoes, while only 23% fall in the multi-product category (ONICRA, 2012).

There are various bottlenecks in the cold chain. Some of the major bottlenecks on cold chain are Inadequate usage/improper management of cold storage (Bhardwaj & Palaparthy, 2008); Inadequate capacities to serve the needs (Narula, 2011), (Halder & Pati, 2011), Lack of cold storage and warehousing facilities (Veena *et al*., 2011); (Bhardwaj & Palaparthy, 2008); (Dharni & Sharma, 2008), Irregular supply of power or shortage of power to run cold chain (Kapoor, 2009); (Shukla, 2010) and Poor post-harvest cold chain technology (Kapoor, 2009). Further, the identified bottlenecks in cold chain of F&V supply chain in India may graphically be represented as Figure 2.5.

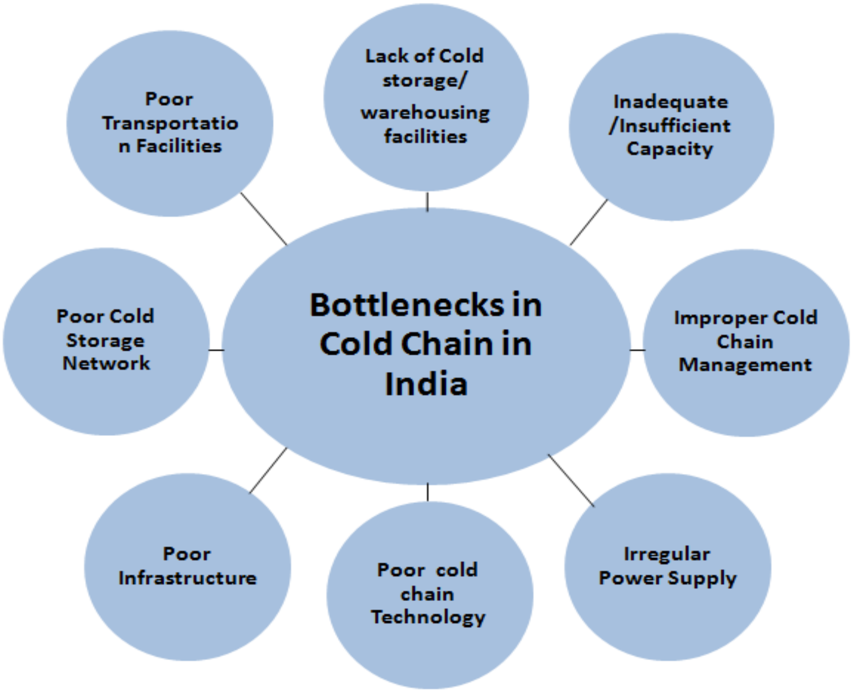



**Figure 2.5: Bottlenecks in Cold Chain**

*Source: Negi and Anand (2015)*

## 2.6. Supply Chain Models of Fruits and Vegetables in India

Generally, three types of supply chain model for F&V sector are followed in India, i.e., Traditional Model, Hub and Spoke Model, and Value Chain Model (Halder & Pati, 2011; Negi and Anand 2016). All these three types of model has been discussed below in detail.

### 2.6.1. Traditional Model

'Traditional Model' is a complex chain for the supply flow of F&V, which is predominantly followed currently in the traditional supply chain. Figure 2.6 outlines the Traditional supply chain model for F&V in India. Players involved in this model are agents (commission agents), auctioneers, wholesalers, a traditional retailer of all type of formats like family run 'mom and pop' stores, roadside shops, pavement shops and cart vendors apart from farmers and customers. Agents, auctioneers, and wholesalers are traders in F&V supply chain. Farmers are the cultivators of produce and source of F&V produce. In this model, farmers sell their produce to the retailers through various intermediate partners who eat the entire price share in the market.

Agent and auctioneers are the first level of middlemen in this model and transfer F&V from producers to wholesalers. Numbers of transfers of ownership as well as transshipments of F&V depend upon the number of agents present in between farmers and wholesalers. Usually, wholesalers do not get involved in transportation of F&V, both inward and outward transportation. The traditional retailers buy F&V from wholesalers and sell directly to customers.

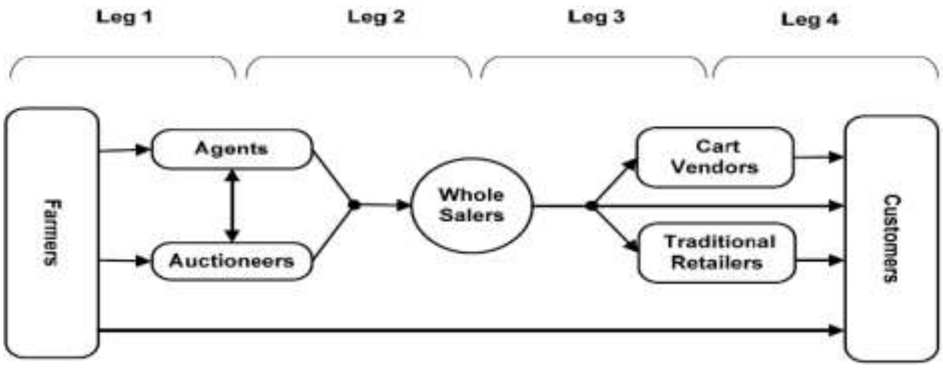



**Figure 2.6: Supply Chain of Traditional Model**

*Source: Halder & Pati (2011)*

Logistics of F&V in this model have four phases that are producers (farmers) to agents (commission), agents to wholesalers, wholesalers to traditional retailers and traditional retailers to customers. These phases are discussed below:

Leg 1: F&V transported from farmland to agent. Farmers are responsible for bringing the F&V to agent's premises/area. In case of a pre-harvesting contract, the auctioneers take care of the transportation of F&V from farm to his premises/area, and the seller is responsible for transportation for the trade of F&V between the auctioneers and agents. Leg 2: Goods are transported in non-temperature controlled or unorganised trucks. Agents manage and make all the arrangements to pick-up F&V directly from farm locations to the wholesaler's (Generally known as Mandis in India) premises for the large quantity of produce.

Leg 3: Buyers of wholesalers from Mandi places make their arrangement for transport from wholesale market or Mandis to their places.

Leg 4: It consists of the Local customers who reach the F&V retail shop by walk, which generally include Kirana store, Typical Mom, and Pop store.

In short and summarize way, this model includes traditional retailers, cart vendors, and commercial customers who buy F&V and make their arrangement for transport from the wholesale market to their destinations.

- Domestic customers shop their F&V at traditional retailer's stores, which are located nearby close to their residence and where they can walk down.
- F&V are also delivered at the doorsteps of the customers by cart vendors who sell in pushcarts, tricycles, and bullock carts.

### 2.6.2. Hub and Spoke Model

Organised retailers including prominent players like Food Bazaar (Pantaloons Retail (India) Ltd), Spencer's Retail and More (Trinethra Super Retail Ltd.) are adopting 'Hub and Spoke' Model for the Supply Chain of F&V. Figure 2.7 illustrates the Hub and Spoke model of F&V Supply Chain. Only a few players are involved in this type of model. Farmers, organised retailers, wholesalers, and customers are the partners involved in this chain. In this type of supply chain model, buying centers, hub, and stores (retail outlets) are operational units of the organised retailers. Small farmers and contract farmers are the primary sources of supply of F&V for organised retailers in this model. The organised retailers collect the F&V directly from the farmers to their buying centers and then transport to their hub that is served by one or more buying center, and then the F&V are further distributed to their retail outlets. Hub infrequently buys a small volume of produce from the local wholesale market to balance demand-supply gap. Only one hub serves a retail store. The store sells F&V in retail quantity to the customers as per the demand.

In this model, F&V travel in four phases/legs, namely farmers to buying centers of organised retailers, buying center to hubs, from hub to the organised retail stores and then finally retail outlet to the end consumer. The transactions and the movement of F&V that takes place in each phase of this model are discussed as:

Leg 1: Farmers transport their cultivated F&V from farming location to the buying centers of the companies. In case of contract farmers, buying centers arrange their self to pick up F&V in a truck from the farm gates of the contract farmers.

Leg 2: The transportation of F&V from buying centers to the hub is arranged and managed by the buying center in unconditioned trucks.

Leg 3: Finally, the fresh F&V are transported from hub to stores, and degraded or shelf life-expiring F&V are picked up from stores to the hub.

Leg 4: Customers buy fresh and healthy F&V from the organised retail stores.

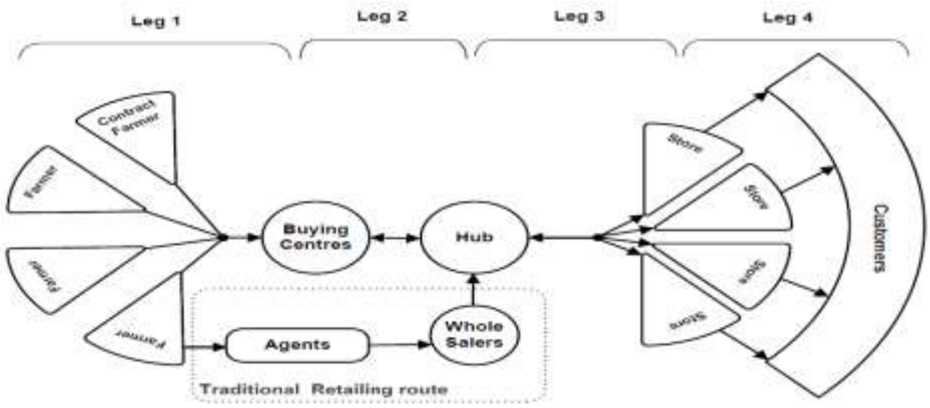



**Figure 2.7: Supply Chain of Hub and Spoke Model**

*Source: Halder & Pati (2011)*

### 2.6.3. Value Chain Model

Currently, only a few organised retail players like Reliance Fresh (Reliance Retail Ltd) follows a Value Chain Model. Organised retailers who adopt this type of model procure the F&V directly from farmers either through contract farming or by taking the farm on lease and sell to customers without the help of any intermediaries. This model is purely based on backward integration and focused towards building an entire value chain by the organised retailers starting from the farmers to the end consumers. Compared to the other supply chain models, Value Chain Model comprises of only a few partners, i.e., Farmers, organised retailers, and customers. In this practice, farmers, organised retailer's operational units, consolidation centers, hub (distribution centers) and retail outlets stores, and customers are the players. Small farmers, contract farmers, and lease farmers are the primary source of supply of F&V to the organised retailers. Contract farmers and lease farmers are those farmers who execute a trade agreement with the organised retailers for sale of F&V. Figure 2.8 illustrates the Value Chain Model of F&V supply chain in India. F&V move from farm locations to customers in four phases, farmers to consolidation centers, consolidation centers to the hub, hub to retail outlets (stores) and stores to customers. Customers buy and pick up fresh F&V from the organised retail stores.

The stores for a shorter coverage area and high value of purchase provide home delivery in this type of model.

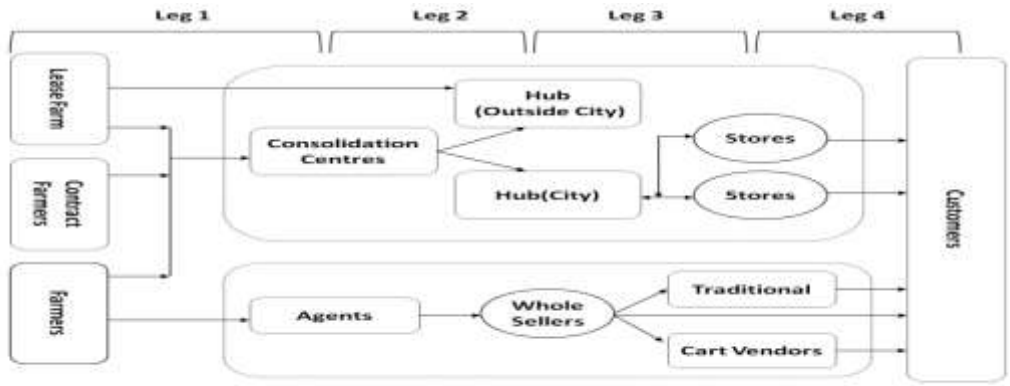



**Figure 2.8: Supply Chain of Value Chain Model**

*Source: Halder & Pati (2011)*

The 4 Legs, which connects the stakeholders in this model are discussed below:

Leg 1: Farmers transport their F&V from farming location to the consolidation centers through farm tractor, bullock cart, mini truck, bicycle, tricycle, and motorcycle. Consolidation centers of the organised retailers arrange to pick up F&V in a truck from the farm gates of the contract farmers/lease farmers.

Leg 2: Consolidation centers arrange transportation of F&V from consolidation centers of the organised retailers to their hub. In this process, both temperature-conditioned and unconditioned trucks are used for the logistics of F&V. In case of contract farming, the hubs get direct delivery from the farm location of contract farmers.

Leg 3: From the place of the hub to the organised retailer store, fresh F&V transported twice a day. F&V whose shelf life is expiring, get back return to the hub once a day in unconditioned small trucks for further disposal.

Leg 4: In this stage, customers buy and pick fresh F&V from the organised retail stores. Some organised retailers also provide the facility of direct home delivery to the customers ranging within a shorter period of distance in case of the high value of the purchase.

As discussed above, the traditional model of F&V supply chain is followed in India where farmers prefer to sell their products to the Mandis through local agents or trader rather than selling directly. According to Artiuch and Kornstein (2012); Sidhu *et al.* (2010); Modi et al. (2009), "More than 90% of the product disposed of through commission agents/wholesalers and a small proportion sells through retailers and directly to consumers".

The entire supply chain of F&V sector in India is suffering from maximum inefficiency resulting in losses and wastage in the supply chain. This leads to a situation where relatively higher money is incurred by the final consumers and less remuneration for the farmers (Negi and Anand, 2014).

## 2.7. Major Companies in Fruits and Vegetables Business in India

Some major players who are involved in F&V business in India are as follows:

1. *Adani Agri Fresh Limited*
2. *Safal by Mother Dairy*
3. *Reliance Fresh*
4. *More by Aditya Birla Group*
5. *Nature's Basket by Godrej Group*
6. *Food Bazaar by Big Bazaar (Future Group)*
7. *Namdhari's Fresh*
8. *Snowman Frozen Foods*
9. *Fresh & Easy*
10. *Big Basket*
11. *Dev Bhumi Cold Chain Ltd*
12. *Fresh and Healthy Enterprises by CONCOR, India*

## Concluding Remarks

This chapter concludes the discussion on SCM in generic and specific to F&V sector. It also discusses the stakeholders involved in the supply chain of F&V, a brief about cold chain and the challenges faced by cold chain in India. Finally, supply chain models of F&V are discussed in this chapter. The next chapter describes the literature available on SCM of fresh produce, Economic analysis, Supply chain inefficiency, and Theory of Constraints. It also brings out the research gap concerning developing a framework for improving supply chain efficiency and the importance of efficient supply chain in F&V sector.

# 3. LITERATURE REVIEW

*This chapter depicts a review of the existing literature on SCM of perishable fresh produce, challenges, losses and wastage in F&V sector, studies on supply chain efficiency, and Theory of Constraints. Extensive and rigorous review has been conducted under nine themes, which tried to comprehend the past research conducted in the area of the supply chain of F&V sector and explores approaches for improving supply chain efficiency. This chapter also presents the logical flow of research from the perspective of understanding of the scenario, to research gaps, concluding the research problem and reviewing the suitability and applicability of theoretical premise to address the research problem and research questions. It also highlights the significance of efficient supply chain in F&V sector, which is the need of the hour and finally shows the theme wise gap.*

The literature review supports in designing research objectives, framing a research design, selection of the variables and developing a questionnaire. In accordance with the business problem of the study, an extensive literature review was carried out under the following nine themes.

Theme 1: Supply Chain Management of Perishable Food Produce

Theme 2: Challenges in the Supply Chain of Perishable Food produce in India

Theme 3: Economic Analysis of Supply Chain losses in F&V

Theme 4: Defining Supply Chain Efficiency

Theme 5: Past Studies on Supply Chain Efficiency

Theme 6: Measuring Supply Chain Efficiency

Theme 7: Measures to Improve Supply Chain Efficiency

Theme 8: Significance of Efficient Supply Chain in F&V Sector

Theme 9: Past studies on Goldratt's "Theory of Constraints" Thinking Processes

Each theme is discussed in detail in this section.

### 3.1. Theme 1: Supply Chain Management of Perishable Food Produce

Various studies have been carried out on perishable fresh produce with respect to supply chain, globally and in Indian scenario particularly. The studies, which have been conducted globally, are discussed below.

Bahinipati (2014) studied the SCM of food and evaluates the longevity of changes introduced in the procurement functions, ICT infrastructure aiding e-market and enables a joint framework, which is controlled in nature that provides inputs to the managers associated with various food companies.

Macharia et al. (2013) conducted a study, which demonstrated consumer-focused oriented approach is lacking in developing countries but has a tremendous potential to negate challenges to food safety and security including several aspects of quality of environment as well as emphasising on the health of the consumer. The main emphasis of the study was on food safety.

Iliopoulos, et al. (2012) identified the various approaches relating to innovation as well as implementation having greater chances of succeeding and have also revealed the factors, which have a deeper impact on implementation of innovations relating to fresh fruits by the end users. The study found that in order to scale new heights in F&V sector, there is a tremendous requirement for ideas on consistent learning, market positioning, and acquisition of knowledge. The study was focused on consumer-driven and responsive fruit supply chains.

Tan (2012) conducted the study in China on logistics management of agricultural produce highlighting the specific environmental aspects in the supply chain. In continuation of the theoretical framework related to green supply chain of the bi-products of agriculture, the researcher evaluates the needs and prerequisite of green supply chain and has suggested mathematical model and organisational system for the betterment of green supply chain.

Xiao and Chen (2012) conducted a study in China on transportation of fresh products in supply chain, wherein the authors consider the delivery of fresh products from the point of origin to the market place. The researcher took into consideration the supply chain mechanism involving a distributor and producer investigated the two most commonly adopted supply chain models i.e. Push and Pull model. It was found that, if the pull model is implemented, both the producer and distributor would be benefitted, thereby on a larger perspective the supply chain would be enriched.

Perdana and Kusnandar (2012) developed a triple helix model for F&V SCM in Indonesia consisting of marginal farmers required to meet the market demand on a global level. In order to overcome from the problem of meeting the quality aspects of the agricultural goods of Indonesia, authors discussed the use of triple helix model for the purpose of communications between exporters, supporting institutions, government and academic institutions in developing SCM of F&V sector. The study highlighted that there is a requirement of innovation with respect to the institution, which has a tremendous potential of reducing the risk and would be able to extend support facilities to the agriculturalists to cater to the demand of global market.

Zheng and Lu (2011) conducted a study on supply chain of agricultural goods and its safety in China and evaluates food safety issues present in each link of the chain (production link, processing link, logistics link, supervision link, sales and consumptive link). The authors suggested various counter measures like, food safety, green supply chain, establishment of an effective purchase, supply and review system, supervision of quality system in each strand of supply chain. Further measures suggested by the authors included; speed up the process of quality standardisation, strengthen the publicity of quality safety, Spread legal and moral issues of the entire society, and ensuring prompt warning systems of food safety.

Lin and Wu (2011) conducted a study on selection of supplier for fresh F&V via direct purchasing in Taiwan. Authors emphasised on assessing the parameters for supplier selection in F&V through direct purchasing for supermarket retailers. The study shows that product quality, pricing in procurement, food safety and consistency of the product are the key parameters for supplier selection. In addition, the collaborative relationships and trust between the partners is a very important aspect.

Fuente and Ros (2010) conducted the research on cold chain of F&V in Spain, in which they focus primarily on the creation of a prototype for strategic model of nodes in supply chain network. The authors developed a combined model for interaction among logistics industries and transportation systems, which allows knowing the location of the merchandise aiding its distribution concerning food safety and traceability.

Blandon et al. (2009) did a research study on marginalized farmer's participation in supply chain with the help of a case of the supermarket supply chain for F&V in Canada. The authors explored the necessity of collective action and transaction cost in determining participation of marginalized farmers. Relationships based on the premises of trust between the seller and buyer, incentivizing the farmers, collective actions and devising mechanism for reducing prices are some of the important factors that should be taken into consideration while including small-scale farmers in a new supply chain.

Ruteri and Xu (2009) studied the supply chain operation, idea about SCM and identified the issues faced by Tanzania food industry. The major challenges that hinder the organisational growth and inhibits them to compete at the global level are Research & Development, physical infrastructures, capital, and technical expertise.

Clements et al. (2008) conducted a study in New Zealand on SCM of fresh produce, which investigated the various links that existed between customer requirements. Authors developed a theoretical framework, where the nature of relationships were characterised as a connection between various parties. The developed framework was operationalised by the use of case studies in South Island of New Zealand.

Hingley et al. (2008) conducted an extensive literature review to evaluate the possible scope available and the positive welfare effects of diverse strategies in food sector. The study analysed the present structure and management of F&V and salads for the requirement of new product sourcing, diverse policies, and innovation conducted by global retailers.

Thron et al. (2007) assessed alternative SCM structures for perishable food items in UK. Authors evaluated the repercussions of manifold supply chain advancements and also analysed characteristics including safety inventory level, inventory delivering, inventory refilling, through-put policies and transparency in increased demand due to integration between multiple on one hand and manufacturer on the other. The significance and effect of the above parameters have been systematically evaluated employing various performance measures. In this study, a higher degree of emphasis is placed on engagement in collaborative replenishment.

Matopoulos et al. (2007) analysed the concept of collaboration in supply chain and developed a conceptual framework, which could be used by further potential researchers conducting empirical studies, using this technical know-how in Greece. The finding shows that collaboration in supply chain is vital for food industries. But, certain issues occurs because of the nature of industry's products, and the specific structure of the sector. Subsequently, supply chain collaboration is frequently central to logistical activities and operational issues.

Fearne et al. (2006) in their study on supplier-buyer collaboration in the fruit sector in UK. This study shows how a joint endeavor in managing demand can substantially enhance customer services, which would eventually benefit fruits suppliers and supermarket retailers. The study emphasises the importance of collaboration in agri supply chain and shows that providing demand access to suppliers cast a vital consequence on the performance and service levels of the supply chain.

Rastoin et al. (2006) discuss the agricultural trade and its economic impact on F&V supply chain of European countries. Through a within region benchmarking approach, the authors developed a vulnerability index.

Taylor and Fearne (2006) developed a structure for enhancing demand management in the supply chain of food sector in UK. Authors stated a tendency for improper management of supply and demand, because of the issues such as unsuitable policies, demand amplification, and continuous irregularities with the data handling aspects and information systems.

Vasileiou and Morris (2006) conducted a study on the supply chain sustainability of potatoes. Authors evaluates anticipation of the relevance of socio-economic and environmental causes, as these are primarily responsible in manipulating crucial decisions made by producers, traders, and retailers. It was found that market factors along with the economic factors, allied with staying in competitive market were the key concern for all members in the supply chain.

Cadilhon et al. (2005) demonstrate the importance of collaborative commerce in multinational organisations through their study on vegetables supply chain in Vietnam. Authors concluded that the outcomes from collaborative commerce are general for all to see but a minimal degree of the same is put into practice in food retail chain, because of unsuitable culture present in organisations and the markets driven by competitive mindset.

Salin and Nayga (2003) conducted a research study on cold chain and tried to understand the nature of relationship in cold chain, which is basically used for export of food items in most of the developing countries. The findings states that issues relating to technical know-how is systematically managed by multinational food retailers with specific guidelines and exclusive supply chain, and the small food retailers employs broad networks for the supply of potatoes that are imported.

Cadilhon et al. (2003) present a framework for analysing the supply chain of vegetables in South East Asian countries and understanding the role of wholesale markets in supply chain. The role of trust and collaboration among stakeholders in vegetables marketing system is highlighted in the study.

Roekel et al. (2002) review the challenges involved in supply chain development with reference to issues in developing countries. Three cases in global fresh food supply chain (Thailand, Netherlands, and Ghana) are discussed in this study. The cases discussed, exhibits various risks involved and also the reasons for success in the development of supply chain. The success factor for supply chain collaboration are transparency, commitment and high level of trust among the partners.

Fearne and Hughes (2000) presented recent evidence of developments in the supply chain of UK food industry and discussed the factors responsible for success. The key success factor identified in the study are cost control, continuous investment, suitable employees, innovations, and growth.

Broekmeulen (1998) presented a tactical decision model that improves the effectiveness of the operations of a distribution center for vegetables and fruits in

Netherlands. The proposed solution strategy for the assignment problem for vegetables and fruits seems to work for problem sizes, such as in the case of the wholesaler of vegetables and fruits.

Folkerts and Koehorst (1997) identified the issues in global food supply chain. The study emphasis on the requirement of the European agribusiness to restructure their operations in supply chain, both at organisational and technical level, to gain operational efficiency and maximise customer satisfaction. The finding shows that there forward and vertical integration is important to gain competitive edge in food industry and agribusiness.

Grimsdell (1996) examines how the agribusiness company named British Field Products has improved its supply chain efficiency. The study shows that the fundamental requirements for efficient supply chain are continuous supply, alliances, scale of operation, quality control, flexibility in production, and continuous communications among the partners.

Wilson (1996a) looks at the concept of SCM with the help of a study conducted in a grocery market in UK with respect to banana supply chain, contemplating the issues linked to marketing and distribution of fresh items. The emphasis of the study was on three major food companies in UK, which found that vertical integration is witnessing an accelerated introduction in food retailing.

Wilson (1996b) shows how supply chain has been moved from neo classical theories to a different paradigm for business. The author puts forward the arguments that competitive advantage can be availed by increasing coordination in the fresh produce supply chain.

It can be seen in the past available literature that various studies have been conducted globally on different specificities of supply chain in fresh food produce. Most of the studies have been conducted in China and Europe where supply chain collaboration is focused more to improve the supply chain of fresh produce. It can also be seen from the past study that there is a lack of study on reasons for supply chain inefficiency with reference to fresh produce at different stages. The summary of the literature review on SCM of perishable food produce-a global perspective is given in Table 3.1.

**Table 3.1: Summary of the Studies on Supply Chain Management of Perishable Food Produce- A Global Perspective**

| Theme | Authors, Year | Inference |
|---|---|---|
| **Supply chain Management of Fruits & Vegetables** | Bahinipati (2014) | This study evaluates the longevity of changes introduced in the procurement functions, ICT infrastructure aiding e-market and enables a joint framework. |
| | Macharia et al. (2013) | Demonstrated consumer-focused oriented approach is lacking in developing countries but has a tremendous potential to negate challenges to food safety and security. |
| | Iliopoulos et al. (2012) | Identified the various approaches relating to innovation as well as implementation having greater chances of succeeding and have also revealed the factors, which have a deeper impact on implementation of innovations relating to fresh fruits by the end users. |
| | Tan (2012) | Study on logistics management of agricultural produce in China highlighting the specific environmental aspects in the supply chain. |
| | Xiao and Chen (2012) | Study on transportation of fresh products in supply chain of China. Considered the delivery of fresh products from origin to the market. |
| | Perdana and Kusnandar (2012) | Developed a triple helix model for F&V SCM in Indonesia consisting of marginal farmers required to meet the market demand on a global level. |
| | Zheng and Lu (2011) | Study on supply chain of agricultural goods and its safety in China and evaluates food safety issues present in each link of the chain. |
| | Lin and Wu (2011) | Evaluated the selection of supplier for fresh F&V via direct purchasing in Taiwan. Emphasis on collaborative relationships and trust. |
| | Fuente and Ros (2010) | Study on cold chain of F&V in Spain. Focus primarily on the creation of a prototype for strategic model of nodes in supply chain network. |
| | Blandon et al., (2009) | The authors explored the necessity of collective action and transaction cost in determining participation of marginalized farmers. |
| | Ruteri and Xu (2009) | Study on the supply chain operation, idea about SCM and identification of the issues faced by Tanzania food industry. |
| | Clements et al. (2008) | Study on SCM of fresh produce in New Zealand, which investigated the various links that existed between customer requirements. |
| | Hingley et al. (2008) | An extensive literature review to evaluate the possible scope available and the positive welfare effects of diverse strategies in food sector. |
| | Thron et al. (2007) | Assessed alternative SCM structures for perishable food items in UK. A higher degree of emphasis is placed on engagement in collaborative replenishment. |
| | Matopoulos et al. (2007) | Analysed the concept of collaboration in supply chain and developed a conceptual framework, which could be used by further potential researchers conducting empirical studies. |
| | Fearne et al. (2006) | Study on supplier-buyer collaboration in the fruit sector in UK. The study emphasises the importance of collaboration in agri supply chain. |
| | Rastoin et al. (2006) | Discuss the agricultural trade and its economic impact on F&V supply chain of European countries. With the help of benchmarking approach, a vulnerability index was developed. |
| | Taylor and Fearne (2006) | Developed a structure for enhancing demand management in the supply chain of food sector in UK. Unsuitable policies, demand amplification, and continuous irregularities with the data handling aspects and information systems are some of the issues for improper demand supply management. |
| | Vasileiou and Morris (2006) | Conducted a study on the supply chain sustainability of potatoes in Britain. Study evaluates anticipation of the relevance of socio-economic and environmental causes. |
| | Cadilhon et al. (2005) | Demonstrated the importance of collaborative commerce in multinational organisations through their study on vegetables supply chain in Vietnam. Study concluded that the outcomes from |

| | | |
|---|---|---|
| | | collaborative commerce are general for all to see but a minimal degree of the same is put into practice in food retail chain |
| | Salin and Nayga (2003) | Study on cold chain to understand the nature of relationship in cold chain, which is basically used for export of food items in most of the developing countries. |
| | Cadilhon et al. (2003) | Framework for analysing the supply chain of vegetables in South East Asian countries and understanding the role of wholesale markets. The role of trust and collaboration among stakeholders in vegetables marketing system is highlighted in the study. |
| | Roekel et al. (2002) | Review the challenges involved in supply chain development with reference to issues in developing countries. The success factor for supply chain collaboration are transparency, commitment and high level of trust among the partners. |
| | Fearne and Hughes (2000) | Presented recent evidence of developments in the supply chain of UK food industry and discussed the factors responsible for success. The key success factor identified in the fresh supply chain are cost control, continuous investment, suitable employees, innovations, and growth. |
| | Broekmeulen (1998) | Presented a tactical decision model that improves the effectiveness of the operations of a distribution center for F&V in Netherlands. |
| | Folkerts and Koehorst (1997) | The study emphasis on the requirement of the European agribusiness to restructure their operations in supply chain, both at organisational and technical level, to gain operational efficiency and customer satisfaction. |
| | Grimsdell (1996) | Examines how the agribusiness company named British Field Products has improved its supply chain efficiency. Fundamental requirements for efficient supply chain are continuous supply, alliances, scale of operation, quality control, flexibility in production, and continuous communications among the partners. |
| | Hughes (1996) | Higher competition, product proliferation, focus on R&D, higher competition for supply chain, branding, demand pattern, better customer understanding are some of the future growth drivers of export markets for UK fresh F&V. |
| | Wilson (1996a) | Examines the concept of SCM with the help of a study conducted in a grocery market in UK with respect to banana supply chain. The emphasis of the study was on three major food companies in UK, which found that vertical integration is witnessing an accelerated introduction in food retailing. |
| | Wilson (1996b) | Study shows how supply chain has been moved from neo classical theories to a different paradigm for business Competitive advantage can be availed by increasing coordination in the fresh produce supply chain. |

The studies, which has been conducted in Indian scenario pertaining to SCM of perishable food products are discussed below:

Balaji and Arshindera (2016) identified the reasons for losses and wastages in food sector and anlyse their interrelationships. The authors identified 16 central reasons, which includes several other causes within its domain. Unavailability of scientific method for harvesting and existence of higher number of intermediaries in supply chain are primarily considered as the root cause of the food wastage and losses.

Negi and Anand (2014) presented the F&V supply chain scenario in India and highlighted the requirement of an efficient and robust supply chain to mitigate the challenges and minimise the losses in F&V sector.

Shukla and Jharkharia (2013) presented an extensive review of literature pertaining to SCM in fresh produce sector and classified the operational issues as the reasons resulting in post-harvest losses. The study also highlighted various research avenues, which can be further explored in the area of fresh produce supply chain. The review revealed that the studies conducted in past focused on revenue maximisation and customer satisfaction while less consideration was placed on the reduction of losses during post-harvest. The review paper also found that the operational issues are the major reasons for losses from the farm gate to the consumers. Further this paper also highlighted some other areas of key concern like, mismatch in supply and demand, poor demand forecasting, minimal coordination.

Dey (2012) studied the supply chain of Rythu Bazaar in Andhra Pradesh, and an attempt was made in identifying and addressing the inefficiencies that may exist in the system and explore options to improve conditions of functioning in Rythu bazaars. A supply chain model is also proposed by the author to address the issue.

Dastagiri and Immanuelraj (2012) explored the supermarkets models, which will bring together marginal and small farmers with respect to Indian supply chain. Information regarding marketing institutions and marketing model that are associated with F&V in India were evaluated, and the characteristics and consequences of various supermarkets of F&V were studied. The finding shows that direct marketing model are the best-suited model because of absence of intermediaries in the chain, hence, higher share in consumer rupee. The results also revealed that supermarkets would completely eliminate the intermediaries and save the marketing cost, transportation cost, and extra charges incurred by the farmers.

Patel (2010) studied the F&V supply chain of reliance fresh in India. In this study the author tried to locate the supply mechanism of reliance fresh and also evaluated the costs incurred in the supply chain. The study found that the fresh produce is kept in proper cold storage for proper supply of F&V.

Rajkumar (2010) made an attempt to study the distance covered with respect to vegetables from the agricultural field to the point of consumption in conventional and modern retailing in city of Chennai. The study found that there is a substantial enhancement of food miles in case of modern retailers.

Reddy et al. (2010) studied the retailing and value chain of F&V in the state of Andhra Pradesh in which they examine the trend and performance of organised retailing and its effect on conventional retailers. It was found that for conventional and modern retailing both the supply and demand side factors make a significant contribution. Therefore, attaining efficiency in supply chain will be largely responsible for value addition and facilitating in getting the fresh produce to the market.

Chandrashekar (2009) studied the supply chain of F&V in Safal Market in the state of Karnataka. Alam and Verma (2007) also identified the drivers in SCM including big retailers and made a comparison of the financial benefits of the growers supplying to big retailers with the ones supplying to private wholesalers with the help of a case of Mother Dairy.

Singh et al. (2009) studied the challenges and opportunities in Uttar Pradesh, India with respect to food retailing. The authors suggested a framework to provide an enabling environment to entice private funding in the agricultural sector.

Artiuch and Kornstein (2012) outline the underlying structure and incentive within India's agricultural supply chain and assess the major issues and problem areas, which contributing to food waste in India. Infrastructure (Storage, Road & Transportation), government purchase and distribution scheme, middlemen, bargaining power, price transparency, price volatility, financing, education, and training are found the major issues contributing to food waste in India. Authors also reported that most of the inefficiencies take place upstream of the wholesale market.

Halder and Pati (2011); Veena et al. (2011); Singh et al. (2009); and Bhardwaj and Palaparthy, (2008) discusses the current supply chain of F&V in India and also identified the opportunities & challenges. It has been highlighted in their studies that the F&V supply chain is highly inefficient, resulting in wastage and high amount of losses. The main drawbacks, which are found in the present supply chain, are non-availability of large scale post-harvest storage facilities, lack of clarity in policy guidelines from the government, fragmented and small farmer degradation, poor infrastructural facilities, high cost, non-reliability of delivery time, compromised quality, significant number of middlemen, inadequate transportation facilities, vulnerability to wastage, lack of technology, lack of market knowledge, inadequate transparency, improper food safety, and farmers knowledge & awareness.

Sidhu et al. (2010) and Modi et al. (2009) evaluated the supply chain of F&V and highlighted the issues and problem faced by farmers. The studies analysed marketing cost, profit generated in cultivation, middlemen's share in marketing the F&V. The studies highlighted the need to enhance efficiency by organising the vegetables sector, which is conventional in nature and is deficient in certain modern practices like, efficient transport system, grading facilities, process standardisation, and pre-cooling facilities.

Ayub and Siraj (2008) studied the present scenario of value chain with respect to mango and tried understanding the contribution made by ICT towards the development of Indian agriculture. The study was conducted in parts of Delhi and Lucknow with primary emphasis on ICT.

Negi and Anand (2015); Halder and Pati (2011); Narula (2011); Veena and Venkatesha (2011); FICCI (2010); Rathore et al., (2010); Joshi et al. (2009); Bhardwaj and Palaparthy (2008); Viswanadham (2007); and Jain (2007) found poor cold chain as a major problem in the supply chain of F&V, which is resulting in various inefficiencies, leading to losses. Cold chain plays a vital role in perishable food with respect to supply chain. Past studies have revealed that there is severe absence of robust and reliable cold chain in developing nation.

Negi and Anand (2015) presented the status of and challenged to cold chain pertaining to the F&V sector in India. The study highlighted the need for cold chain infrastructure to remove the bottlenecks in F&V sector in India.

Narula (2011) conducted an interview on the status of cold chain industry in India, in which the discussion centered on supply chain issues of hilly areas and considered the potential role a cold chain can play in preventing loses incurred post-harvest. The author also discussed the different kinds of the model in cold chain operating in

India and highlighted the need for the cold chain to reduce the increasing amount of losses in F&V sector in India.

Rathore et al. (2010) also discussed the potential of agri business in India and highlighted the requirement for robust infrastructure related to cold chain for reducing losses and wastages after the harvesting process. The study also found that in case of an absence of an efficient and effective supply chain, chances are quite high that the companies will have to shell out significantly higher cost due to wastage.

Joshi et al. (2009) identified the factors prohibiting smooth cold chain management and their inter-relations in developing countries, like India. The finding of the study suggested that unavailability of proper infrastructure related to cold chain is the major drawback in ensuring efficient food supply chain.

Viswanadham (2007) highlighted the possibilities of growth of food business in India and documented various methods through which the issues can be dealt with using prior knowledge and technology. The study highlighted that inefficient supply chain is the major impediment in Indian agriculture and absence of cold chain facilities and processed food industry are primarily responsible for 20% (Rs. 500 billion) of the total food loss.

Maheshwar and Chanakwa (2006) discussed the wastage and losses in F&V sector with respect to post-harvest due to severe gaps in cold chain in India. The study highlighted efficient cold chain as the solution to this problem and it also documented that huge amount of food loss happened because of inadequate capacity for cold storage, poor cold chain infrastructure, inadequate infrastructure related to transportation, and lack of cold storage nearby farm areas.

The major bottlenecks, which are found from the literature with respect to cold supply chain are Lack of cold storage and warehousing facilities (Veena et al., 2011; Bhardwaj & Palaparthy, 2008; Dharni & Sharma, 2008), inadequate capacities to serve the needs (Narula, 2011), inadequate usage/improper management of cold storage (Halder & Pati, 2011; Bhardwaj & Palaparthy, 2008), irregular supply of electricity to run cold chain (Shukla, D. 2010; Kapoor, 2009) and poor technology related to post-harvest cold chain (Kapoor, 2009).

These bottlenecks in the cold supply chain are leading to maximum inefficiency and decrease in the returns of F&V, which affect the income of the farmers and their livelihood. It plays a vital role and is the backbone for the supply chain of F&V industry, but due to the bottlenecks, it becomes a very weak link and one of the main reasons for supply chain losses in food.

It can be seen in the past available literature that various studies have been conducted on different aspects of supply chain in fresh food produce. Most of the studies have been conducted with reference to retail aspects (traditional and organised) and cold chain. Extensive review of the literature on the present study reveals that there is inadequate study on reasons for efficient supply chain in activities across the stages with reference to F&V. The review of literature on SCM of perishable food produce-an Indian context is presented in Table 3.2.

**Table 3.2: Summary of the Studies on Supply Chain Management of F&V (Indian Review)**

| Theme | Authors, Year | Inference | Gap |
|---|---|---|---|
| **Supply chain Management of Fruits & Vegetables** | Balaji and Arshindera (2016) | Authors identified the reasons for losses and wastages in food sector and anlyse their interrelationships. | Focus on wastage in general. Stage-wise causes and also causes of high cost and high lead time in the SC is unidentified. |
| | Negi and Anand (2014) | Authors presented the F&V supply chain scenario in India and highlighted the requirement of an efficient and robust supply chain to mitigate the challenges and minimise the losse | Reasons for inefficiency in SC stages and activities are not identified. |
| | Shukla and Jharkharia (2013) | Presented an extensive review of literature pertaining to SCM in fresh produce sector and classified the operational issues as the reasons resulting in post-harvest losses. The study also highlighted various research avenues in the supply chain of F&V sector. | Focused on literature review. Lack of focus on stage, activity and the supply chain efficiency as a whole. |
| | Bhushan (2013) | The author presented a report on the post-harvest profile of mango in Andhra Pradesh, India. | The study is focused on Andhra Pradesh state. |
| | Dey (2012); Dastagiri and Immanuelraj (2012); Rajkumar (2010); Patel (2010); Reddy et al. (2010); Chandrashekar (2009); Singh, et, al. (2009); Alam and Verma (2007) | The value chain and supply chain of organised and traditional fresh F&V retailers (Reliance Fresh, Safal, and Rythu Bazaar) are studied in different states of India like Andhra Pradesh, Karnataka, Tamilnadu, and Uttar Pradesh. The studies compared the advantages of selling the fresh produce to the traditional retailer and organised retailers. Also highlighted the problems faced by farmers. | More focused towards retail perspective. Study pertaining to supply chain efficiency is missing |

| | | | |
|---|---|---|---|
| | Artiuch and Kornstein (2012) | Authors outline the underlying structure and incentive within India's agricultural supply chain and assess the major issues and problem areas, which contributing to food waste in India. | The study is focused on entire agriculture sector with lack of focus on the supply chain of F&V. |
| | Halder and Pati (2011); Veena et al. (2011); Singh et al. (2009); Bhardwaj and Palaparthy (2008) | Discusses the opportunities & challenges in F&V supply chain. It has been highlighted that F&V SCM is suffering from maximum inefficiency, which is resulting in waste. | Study pertaining to supply chain efficiency is missing. |
| | Sidhu et al. (2010); Modi et al. (2009) | Supply Chain of F&V has been evaluated to highlight the issues and problem faced by farmers. Studies analysed and estimated the costs involved in marketing and the margin & returns to the farmers. Also highlighted the need to enhance efficiency. | Study pertaining to supply chain efficiency is missing. |
| | Ayub and Siraj (2008) | Authors studied the present scenario of value chain with respect to mango and tried understanding the contribution made by ICT in Indian agri sector. The survey was conducted in Lucknow and Delhi. | Focused on ICT in India agri sector |
| **Supply chain Management of Fruits & Vegetables: Cold Chain** | Negi and Anand (2015) | Authors presented the status of and challenge to cold chain pertaining to the F&V sector in India | Lack of focus on supply chain efficiency. |
| | Narula, (2011); Rathore et al. (2010); Viswanadham (2007); Maheshwar (2006) | There has been a staggering loss (30-40%) in the perishable fresh items because of inadequate infrastructure facilities related to cold chain. The studies highlighted that inefficient supply chain leads to high cost of wastage. | Papers are limited to the discussion on status and challenges in F&V SCM. Stage-wise and activity wise study are missing. Lack of focus on supply chain efficiency. |
| | Joshi et al. (2009) | Identified the factors prohibiting smooth cold chain management and their inter-relations in developing countries, like India. | The study is focused on general food items (Confectionery, Dairy, and Meat). The study is limited to Cold Chain. Identification of root causes responsible for inefficient supply chain in perishable fruit & vegetables sector is needed. |

### 3.2. Theme 2: Challenges in the Supply Chain of Perishable Food produce in India

Various issues and challenges have been identified and highlighted by the authors in past studies conducted on the supply chain of F&V sector in India. The entire supply chain of F&V in India is affected by various issues and challenges, which acts as an impediment for effective and efficient supply chain of F&V sector in India. The broad identified issues are Lack of Cold Chain Facilities, Large number of Intermediaries, Poor Linkages and Integration between the partners, Poor Infrastructure Facilities, High Cost of Packaging Material, Lack of appropriate technology and techniques, Lack of Farmer's Knowledge and Awareness, Poor Quality and Safety standards, Poor Transportation facilities, Lack of Information regarding demand and market, Poor Shelf life, and Poor Handling. The sorted issues which are further expanded into different variables (as shown in Table 3.3) and their observations are discussed below.

***Cold Chain issues***

There are various issues related to cold chain in India, such as lack of cold chain facilities, inadequate capacity of the cold chain, lack of cold chain network. Due to this concern, it has become difficult for the farmers and businessman to do their business effectively and get proper remuneration for their produce.

***Fragmentation issues***

One of the main issues in the supply chain of F&V sector in India is a large number of local trader and intermediaries who eat all the share of farmer’s income. The entire fresh produce supply chain in India is dominated by local traders and middlemen.

***Integration issues***

Linkage and integration between the various players in the supply chain play a very important role to make the whole supply chain effective and profitable. However, in the supply chain of F&V sector in India, there is a lack of forwarding and backward integration between the farmers and the other partners.

***Infrastructure issues***

Supply chain infrastructure plays an important role in the F&V sector. Proper and adequate infrastructure helps farmers and agribusinessman to run their business successfully and helps to deliver the goods at the right time with right condition. In India, infrastructure pertaining to storage and transportation is the main impediment in the supply chain of agricultural products that leads to high amount of losses.

***Packaging issues***

Packaging is very important for F&V as they are highly perishable in nature and needs proper packaging for the handling of this fresh produce. Without proper packaging, it is very difficult to maintain their shelf life. Cost is also a very important aspect of this issue. The high cost of packaging material makes difficult for the farmers to do proper packaging of their goods.

***Technological issues***

Many technical issues, such as advancement issues, inefficient technology, obsolete techniques, and old machinery, surround the technology. Due to these concerns, it has become difficult for the farmers and agribusinessman to use appropriate technologies and techniques to reduce the post-harvest losses and time in operational activities.

***Farmer's Knowledge and Awareness***

Farmer’s in India have very poor knowledge regarding the use of latest technologies and techniques to work effectively and efficiently. They have very poor knowledge about the management of post-harvest produce, quality of seed; also, they have poor information regarding market demand, market price. Without proper knowledge and awareness level of the farmer, the supply chain of F&V cannot be efficient, as farmers are the main source of the fresh agri produce.

***Quality issues***

Quality is a very important and key area of concern in the supply chain of food industry/sector, as it directly relates to the health and lives of the people. It is very important for the supply chain to deliver the fresh goods in a timely manner and in a proper quality to the customer. Proper supply chain helps to maintain the shelf life of fresh produce and prevents it from deterioration. Quality has a strong impact on the supply chain, so it leads to efficiency and less rejection by the customer. In India, there is a lack of quality standards to meet international quality for export like poor hygiene and safety standards, and high-quality degradation.

### *Processing and Value addition issues*

Processing and Value addition is a way to increase the shelf life of food produced and reduce the losses. The high amount of food processing may lead to low wastage of F&V. It gives an immense opportunity to export the processed food to the various destinations. However, in India, the food processing is very low as compared to other countries. The country process about only 1-2% of total F&V's produce and there is a very low level of value addition due to lack of processing units and no closest proximity of processing units.

### *Financial issues*

Income of farmers in India is very low. They do not get proper income for their farm produce, and the middlemen tend to consume most of the share. The difference between the final consumer price and the price received by farmers is high (25% of the total price paid by the consumer goes to farmers). There is lack of transparencies in pricing at all Mandis in India due to which farmer doesnot get right prices for their efforts and fresh produce.

### *Post-harvest losses issues*

In supply chain of F&V sector, losses incurred during post-harvest are among the major problems in India. Most of the losses happens usually while the food reaches to the main markets and in food processing units. Close to 40% of total food produced in India is wasted during storage and transportation. Unavailability of cold chain facilities and insufficient logistics connectivity are the factors behind high post-harvest losses.

### *Transportation issues*

In supply chain of F&V, transportation happens to play a crucial role without which the goods cannot be delivered to the customer at the right time and in a right quality. It plays even a more important role in perishable food like F&V because of short shelf life, high perishable, required controlled temperature. Transportation-related challenges are very high in India because of unavailability of well transportation mode, the high cost of transportation, and lack of temperature-controlled vehicle for the movement of goods.

### *Market Information issues*

Proper information is the basis of the efficient supply chain. Without proper information regarding market demand, the supply chain cannot run successfully. In India, farmers have lack of information regarding the prices in the market, demand, and food processing units. Poor information leads to the poor realization of prices, high amount of losses, and late delivery of goods in the marketplace.

**Table 3.3: Summary of issues and challenges in the supply chain of F&V in India**

| Issues | | Variables | Source |
|---|---|---|---|
| **Cold Chain Issues** | Cold Chain Facilities | • Lack of cold storage & Warehousing facilities.<br>• Infrastructure in terms of cooling shed, cold storage.<br>• Inadequate cold chain capacities to serve the needs.<br>• Need for cold chain network in the hilly areas. | Negi and Anand (2015); Joshi et. al. (2013); Sharma & Singh (2011); Veena et al (2011); Narula (2011); Halder & Pati (2011); FICCI (2010); Rathore et al.(2010); Singh et al. (2009); Bhardwaj & Palaparthy (2008); Jain, (2007); Viswanadham(2007) |
| **Fragmentation Issues** | Fragmented Supply Chain | • A large number of Intermediaries present in the Supply chain.<br>• Traders dominant supply chain.<br>• Farmers have a greater reliance on Intermediaries.<br>• Presence of a large number of local agents and commission agents. | GOI (2012); Halder & Pati (2011); Narula (2011); Veena et al. (2011); Singh et al. (2009); Modi et al. (2009); Dharni and Sharma (2008); Bhardwaj and Palaparthy (2008); Satyanarayana et al (2007); Mathi (2007); Viswanadham (2007) |
| **Integration Issues** | Linkages and Integration between the partners | • Lack of backward-forward integration from farmer to customer in the hilly areas.<br>• Lack of linkages between Industry, Government, and Institution.<br>• Poor linkage in the marketing channel, from farm gate to mandi because of small land sizing farmers.<br>• Lack of linkage between farmer and processing unit because of unavailability of the processing unit. | Singh et al. (2009); Jain (2007); Satyanarayana et al. (2007); Mathi (2007) |
| **Infrastructure issues** | Infrastructure Facilities | • Lack of storage / Warehouse condition in the village areas.<br>• Poor loading/unloading facilities in the farm and Mandi place.<br>• Lack of Processing facilities (Waxing, washing).<br>• Lack of Packaging facilities.<br>• Hilly terrain and poor road connectivity.<br>• Poor transportation infrastructure (Road & Rail).<br>• Infrastructure connecting the farm is very poor.<br>• Inadequate Marketing infrastructure such as grading, standardisation and other machinery near the farm region and at Mandi place. | GOI (2012); Narula (2011); Sharma & Singh (2011); Veena et al. (2011); Halder and Pati (2011); Shukla (2010); FICCI (2010); Kapoor (2009); KPMG & ASSOCHAM (2009); Singh et al (2009); Dharni & Sharma (2008); Bhardwaj and Palaparthy (2008); Satyanarayana et al. (2007); Jain (2007); Viswanadham (2007) |

| | | | |
|---|---|---|---|
| **Packaging issues** | Packaging Material | • High cost of packaging material<br>• Unavailability of packaging material | Sharma & Singh (2011); Jain (2007); Mathi (2007) |
| **Technological issues** | Technology and techniques | • Limited use and lack of appropriate technologies & advanced techniques in food processing.<br>• Nonadoption of efficient technology.<br>• Processing plant with cost-effective machinery and packaging technologies. | Narula (2011); FICCI (2010); Rathore et al. (2010); Kapoor (2009); Singh et al (2009) |
| **Knowledge and Awareness** issues | Farmer's Knowledge and Awareness | • Lack of knowledge of post-harvest technologies<br>• Lack of farmer's awareness and education related to post-harvest management<br>• Lack of knowledge about the quality seeds<br>• Lack of information regarding market demand | Shukla & Jharkharia (2013); GOI (2012); Sharma & Singh (2011); Shukla (2010); FICCI (2010); Singh et al (2009); Modi et al (2009); Bhardwaj and Palaparthy (2008); Mathi (2007) |
| **Quality issues** | Quality and Safety standards | • Poor level of productivity and quality standards to International market.<br>• Poor hygiene and safety standards.<br>• Lesser control of product safety and quality across the supply chain because of manual handling.<br>• Lack of tracking and traceability facilities.<br>• Quality degradation is very higher. | Veena et al (2011); Halder & Pati (2011); Narula (2011); FICCI (2010); Shukla (2010); Blackburn & Scudder (2009); Singh et al (2009); Kapoor (2009); Ramesh (2009); Naidu (2007) |
| **Processing and Value addition** . | Processing and Value Addition | • Low level of value addition because of lack of processing unit.<br>• Poor infrastructure facilities connecting to processing units. | GOI (2012); Halder & Pati (2011); Narula (2011); Sharma & Singh (2011); FICCI (2010); Kapoor (2009); Bhardwaj & Palaparthy (2008); Satyanarayana et al (2007) |
| **Financial issues** | Farmer's Income | • Difference between the final consumer price and farmer's realization is very high.<br>• Lack of transparency in pricing at local Mandis.<br>• Heavy fluctuations in the Mandi prices.<br>• Farmers are not getting the right price for their produce in the market even in seasonal F&V. | GOI (2012); Narula (2011); Sharma & Singh (2011); Veena et al (2011); Halder & Pati (2011); Ramesh (2009); Modi et al (2009) |
| **Wastage Issue** | Supply chain losses and wastage of fresh produce | • High wastage along the supply chain.<br>• High wastage in reaching to the processing unit.<br>• Losses during transportation and storage are high.<br>• High level of wastage because of lack of cold chain and infrastructure. | Negi and Anand (2014); GOI (2012); Veena et al (2011); Narula (2011); FICCI (2010); Rathore et al. (2010); Ramesh (2009); KPMG & ASSOCHAM (2009); Murthy et al (2009); Modi et al (2009); Singh et al (2009); Satyanarayana et al. (2007) |
| **Transportation issues** | Transportation Facilities | • Unavailability of transportation mode.<br>• Inefficient and costly transportation for the movement.<br>• Lack of Refrigerated vehicles for the transportation of F&V in hilly and rural areas. | GOI (2012); Narula (2011); FICCI (2010); Shukla (2010); Modi et al (2009); Singh et al (2009) |

| | | | |
|---|---|---|---|
| **Information issues** | Market Information | • Lack of market information to the farmers such as prices, the flow of the product, and food-processing unit.<br>• Lack of knowledge about the demand in the market.<br>• Lack of timely information.<br>• Lack of knowledge about the intermediaries. | Shukla and Jharkharia (2013); Veena et al (2011); Halder & Pati (2011); Narula (2011); Singh et al. (2009); Modi et al (2009); Bhardwaj & Palaparthy (2008); Mathi (2007); Viswanadham (2007) |

The study and research conducted on the supply chain of F&V in India suggest that the entire supply chain of F&V is laden with the issue of supply chain inefficiency, which is resulting in post-harvest losses and wastages. The inefficient supply chain is the major impediment in the path of speedy growth of agriculture sector in India, so there is a need to identify the activities leading to inefficiency across the stages of F&V supply chain and the major reasons behind that.

### 3.3. Theme 3: Economic Analysis of Supply Chain losses in F&V

This theme discusses the literature available on post-harvest losses and wastage scenario in the supply chain of F&V sector. In the present study, authors have carried out a detailed and extensive literature review and discussed the standpoints of various researchers on the present problem of losses in F&V sector from farm to the consumer end with reference to global and Indian perspectives (shown in Table 3.4 and Table 3.5).

Post-harvest losses have been highlighted as one of the determinants of the food problem in most developing countries (Babalola et al., 2008; Ojo, 1991). However, food wastage is not good for two main reasons: firstly, there may be a material loss in terms of energy protein and other nutrients; and secondly, there may be an economic loss in terms of the value of food. In today's scenario of F&V SCM, post-harvest losses and wastage is the major impediment to the growth of this sector (Negi and Anand 2015). It has been reported that a huge amount of F&V is wasted in various operational stages of this sector (Murthy et al., 2009). Many authors have made an attempt to estimate the post-harvest losses at various stages of supply chain of F&V (Murthy et al. 2002; Sudha et al. 2002; Gauraha, 1997; Srinivas et al., 1997; Madan & Ullasa, 1993; Aradya, et al. 1990; Atibudhi, 1987; Waheed et al.,1986; Anon, 1985; Anon, 1982) and banana in particular (Murthy et al. 2009; Murthy et al. 2007; Murthy et al. 2003; Gajanana et al. 2002). Various past studies have reported harvest and post-harvest losses in the supply chain of F&V (Murthy et al. 2009;

Turan, 2008; Ozcan, 2007; Troger, 2007; Karabulut et al., 2005; Lawande, 2004; Reddy, 2004; Kumar et al., 2004; Singh et al. 2004; Tatlidil et al. 2003; Gunduz, 1997; Dokuzoguz, 1997; Ozcan et al. 1997; Ozcan and Baklaya, 1995; Klein and Lurie, 1991; Kaynas et al. 1988). According to the estimates of CIPHET, total value of harvest and post-harvest losses of agricultural goods amounted to Rs, 92651 crores and found that most of the wastage is occurs in F&V of about 4.58-15.88% (GoI, 2016). According to the study on conducted by ASSOCHAM, India (2013), the farmers have to forgo every year about Rs. 2.13 lakh crore due to losses incurred in the supply chain of F&V. In their another study in 2010, CIPHET has estimated harvest and post-harvest losses of major agricultural produces in India was of the order of Rs 44,143 crore per annum at wholesale prices and found that most of the wastage is occurs in F&V of about 5.8-18% worth value of Rs 7,437 crores in fruits and Rs 5,872 crores in vegetables (GOI, 2012). According to National Academy of Sources (1978), estimates of postharvest losses in developing countries vary greatly from 1 to 50% or even higher and the average loss of food products over the supply chain starting from production to the retail shelf and finally to the consumer’s fridge is estimated to be 35% (Parfitt et al., 2010); in other words, it can be stated that only two-thirds of the total food produced remains intact, whereas as the remaining one-third is wasted (Gustavsson et al. 2011). Jha (2007) discussed the Food Facts in India and mentioned that Rs. 58,000 Crore worth fruits, vegetables, and cereal grain are wasted each year in India, which is ample to feed about 27% of the below poverty line population and amounts to more than a third of total food production. Dagar (2007) founds that 25-40% of farm produce worth $12 billion (Rs 50,400 crore) rots every year even before it reaches to the final consumers, thereby squeezing both ends of the supply chain namely, the farmer and the retailer. The amount of post-harvest loss ranges from 20 to 60% of the total production across the countries (Widodo et al., 2006). According to Viswanadham (2007), Rs. 70,000 million value of goods is wasted each year due to poor transportation, lack of proper storage facilities, and inadequate cold chain facilities. Kader (2005) also estimated that worldwide about one-third of all F&V produced are never consumed by humans.

Storage facility for available goods is considerably poor, with only cold storage available for 10% of India’s total F&V production and almost 30-40% is wasted

(MOSPI, 2012). Due to inadequate infrastructure related to cold chain, inadequate storage and transportation, poor post harvesting technology and lack of food processing industry, about 20 -30% of all foods produced in India (Rs. 500 b) gets wasted annually (Mishra & Anjani, 2010; Viswanadham, 2007; Jain, 2007). Indian fresh agro supply chain is dominated by Mandi system (traditional method), and it plays a vital role in F&V Supply Chain. The faulty system is vulnerable to several inefficiencies like, no transparency in price determination, this result in a loss-loss situation for both buyers and sellers, as they are often cheated. Moreover, huge amount of losses are incurred in operations at Mandis due to non-scientific handling and storage (Singh et al., 2009).

Veena et al. (2011) estimated losses and wastage in unorganised and organised retailing and found 25% losses in unorganised retailing, which speaks about the importance of SCM. The wastage was far less (16-19%) with organised retailers compared to unorganised retailers. A study conducted by the Indian Institute of Management Bangalore (IIMB) reveals that the ratio of retail price to producer's price is between 3 and 4.1, which is one of the highest in the world, as the result of significant losses incurred in the supply chain. The cumulative waste for tomatoes and potatoes has been observed to be 24% and 40%, respectively as they move towards the supply chain starting from the farm to the end user (Parkan & Dubey, 2009). The evidence of food losses suggested that extent of losses tend to be the highest in the nations where the need for food is greater. Zaldivar (1991) cited several reports, which discussed several loss figures of 25% or 28-42% worldwide, and 15-60% or 15-50% in less industrialized countries specifically, which means that half of the production never reaches to the consumer for whom it was grown, and the effort and money required to produce it are lost forever in terms of losses.

With reference to the several research surveys, the total amount of food that is wasted in India every year is equal to total annual food intake in UK (Rathore et al. 2010). An estimate says that around 35% to 40% of the total production of fresh F&V gets waste in India, which is about the total production of Great Britain (Khan, 2005). Cumulative waste is worth $6.7 billion, the equivalent of 40% of the total production of fruit and vegetables grown in India (Jain, 2007). Massive quantity and quality losses in the fresh produce giving rise to the 40% value loss in the supply chain of F&V sector in India (Narula, 2011). Murthy et al. (2009) highlighted that about 1.2% of agriculture GDP (approx. 33.85 lakh tonnes in mango, 35.26 lakh tonnes in banana and 2.12 lakh tonnes in grape) or value of Rs.7, 618.77 crores are rejected every year in India as post-harvest losses. The post-harvest losses are of worth Rs. 29214 Cr. in Perishable (F&V) produce (Jain, 2007). The fresh F&V sector is one that contributes mostly to the food waste and is crucial in having an impact on the total turnover of all aspects in the supply chain (Mena et al. 2011; Griffin et al. 2008; Kantor et al. 1997). Many researches have revealed that a losses incurred in the process of post-harvest amount to Rs. 75,000-1,00,000 crores annually. Kachru (2002) found an extent of post-harvest losses in perishable foods (fruits, vegetables, milk, meat, fish, and eggs) is Rs.63, 000 crores and 20% of the level of production that includes losses during storage, handling and milling/processing.

Mishra & Anjani (2010) mentioned that inefficient supply chain is the central impediment for halting the growth and development of Indian agriculture. Due to the inefficient supply chain, the extent of loss of fruit and vegetables is about Rs. 10,000 crores to Rs. 12,000 crores per annum and the loss of quantity ranges from 10% and 80% in some of the most perishable F&V (Mittal, 2007). Hazarika (2006) estimated the post-harvest losses of the major perishable horticultural crops in Assam and maximum post-harvest loss was found to be 22.62% for tomato followed by ginger, orange, and pineapple. Sharma & Singh, (2011) assessed the degree and extent of losses in the supply chain of major vegetables produced in the Kumaon region of Uttarakhand, India. Tomato experiences maximum losses during post-harvest period followed by potato and brinjal.

Negi and Anand (2015) also discusses the issues and challenges pertaining to the supply chain of F&V agribusiness in Uttarakhand, India and highlighted losses and wastage as one of the major problems in Uttarakhand agro fresh produce sector. According to Verma & Singh (2004), if the supply chain management is not taken care of, then there is higher probability of vegetables losses rising upto 25% of the total production.

Bhardwaj & Palaparthy (2008) did a rigorous review of the basic and contemporary literature and identified the reasons creating an impact on F&V markets and its effects on supply chain members. In their study, authors cited that according to Food Corporation of India (FCI) estimates, 20-30% of total food produce is wasted during the process of transportation. According to HMNEH (2010), out of total fruit production, banana constitute a fair portion of the share amounting to approximately 33%; but the export of the same is quite negligible because of higher amount of wastage (approximately 40%). It is estimated that the food production in India is going to double in the next ten years, but post-harvest losses of about 35-40% of the total produce that amounts to Rs. 58,000 cr annually is a cause for concern. This results in price instability, farmer's non-remuneration, rural impoverishment resulting in farmers' frustrations and suicides (Rathore et al., 2010). This post-harvest waste reduces the farmer's profit and eventually results in revenue loss. Therefore, farmers are demotivated to be engaged in agri production, as it substantially decreases the bargaining powers of them. Speaking from the viewpoint of consumers, wastage of food products means lower availability at a higher price. The act of supply chain losses also severely diminishes the quality of the available products as well as the options available for the consumers. At the micro level, these losses increase the supply chain cost of the product and at the macro level, reduces the per capita availability of the products (Halder & Pati, 2011).

Therefore, it is important to evaluate the position of FSCM and document areas of improvements. Focus should be placed on reduction of wastage by embracing effective and efficient methods. Murthy et al. (2007) found that the efficiency in operations is reflected by lesser amount of losses during post-harvest due to lower marketing costs, proper handling, effective transportation and strict procurement procedure. Even though India has a strong agricultural production base, wastage is colossal. This can be reduced by increasing the processing level of agricultural produce, which is only about 2.2% for F&V (Rathore et al., 2010). Increasing processing and reduction in food waste can be a better solution to reduce the consumer prices and increase the revenue of the farmers & other stakeholders rather than focusing on increasing the production (Kader, 2005).

Many researchers found highest losses in Tomato in Vegetables (Sharma and Singh, 2011; Parkan & Dubey, 2009; Hazarika, 2006; Gajanana et al., 2006; Verma and

Singh, 2004; Singh et al., 2004) and Mango in Fruits (Bhushan, 2013; Sinha, 2011; CIPHET, 2010; Murthy et al., 2009; Chadha and Pareek, 1993).

**Table 3.4: Summary of Economic Analysis of Supply Chain losses in F&V (Global Review)**

| Theme | Authors, Year | Inference |
|---|---|---|
| **Supply Chain Losses and Wastage: Global** | Raak et al. (2017); Buyukbay et al. (2011); Gustavsson et al. (2011); Babalola et al. (2010); Parfitt et al. (2010); Adeoye et al. (2009); Babalola et al. (2008); Turan (2008); Griffin et al. (2008); Ozcan (2007); Troger (2007); Rehman et al. (2007); Karabulut et al. (2005); Tatlidil et al. (2003); Ozcan et al. (1997); Dokuzoguz (1997); Kantor et al. (1997); Gunduz (1997); Ozcan and Baklaya (1995); Klein and Lurie (1991); Zaldivar, C. (1991); Kaynas et al. (1988); Waheed et al. (1986); NationalAcademyofSources (1978) | Estimated the post-harvest/marketing losses and analysed the determinants of losses during and after harvest. |
| | Kader, 2005 | Discussed Socioeconomic factors of losses and give strategies for reducing Post Harvest losses in USA. |

**Table 3.5: Summary of Economic Analysis of Supply Chain losses in F&V (Indian Review)**

| Theme | Authors, Year | Inference | Gap |
|---|---|---|---|
| **Supply Chain Losses and Wastage** | Ramanathan and Parthasarathy (2014) | The study is focused on identification of losses in various stages in supply chain of fruit sector from the grower to the retailer. This study is limited to losses in food processing units as it is seen to be the major point of losses after retailing. | Studies are limited to losses and wastage only. Supply Chain Efficiency perspective is missing. Lack of emphasises on the Stage wise activities contributing to Supply Chain Inefficiencies. |
| | Sudharshan et al. (2013); Bhushan (2013); Gauraha and Thakur (2008); Verma & Singh (2004) | Losses in various F&V were ranged from 20 -30%. In vegetables, highest amount of losses was found in Mango & Tomato. Losses were found highest in the grower level to Wholesale level. Nearly 15% of India's Mango production is wasted due to lack of adequate infrastructure facilities. | |
| | Sharma and Singh (2011) | Estimated the losses during post-harvest in the major vegetables supply chain in Uttarakhand. The highest consolidated losses was found in tomato at producer, wholesale and retail level. | |
| | Murthy et al. (2009) | Authors assessed the post-harvest losses in major fruits (mango, banana, grape, and pomegranate) both in economic and physical terms at various handling stages and found nearly 38% of the total post-harvest losses occurs in mango. | |

| | | | |
|---|---|---|---|
| | Parkan & Dubey (2009) | The cumulative waste for potatoes and tomatoes, as they move from the producer to the consumer on their supply chains has been observed to be 24% and 40%, respectively. | |
| | Singh et al. (2008); Hazarika (2008); Gajanana et al. (2006); Kumar et al. (2004) | Estimated the losses at different stages and found lack of adequate storage and proper transportation facilities being the factors creating an impact on post-harvest losses. | |
| | Murthy et al. (2007); Kumar et al. (2006); Singh et al. (2004); Murthy et al. (2003); Sudha et al. (2002); Gajanana et al. (2002); Murthy et al. (2002); Gauraha (1997); Srinivas et al. (1997); Madan and Ullasa (1993); Aradya et al. (1990); Atibudhi (1987); Anon (1985); Anon (1982) | Evaluated and analysed the marketing losses in F&V in both economic and physical terms. | |
| | Hazarika (2006) | Estimated the post-harvest losses of the major perishable horticultural crops in Assam. The maximum post-harvest loss was found to be 22.62% for tomato followed by ginger, orange, and pineapple. | |

Available literature states some of the primary causes for wastages and losses in the logistics and SCM of fresh food produce can be categorised as following: Poor Infrastructure, Large number of Intermediaries, Harvesting, Transportation, Information, Farmer's Education, Knowledge of Farmer's, Farmer's Experience, Storage and Handling, and Poor Packaging. These causes are discussed below in detail.

***Poor Infrastructure***

The role of infrastructure is extremely crucial in supply chain industry as it acts as the driving force. In perishable fresh produce supply chain, it constitutes cold chain, transportation infrastructure, road connectivity and network, port infrastructure, marketing facilities, and processing facilities. In India, the Infrastructure for perishable food supply chain is very weak and is one of the main reasons for losses and wastage of food. Singh et al. (2009) found that lack of support with regards to infrastructure amount to high losses (40%) of F&V. The losses at various stages of the supply chain are incurred because of gaps in cold chain such as inadequate cold storage capacity, lack of cold storage nearby farm area, and poor transportation.

The losses and wastages in the food production decrease the returns of F&V and occur mainly because of lack of infrastructure**.** Viswanadham (2007) mentioned in his study that the causes for the losses are unavailability of proper processing infrastructure, lack of cold storage, and dearth of transportation in India. In developing countries, the unavailability of marketing facilities and poor infrastructure resulted in high losses in F&V, which ranges from 20 to 50% (Verma & Singh, 2004). In order to properly maintain the quality and shelf life of perishable goods, there is a need of temperature management. However, there has been massive losses in F&V primarily due to absence of cold chain infrastructure (Rathore et al., 2010) and lack of proper marketing facilities and systems (Gauraha & Thakur, 2008; Singh et al., 2008) ensuing losses and wastages in the supply chain of perishable food produce. Kader (2005) found inadequate storage facilities as a cause, therefore, produce exposed to the direct heat of the sun that may accelerate metabolism leading to higher levels of damage and decrease the shelf life of the produce. Around 95% of the cold storages are in private hands, and because of high charges, an average Indian farmer is not able to avail the facilities of cold storage (Dharni & Sharma, 2008). Negi & Anand (2015) in his study on the cold chain also showed that the cold chain in India has emerged as one of the weakest link in the supply chain of F&V sector in India resulting to losses.

According to Maheshwar & Chanakwa (2006) about 30% of the F&V grown in India, which is 40 million tonnes amounting to $13 billion gets wasted annually. There is a lack of ownership within the chain. All the players are concerned with their own revenue maximisation with limited attention towards the overall profit of the chain. This lack of a holistic view of a supply chain is leading to the post-harvest waste (Shukla & Jharkharia, 2013). The magnitude of losses also depends on the road connectivity and network (Kader & Rolle, 2004)**.** In India, most of the northern and eastern region is covered with hilly terrain areas and are the major sources of F&V. The road connectivity and network infrastructure in such areas are very poor, which takes a long time to take the fresh F&V product to the market and deteriorate the quality and condition of the product, which results in wastage. Modi et al. (2009) also highlighted in his study that the villages, farms and the markets in the Uttarakhand state (Hilly region) are not well connected and the farmers had to somehow bring their harvests to the nearby road for transportation, which increased the wastage of their produce. On its way to market, a lack of proper infrastructural facilities results in greater wastage of the fresh produce. Negi and Anand (2015) also discusses the issues and challenges pertaining to the supply chain of F&V agribusiness in Uttarakhand, India and highlighted losses and wastage as one of the major problems in Uttarakhand agro fresh produce sector.

***Transportation***

Murthy et al. (2009) has documented that losses during transportation are the major operational reasons causing severe wastage in the supply chain followed by inventory management (Shukla & Jharkharia, 2013). Rehman et al. (2007) found in his study that the losses mainly occurred during the process of transportation of perishable goods to the market. Poor and inadequate transportation facilities contribute more to this problem (Gauraha & Thakur, 2008; Sharma & Singh, 2011; Kader, 2005)**.** Singh et al., (2008) attempted to assess the extent and magnitude of post-harvest losses in Uttar Pradesh and found transportation and distribution of agricultural commodities as the factor responsible for such losses. The author found transit loss contributing around 24% of the total loss. In transportation, time is a critical factor to deliver the fresh produce at the right time ensuring adequate quality. At farm level, also there are various losses due to the ignorance of time factor.

Verma & Singh (2004) found delays in moving the harvested fresh produce to the market as the reason of losses at the farm level. There is inherent difficulty of collecting and transporting small quantities of fresh produce from the numerous small farm's results to high post-harvest losses. Rehman et al. (2007) observed during the survey that most of the farmer picked their crops in the morning, packed in wooden crates and using pickup/truck as a mode of transportation to transport their produce to the outside market. The loss at Market level is mainly due to the transportation practices followed in marketing channels (Verma & Singh, 2004). Mathi (2007) studied the SCM of Guava in Allahabad Uttar Pradesh and found ordinary transportation, irresponsible driving, and rough roads as one of the reasons for post-harvest losses. Some crops required special facilities like controlled temperature transportation and unavailability of such is the reason for the marketing loss (Ozcan, 2007). Produce are handle roughly and transported in open trucks that take twenty-four hours or more to the fresh produce to arrives at the retailer, typically an open-market vendor or a pushcart after harvesting. It is piled into large cane baskets or on to truck beds without cushioning or packaging, which leave it exposed to the sun in temperature and deteriorates the quality of the fresh produce (Jain, 2007).

The faulty system of transport and delayed delivery of fresh produce causes wastage in the retail market (CEAGESP, 2002). It reaches the store shelf too late and with a short remaining shelf life, which causes wastage in the perishable food supply chain at the retailer level (Mena et al., 2011) and additionally results to the penalty (Shukla & Jharkharia, 2013). The bulkiness in the transportation of the fresh produce makes the handling and transportation a difficult task, leading to huge wastage of around Rs. 23,000 crores (35% of the total production) (CII, 1997)**.** Transportation-related challenges are very high in India because of unavailability of well transportation mode, the high cost of transportation, and lack of temperature-controlled vehicle for the movement of goods. (Negi & Anand, 2015).

Usage of advanced transportation method strengthens the need for dedicated transportation vehicles like reefer trucks for perishable products, which can maintain the quality of fresh produce and enhance the shelf life and will result in reducing the transit losses (Murthy et al., 2007).

***Large number of Intermediaries***

Supply chain of perishable fresh produce is inefficient because of higher number of intermediaries and fragmented chain. The unorganised supply chain for perishable goods is fragmented and long where it extracts a huge sum of money from the customers for the produce (Singh et al., 2009). There are a large number of middlemen in the supply chain of fresh F&V, i.e., Farmers, Pre-harvest Contractors, Agents, Wholesaler, and Commission Agents at the wholesale level, Auctioneers, Retailers and the customers. From the field to the customer, F&V passes through various channels. A large number of intermediaries adds severely to the waste and enhances consumption price (Boer & Pandey, 1997). Several losses occur because of market intermediaries (Gauraha & Thakur, 2008)**.** Verma & Singh (2004) analyses the losses in fresh vegetables and found that the losses at wholesale level depend on the number of participants in the marketing channel and length of the channel.

The horticulture supply chain of India is fragmented due to small and marginal land-holdings by the farmers. Because of the limited landholdings, the produce from these farmers is very low that poses problems in transportation, which results in increased reliance on intermediaries to market their F&V**.** The middlemen are least bothered about the wastage that the farmer incurs and are reluctant to spend on better cold storage other infrastructural facilities. This leads to quality and quantity losses in F&V supply chain amounting to 40% value loss (Narula, 2011).

***Information on Market Demand***

The flow of Information is very crucial in the supply chain to ensure smooth flow of functions. In case of the supply chain of perishable goods, it is even more important because of short shelf life and perishable nature. This section categorises the causes of loss occurring because of limited demand information. Non-availability of information relating to demand was outlined as primary factor for losses (Buyukbay et al., 2011; Viswanadham, 2007). Kader (2005) also found Lack of information as one of the socioeconomic factor causing post-harvest losses. Most of the time fresh food remains unsold at retail stores, and the expiry dates of that product passes, which is the most common reason of waste at the retail level. This occurs when there is no information regarding demand and retailer orders more than the real demand (Mena et al., 2011)**.** Information should be provided to the farmers in a timely manner, so they can plan and take care of the planting and harvesting activities, as lack of proper planning and management practices are the key reasons for losses in fresh produce supply chain (Shukla & Jharkharia, 2013).

***Farmers Knowledge and Experience***

Knowledge of farmers and their experience plays a very important role in the supply chain of perishable fresh food products.Farmers are the main source and supplier of all the fresh produce and their education, experience, and knowledge regarding the technology, market information, and new equipment are the factors responsible for losses in the supply chain of perishable fresh produce. Most of the growers are the tiny landholder and sharecroppers, having minimal knowledge regarding the technology, financial incentives, and demand in the market (Shukla & Jharkharia, 2013). Babalola et al. (2010) found in his study that most of the farmers around 82.95% were illiterate, which is a cause resulting in high wastage of tomato because they do not use available post-harvest technology, only the farmers with post-primary education can use it. The author also found that majority of the farmer 68.17% had below the experience of 16 years in tomato production, which could bring about a massive effect on losses related to production of tomato. Ozcan (2007) also listed lack of training and experience for workers as one of the reasons for post-harvest losses. Sharma & Singh (2011) also found that the losses at grower end result from lack of farmer's knowledge about the post-harvest management. They also have the very less knowledge about the appropriate maturity of fresh produce and proper time of harvesting, which results in losses.

***Improper and Poor Harvesting***

Harvesting of the fresh produce at a wrong time or before their maturity age can lead to the wastages in the perishable fresh produce supply chain. Many researchers found poor harvesting as one of the reasons for post-harvest losses. Rehman et al. (2007) found that losses mainly occurred during picking of the crop. The author found harvesting prior to maturity and improper care during harvest as the primary factor responsible for losses in tomato supply chain**.** Babalola et al. (2010) revealed through regression analysis that the age of fruits at harvest and total number of harvested baskets are the primary factors determining losses, because harvesting more than the actual demand at a wrong time may cause loss and wastage. Sharma & Singh (2011) also found that harvesting the pre-matured F&V results in waning quality and uneven ripening as one of the important factors of losses. Buyukbay et al. (2011) determined 5-12.97% and 18.44% of losses due to early and late harvest in beans and tomato production in Turkey. Ozcan (2007) also listed early or late harvest, usage of improper machineries and tools, and improper method of harvest by the farmers in harvesting their fresh farm produce as the reasons for the marketing losses.

Verma & Singh (2004) estimated post-harvest losses in fresh vegetables at farm stage and found that wastage are mainly caused by inadequate means of harvesting. Singh et al. (2008) identified the faulty method of harvesting as the factor responsible for wastage and losses. The first stage from where the losses begin is harvesting in the supply chain of perishable fresh produce. Therefore, it is essential to adopt proper machineries and harvesting tools, timely harvesting of produce to avoid wastage.

### *Storage and Handling*

Perishable fresh produce has a constraint of limited shelf life, so they need adequate storage and handling after post-harvest. Proper storage helps to maintain the quality of the fresh produce and safeguard them to deteriorate from rough handling, bacteria, fungus, mildew, and insects. Farmers piled their produce into large cane baskets or onto trucks without proper measures and exposed to the sun in temperature causing losses. Jain (2007) found the rough handling of produce as the main reason for post-harvest losses. There are several inefficiencies in storage and poor handling process, which are the operational cause of wastage (Murthy et al., 2009; Prigojin et al., 2005)**.** Over 25% of F&V production is spoiled due to unsuitable handling and storage (Veena et al., 2011). Farmers do not take proper care of fresh produce and handle, grade and pack these products in a poor manner, which subjected fresh produce too extreme of temperatures, atmospheric modification or contamination, and attack by parasites/diseases. Gajanana et al. (2006) found pest and diseases at the field level, crushing of fruits at the market level and injury to fruits due to pressing at the retailer's end as the primary factor of loss due to improper handling and storage. Ozcan (2007) listed lack of specific conditions during the storage as one of the reasons for marketing losses in the fresh produce.

### *Poor Packaging*

Poor packaging is also the reason causing losses in fresh produce supply chain. Farmers use wooden crates and improper method of packaging, which causes loss. Rehman et al. (2007) found Packaging in bulk without sorting, and grading of produce are the factors responsible for the losses. Adeoye et al., (2009) also found such reasons as the causes of economic losses to tomato. The author also found that improper handling of perishable goods results in bruising, leading to splitting and skin breaks in the fresh produce. Rough handling causes damage during off-loading of the produces resulting in high percentage of losses in the F&V. Baskets are staked over the other in a poor manner while moving the goods from growers end to the marketplace. The bulkiness in the handling of the fresh produce makes handling a very difficult task during the transportation. Most of the farmers use the faulty method of cleaning, drying, and storage (Verma & Singh, 2004)**.**

### 3.3.1. Supply Chain losses and Wastage at different stages

Wastage in F&V supply chain starting from harvesting to delivery of fresh produce to consumers is significantly high in India (Balaji and Arshinder 2016). Losses and wastage during storage, transportation, handling and distribution are the significant issues in agrarian economy. It has been reported that a huge amount of agri-fresh produce is wasted in various operational stages of the perishable fresh food supply chain (Murthy D. S., Gajanana, Sudha, & Dakshinamoorthy, 2009). In U.K roughly one quarter of food produced is wasted from the time the food commodities leave the farm until they are presented to the consumer on a plate (Osner, 1982), proportionately most wastage (nearly 20% by weight) occurs on the farm. Author estimated wastage at Storage level, Processing, and during Distribution and retailing. Although storage conditions in UK are better than in many countries, about 30% of stored carrots and between 25 and 45% of winter cabbages and cauliflowers become unacceptable during storage. However, only 5 to 8% of main crop potatoes are discarded. In processes such as peeling, trimming, coring and seeding of fruit and vegetables all result in waste. Apart from lesser availability and severe losses in monetary terms, it also enhances costs incurred towards marketing and transportation (Subrahmanyam, 1986). Kader (2005) gave the general difference that more of the losses occur between production and retail sites in developing countries than in developed ones. As per National Centre for Cold Chain Development (NCCD), the highest losses occurs during transportation. From field to consumption point, F&V happens to go through several distribution channels, which amounts to a loss of 5-7% at each step (MOSPI, 2012). Shukla & Jharkharia (2013) mentioned that the major portion of the agri-fresh produce wasted at the farmer’s end. Bhardwaj & Palaparthy (2008) also cited that 20-30% of the produce is wasted during the phase of transportation from the point of origin to the processing units as per the estimates of FCI.

#### 3.3.1.1. Supply Chain losses and Wastage at different Stages-Fruits

Murthy et al., (2009) assessed the post-harvest losses in major fruits (mango, banana, grape and pomegranate) both in economic and physical terms at various handling stages and found that nearly 38% of the total post-harvest losses in mango occurs due to disease; distant marketing in grapes increased the losses by 50%. Sudharshan et al., (2013) also assessed the losses occurred during post-harvest in pomegranate in two markets and found losses occurring ranging from 25.48% in Bangalore market to 38.44% in Mangalore market. The explicit evaluation of the post-harvest losses at different stages of marketing and their impact on farmers' net price, efficiency, margins, and marketing costs have been documented by Murthy et al., (2007). 28.84% of losses were witnessed during post-harvest in the wholesale channel, which included 5.53% losses at farm stage, 6.65% at wholesale stage, and 16.6% at the retailer's stage. The said losses occurring in co-operative market were 18.31% with 7.82%, 1.77% and 8.72% in the subsequent stages. In the wholesale stage and retail stage, the losses amounted to 23% and 58%, respectively, in comparison with 10% and 48% in the co-operative marketing channel.

Mathi (2007) determined the existing supply chain available for guava in Allahabad district and determined the post-harvest losses due to the existing SCM. The author found 9.89 kg of loss at one Quintals fruits drawn at Farm level, which comprises loss at harvesting-2.67 kg, grading-0.72 kg, transportation-3.00 kg, and storage 3.50 kg. This amount to a physical loss of Rs. 49.45 and the total return realized was Rs. 450.55.

#### 3.3.1.2. Supply Chain losses and Wastage at different stages - Vegetables

Verma & Singh (2004) assessed the post-harvest losses of vegetables in quantitative terms at wholesaler, retailer and farm level at transportation, storage and sorting level. It was found that the overall losses vary up to 25% in vegetables viz. tomato, cabbage, cauliflower and chili. Monetary losses were estimated worth Rs. 156.72 lakh in Tomato, Rs. 27.79 lakh in Cabbage, Rs. 35.10 lakh in Cauliflower, and Rs. 0.19 Lakh in Chili. The post-harvest losses of tomato were observed to be very high in quantitative as well as in monetary terms. Hazarika (2006) also found that the losses are more during the transportation and storage of the product. Apart from tomato, the losses in the other F&V was found to be more in the market level than the loss at the grower's level. Kumar et al. (2006) assessed the losses in vegetables supply chain in state of Karnataka. It was found that losses resulting in post-harvest period at farm stage with respect to potato and onion were 7.34 kg/qtl and 6.21 kg/qtl respectively. Further, the losses experienced at wholesale stage amounted to 17.12% and 17.75% for potato and onion respectively. At retail stage, the losses incurred were 26.29% and 22.65% for potato and onion respectively. Hence, 25% of the losses are witnessed at retailer's stage, whereas 60% of the losses occur at farm stage. Sharma & Singh (2011) estimated the losses at different stages in producer level (handling, harvesting, sorting and grading, packaging, transportation and marketing); and trader level (loading unloading, transportation, grading and selling stages). At farm stage, the losses have been witnessed higher in case of tomato (15.16%), followed by french bean (11.06%), and brinjal (11.00%). At the retailer's end also, tomato suffers the maximum loss, followed by okra and chilly. The highest post-harvest losses were found in tomato (23.19%) and minimum in radish (6.52%) at producer, wholesale and retail level. Across different levels, the maximum wastage occurred at the farm stage for all the vegetables. Gajanana et al., (2006) have undertaken a study in the major tomato growing state of Karnataka to assess the post-harvest loss at different level of handling. Total post-harvest loss was observed to be about 19% consisting of 9.43% at field level, 4-5% at market level and about 5% at the retail level. Rehman et al. (2007) found post-harvest loss of tomato in Peshawar was 20% that may have occurred during harvesting, transportation, and product handling. The losses in tomato was found between 5.15% to 9.83% during harvesting time in Nallihan and Ayas districts of Ankara (Tatlidil, et al., 2003) and ranged from 6.7%-33.5% in Indian context (Singh et al., 2004). The summary of losses and wastage in different stages are shown in Table 3.6.

**Table 3.6: Summary of losses and wastage in different stages**

| Authors | Losses and Wastages in Supply Chain Stages |
|---|---|
| Jha et al. (2015) | As per the study of CIPHET, Ludhiana, under GoI, highest amount of losses in F&V are found in **farm-level operations**. |
| Shukla & Jharkharia (2013) | The major portion of the agri-fresh produce is wasted at the **farmer's end**. |
| MOSPI (2012) | As per NCCD, the largest losses and wastage occurred during the **transportation** of F&V from the point of origin to the destination. |

| | |
|---|---|
| Sharma and Singh (2011); Murthy et al. (2009); Hazarika (2008); Gauraha and Thakur (2008) | Losses were majorly found at **Farm to Wholesale level** |
| Murthy, Gajanana, Sudha, & Dakshinamoorthy (2009) | Losses and wastages during storage, transportation, handling, and distribution are the central issues in agricultural economy, especially in F&V. Higher amount of F&V is lost during several operational stages |
| Singh, et al. (2009) | Losses during the **transportation stage** and storage are one of the current problems in Indian fresh produce supply chain also a huge amount of losses incurred in operations at **Mandi.** |
| Kumar, Basavaraja, & Mahajanshetti (2006) | At the **farm level**, approximately 60% of total post-harvest losses occur |
| Gajanana et al. (2006) | Across different levels, i.e., Grower level, Wholesale level and retailers' level, the maximum wastage were found at the **Farm level** in case of all the vegetables. |
| Singh, Banerjee, Singh, Pandey, Sudhakar and Rai (2004) | The losses and wastages during **harvesting** of tomato ranges from 6.70% to 33.50% in India. |

It can be seen in the past available literature that numerous studies have been done on estimating economic analysis of losses and wastage in F&V sector. Most of the studies have been conducted with reference to quantifying the losses and there is a dearth of study on identifying the most significant activities leading to supply chain inefficiency with reference to cost, time, and quality across the stages of supply chain, which is ultimately resulting to losses and wastage, and the reasons for that inefficiency.

### 3.4. Theme 4: Defining Supply Chain Efficiency

Different authors have discussed and highlighted important aspects of supply chain efficiency from the different perspective, and they have given different opinions as discussed below:

Labs (2010) defined it as "Supply chain efficiency must ensure that it upholds the promise to the customer while eliminating non-value add or waste in the process. Supply chain efficiency, therefore, is the measure of getting the right quality product to the right place at the right time at the least cost."

Stephen Halula, Manager-supply chain consulting, CDC Software, said that, supply chain efficiency can be viewed as:

"Providing the right product in the right quantity to a customer when desired, at a fair price with a fair margin, adapting to market changes, remaining flexible enough to accommodate problems as they are encountered, and providing adequate information to all parties (customer, management, manufacturing)".

Jim Stollberg, Vice president- Strategy and business development, HK Systems, explains, "Supply chain efficiency must ensure that it upholds the promise to the customer while eliminating non-value add or waste in the process."

Pettersson (2008) stated, "The most efficient supply chain has the lowest possible cost and at the same time meets the customer’s expectations on service like delivery precision and lead time."

Collin (2003) highlighted that "Success of Supply chains are composed of Customer service, Capital employed, Total cost."

Hoover et al. (2001) highlighted that "An excellent supply chain is when a company provides requested customer support."

Bowersox et al. (2000) highlighted that "Three perspectives to create value for customers are economic, market and relevancy value."

Simchi-Levy (2000) highlighted that "Efficient supply chain strategies must take into account the interactions at the various levels."

Beamon (1999) defined it as "Efficiency is the measure of how well the resources are utilised."

Christopher (1998) stated, "The future market leaders will be the ones that have achieved cost and service leadership."

Dornier (1998) said, "The overall objective of any logistics system is to maximise profitability."

Bowersox and Closs (1996) highlighted that the "Relationship between customer services level and the cost is important."

Mentzer and Konrad (1991) defined "Effectiveness is as the extent to which goals are accomplished."

Goonatilake (1990) stated that "An excellent supply chain when a company provides products at low cost."

De Meyer et al., (1989) stated that "An excellent supply chain when a company provides products with high quality."

Haug (1985) defined it as "An excellent supply chain is when a company provides products with short lead time."

Several scholars have debated and deliberated on supply chain efficiency, as shown in Table 3.7. The conclusion that can be drawn here is that, the central factors that happens to determine supply chain efficiency are as follows: sustainable utilization of resource, enhanced customer service, greater value, lesser cost, minimum lead-time, better quality, profitability, and less wastage. It can also be concluded that in order to achieve efficiency in supply chain F&V, the focus must be on delivery of fresh produce to the consumer in right cost, right quality and at the right time (Negi and Anand 2014).

**Table 3.7: Defining Supply Chain Efficiency**

| | **Authors (Years)** | **Inference** |
|---|---|---|
| **SUPPLY CHAIN EFFICIENCY** | Labs (2010) | "Supply chain efficiency is the measure of getting the **right quality product** to the **right place** at the **right time** at the **least cost**." |
| | Pettersson (2008) | "The most efficient supply chain has the lowest possible **cost** and at the same time meets the customer's expectations on service like delivery precision and **lead time**." |
| | Collin (2003) | "The success of Supply chains is composed of **Customer service, Capital employed, Total cost**." |
| | Hoover et al. (2001) | "Excellent Supply chain when a company provides requested **customer support**." |
| | Bowersox et al. (2000) | "Three perspectives to **create value** for customers are economic, market and relevancy value." |
| | Simchi-Levy (2000) | "Efficient Supply chain strategies must take into account the **interactions at the various levels**." |
| | Beamon (1999) | "Efficiency is the measure of how well the **resources are utilised**." |
| | Christopher (1998) | "The future market leaders will be the ones that have achieved **cost and service leadership.**" |
| | Dornier (1998) | "The overall objective of any logistics system is to maximise **profitability**." |
| | Bowersox (1996) | "The relationship between **customer services level and the cost** is important." |
| | Mentzer (1991) | "Effectiveness is defined as the extent to which goals are accomplished." |
| | Goonatilake (1990) | "Excellent Supply chain when a company provides products at **low cos**t." |
| | De Meyer et al. (1989) | "Excellent Supply chain when a company provides products with **high quality**." |
| | Haug (1985) | "Excellent Supply chain when a company provides products with **short lead time**." |

Further, the identified factors defining supply chain efficiency is graphically represented in Figure 3.1.

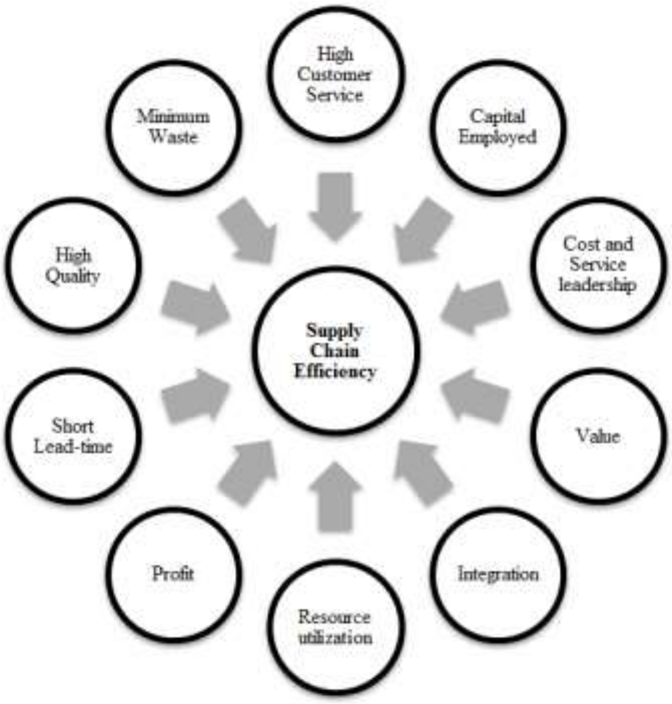



**Figure 3.1: Factors Defining Supply Chain Efficiency**

### 3.5. Theme 5: Past Studies on Supply Chain Efficiency

This theme discusses the literature available on the past studies conducted on supply chain efficiency. Authors have carried out a detailed and extensive literature review and discussed the past studies conducted by various researchers globally and in Indian perspectives (as shown Table 3.8). The past studies that has been conducted so far are also discussed below:

Negi and Anand (2014) presented a review paper on supply chain efficiency with insight from F&V sector in India where they highlighted the business problem of supply chain inefficiency, which is leading to huge amount of losses and wastage. The study also emphasised the need and importance of efficient supply chain for better planning and management in the field of F&V sector to remove various bottlenecks and to reduce the losses and wastage.

Zelbst et al. (2012) examine the impact of RFID (Radio Frequency Identification) technology utilisation in manufacturing firms of the USA on manufacturing efficiency and effectiveness and found that utilisation of RFID technology leads to improved manufacturing efficiency and manufacturing effectiveness.

Mishra (2012) measured the supply chain efficiency of pharmaceuticals industry in India using DEA (Data Envelopment Analysis) tool by considering inputs and outputs.

Lau (2012) examines the role of demand management in balancing distribution efficiency and responsiveness to customer needs in the downstream of a retail supply chain with the help of a case study in Australia.

Sidhu et al. (2011) studied the marketing efficiency of Green peas in India and analysed it by three different supply chains. The study found that the most efficient supply chain has higher marketing efficiency and the chain involves higher number of middlemen resulting in lower efficiency.

Kim and Min (2011) measured the efficiency of the supply chain in USA from a green perspective and proposed the Green Logistics Performance Index (GLPI) integrating the Environmental Performance Index (EPI) and Logistics Performance Index (LPI).

Bhardwaj et al. (2011) analysed the value chain of tomato in the Uttarakhand state of India to figure out the developments at various stages of value chain and suggest necessary measures. Establishment of small cold storage near Mandi, forward and backward integration, and Minimum Support Price (MSP) for F&V are some of the measures suggested by the authors to improve the supply chain.

Hamalainen and Tapaninen (2011) examines the cost efficiency in a Nordic paper mill and found that cost efficiency per machine hour is under tremendous pressure in the paper mill.

Danese and Romano (2011) conducted a study in which the authors evaluates the effect of customer integration on supply chain efficiency and the role played by supplier integration in manufacturing industry in Italy. The findings of the study shows that supplier integration positively moderates the relationship between efficiency and customer integration.

Shukla et al. (2011) proposed a design framework that addresses the facility and link failures explicitly by accounting for their impact on a network's performance measures of efficiency and robustness. The study shows that on a long-term basis, supply chain happens to be quite reliable and a higher degree of robustness can be integrated into the system.

Ip et al. (2011) put forward an approach to evaluate and modelling of the performance and consistency of supply chain using system dynamics and the autoregressive integrated moving average. Effectiveness and efficiency, with six corresponding indicators (product reliability, employee fulfillment, customer fulfillment, on-time delivery, profit growth, and working efficiency) were found to be the most significant factors in the performance of supply chain. It is concluded that to ensure better performance, continuous improvement in supply chain efficiency is required.

Labs (2010) highlighted the importance of top-level management involvement in food processing industry (Food & Beverages) to achieve efficiency in the supply chain process. The author also mentioned that, availability of several tools to enable supply chain respond to fast and unplanned deviations, top management should initiate success.

Tippayawong et al. (2010) made a comparative study among two groups of manufacturing industries in Thailand with varying features of technology on their operational performance and prospective reasons that involve effective operational performance. An attempt was made to identify the prospective causes for improvement of SCM. The study concluded that the prospective reasons, which involved the effective operational performance in case of both groups (consisting of low and high technology intensity), varied completely with respect to IT application, responsive and flexible supply chain.

Sharma and Yu (2010) examine the supply chain efficiency of manufacturing industry in Korea. To increase and spread the variant of DEA approach, this research helps to complement the available literature on DEA with respect to its application on efficiency measurement in supply chain.

Chang and Chiu (2010) conducted a study titled Supply Chain Efficiency Analysis: A Theoretical Approach in Taiwan, in which the authors made a comparison of supply chain between decentralised and centralised control system case. It was found that the capital-intensive industry is superior in terms of supply chain efficiency in central control system case.

Bigliardi and Bottani (2010) in their study devised balanced-scorecard model, which was intended and restricted for the performance evaluation of Italian food supply chain. The primary findings of the study was the design of a set of KPIs embodied into a Balanced-Scorecard tool for performance evaluation in food supply chain.

Ali, Singh, and Ekanem (2009) made a study on 12 major divisions of food producing companies in India, for analysing output and efficiency during pre and post-liberalization era. The authors measured the performance of significant inputs required in food-processing units and brought forward the factors of inefficiency. The study also concluded that raw material used in an inefficient manner results in higher inefficiency, which happens to be a major share of the cost incurred to the food-processing units. For procurement of raw material, the intervention by the Government is crucial and facilitates reforms at policy level to permit direct private-participation for procurement of raw materials.

Pettersson (2008) in its study on Measurements of efficiency in a supply chain emphasised on performance evaluation and cost assessment. The study focused on supply chain efficiency measurement. The central research questions of the study investigated are; How to measure supply chain efficiency and does an elementary model measuring efficiency in an organisations exist?

Albeniz and Simchi-Levi (2007) conducted a study on improving retail supply chain efficiency through wholesale price renegotiation in Spain focusing on double marginalization, which is a crucial factor for inefficiency. Authors suggested a mechanism to decrease double marginalization, which employs consistent negotiation and wholesale price contract.

Kull et al. (2007) conducted a study on last-mile efficiency in online ordering in context to the USA. This study focuses on customer order cycle efficiency that gains through the learnability of websites. It lends insight into how websites influence last-mile supply chain efficiency via differing learning rates in the order cycle. This study incorporated three different research fields to examines the factors that define the true nature of online learning of the consumer. By arguing that e-commerce learning is an essential component of interface between the organisation and customer, it suggested that understanding of online customer's learning is essential for successful and efficient supply chain in e-commerce industry.

Aramyan et al. (2007) developed a model for integrated supply chain performance measurement in a Dutch-German tomato supply chain. Various categories of performance measures (efficiency, flexibility, responsiveness, and food quality) are identified as key performance components of the tomato supply chain.

Zokaei and Hines (2007) conducted a study on gaining customer attention in FMCG supply chain in UK. The authors defined and explore the distinction between supply chain effectiveness and supply chain efficiency with the help of case study of FMCG sector. The study exhibits how the Kano-QFD technique can be employed in the organisations to increase the product value. It has also been seen that, there is a strong focus on efficiency improvements while little consideration is placed to enhance supply chain effectiveness.

Wong, W. and Wong, K. (2007) evaluated the performance of the supply chain of manufacturing industry in with special focus on internal performance using DEA. Cost efficiency model and technical efficiency model were the ones developed the authors. The knowledge gained through the DEA models assists the managers to categorise the reasons of inefficiency in operations and formulate strategies to ensure improvement.

Callanan (2006) conducted a study on improving supply chain efficiency in UK retail sector. The study focused on improving the supply chain efficiency (i.e., high service level and inventory level with low cost) of the retail sector. The author highlighted that appropriate technology (RFID) in retail could improve customer satisfaction.

Rytila and Spens (2006) conducted a research study in the blood supply chain in Finland to enhance efficiency. The study aims to enhance efficiency in blood SCM considering the fact that blood is scarce. Simulation technique was primarily used for enhancing the supply chain efficiency. The finding shows that individuals taking crucial decisions can readily make sound and risk-free decisions relating to changes in the supply chain on the basis of information gained from simulation. Simulation techniques is generally employed to make complicated and unstructured systems into more systematic and efficient ones.

Borgstrom (2005) describes and evaluates effectiveness and efficiency as concepts relying on activity based systems in the manufacturing industry of Sweden. The evaluation involves the connotation, the application and the interconnection among effectiveness and efficiency. The framework suggested that effectiveness and efficiency should be viewed separately in the context of supply chain. Margins, dependency, and time were the major difficulties identified in the analysis of effectiveness and efficiency.

Fairchild (2005) developed a framework of SCM in the financial services industry of Netherlands by exploring the role of flow of ideas in developing efficiency through intelligent matching. The study highlighted that business process integration requires computational and human intelligence to target automation efficiency.

Park and King (2004) evaluated efficiency impact of the use of Information Technology in Food retailing firms of Georgia. The emphasis was made on figuring out the performance measures that are linked to the balanced-scorecard approach supported by various industry analyst and on evaluating productivity related to store level effects of IT adoption. Retailers that implement a bigger portfolio of information sharing technology (vendor managed inventory, and use of bar code and RFID) have enhanced the results. Store organisation and the adoption of data sharing and decision sharing technologies were found the significant factors influencing efficiency.

Karkkainen (2003) did a research on enhancing efficiency in SCM of lesser shelf-life products by the usage of RFID tagging in Finland. The focus of the study was on implementation of RFID on a trial basis at Sainsbury’s, which were further disseminated to understand the positives of RFID in food retail sector. It was inferred that an effective data capturing mechanism could assist in solving the issues of lesser shelf-life products.

Prasad and Sounderpandian (2003) provides a checklist of reasons having an impact upon international supply chain efficiency in USA. The study focused on three aspects i.e. sourcing, processing and distribution and provides recommendations for managers in global supply chain to achieve competitive edge.

Stephens (2001) discussed the Supply Chain Operations Reference (SCOR) Model, its expansion, and its implementation to enhance efficiency in supply chain. SCOR model is a business process reference model, which offers inclusive toolset combining organisational processes to effective practice, metrics, and technology. This model has been successfully implemented in European countries, Latin America, North America, Asian countries, New Zealand, and Australia.

The concept of efficiency and effectiveness of the process are evaluated by Hewitt (1994), in connection with redesigning of supply chain of various companies and found that supply chain having process orientation results in a level of inter and intra organisational efficiency and effectiveness with respect to operations.

Horscroft and Braithwaite (1990) describe the strategic lead-time approach to enhance supply chain efficiency and improve the performance of customer service in the manufacturing industry in UK.

It can be seen in the past available literature that various studies have been conducted globally on supply chain efficiency, but to the best of author's knowledge, there is a lack of study on supply chain efficiency specifically to F&V sector in India. The summary of the literature review on supply chain efficiency is shown in Table 3.8.

**Table 3.8: Summary of Past Studies on Supply Chain Efficiency**

| Author (Year) | Context | Inference | Country |
|---|---|---|---|
| Negi and Anand (2014) | Fruits and Vegetables | Authors highlighted the need and importance of efficient supply chain for better planning and management in the field of F&V sector to remove various bottlenecks and to reduce the losses and wastage. | India |
| Mishra (2012) | Pharma Industry | Measured the supply chain efficiency of pharmaceuticals industry in India using DEA tool by considering inputs and outputs. | India |

| | | | |
|---|---|---|---|
| Zelbst et al. (2012) | Manufacturing SC | Examines the effect of RFID technology utilisation in manufacturing firms on manufacturing efficiency and effectiveness and found that RFID implementation leads to improved manufacturing efficiency and manufacturing effectiveness. | USA |
| Lau (2012) | Retail SC | This case study examines the role of demand management in balancing distribution efficiency and responsiveness to customer needs in the downstream of a retail supply chain. | Australia |
| Sidhu et al. (2011) | Vegetables (Marketing Efficiency) | The marketing efficiency of Green peas has been studied and analysed by three different supply chains. The supply chain, in which marketing efficiency was higher, has been the most efficient supply chain. The large number of middlemen results in lower marketing efficiency. | Punjab, India |
| Kim and Min (2011) | Green Supply Chain | Measured the efficiency of the supply chain in USA from a green perspective and proposed the Green Logistics Performance Index (GLPI). | USA |
| Bhardwaj et al. (2011) | Tomato | Authors studied and analysed the value chain of tomato in Uttarakhand and figure out the developments at various stages of value chain and suggest necessary measures. | Uttarakhand, India |
| Hamalainen and Tapaninen (2011) | Paper mill | Examines the cost efficiency in a Nordic paper mill and found that cost efficiency per machine hour is under tremendous pressure in the paper mill. | Nordic |
| Danese and Romano (2011) | Manufacturing SC | This paper analyses the impact of customer integration on supply chain efficiency, and the moderating role of supplier integration in a manufacturing industry. | Italy |
| Shukla, Lalit, and Venkatasubramanian (2011) | Supply Chain Network | This study proposes a design framework that addresses the facility and link failures explicitly by accounting for their impact on a network's performance measures of efficiency and robustness. | USA |
| Ip, Chan, and Lam (2011) | Manufacturing SC | Effectiveness and efficiency, with six corresponding indicators (product reliability, employee fulfillment, customer fulfillment, on-time delivery, profit growth, and working efficiency) were found to be the most significant factors in the performance of the supply chain. | China |
| Labs (2010) | Food Processing | The author discussed the significance of involvement of higher-level management in food processing industry (Food & Beverages) to achieve efficiency in the supply chain process. | Global |
| Tippayawong et al. (2010) | Technology Companies | Comparative study was done among two groups of manufacturing industries in Thailand with varying features of technology on their operational performance and prospective reasons that involve effective operational performance. | Thailand |
| Sharma and Yu (2010) | Manufacturing SC | Examines the supply chain efficiency of manufacturing industry in Korea to increase and spread the variant of DEA approach. | Korea |

| | | | |
|---|---|---|---|
| Chang and Chiu (2010) | Manufacturing SC | Authors made a comparison of supply chain between decentralised and centralised control system case.<br>Capital-intensive industry is superior in terms of supply chain efficiency in central control system case of centralised control system. | Taiwan |
| Bigliardi and Bottani (2010) | Food SC | Authors devised balanced-scorecard model, which was intended and restricted for the performance evaluation of Italian food supply chain. | Italy |
| Ali, Singh, and Ekanem (2009) | Food Processing Industry | Authors measured the performance of significant inputs required in food-processing units and brought forward the factors of inefficiency. The study also concluded that raw material used in an inefficient manner results in higher inefficiency, which happens to be a major share of the cost incurred to the food-processing units. | India |
| Pettersson (2008) | Supply Chain | Study emphasised on performance evaluation and cost assessment. It was focused on supply chain efficiency measurement. | Sweden |
| Albeniz and Simchi-Levi (2007) | Retail Sector | Study emphasised on improving retail supply chain efficiency through wholesale price renegotiation in Spain focusing on double marginalization, which is a crucial factor for inefficiency. | Spain |
| Kull, Boyer, and Calantone (2007) | E-Commerce | This paper focuses on customer order cycle efficiency gains through the learnability of websites. It lends insight into how websites influence last-mile supply chain efficiency. | USA |
| Aramyan et al. (2007) | Agri-Food SC | Developed a model for integrated supply chain performance measurement in a Dutch-German tomato supply chain. Flexibility, efficiency, responsiveness, and food quality are key component in performance measurement system. | Germany |
| Zokaei and Hines (2007) | FMCG Sector | Defined and explore the distinction between supply chain effectiveness and supply chain efficiency with the help of case study of FMCG sector in UK. | UK |
| Wong and Wong (2007) | Manufacturing SC | Evaluated the performance of the supply chain of manufacturing industry in with special focus on internal performance using DEA. Cost efficiency model and technical efficiency model were the ones developed the authors. | Singapore; Malaysia |
| Callanan (2006) | Retail Sector | The article focused on improving the supply chain efficiency (i.e., high service level and inventory level with low cost) of the retail sector. The author highlighted that appropriate technology (RFID) in retail could improve customer satisfaction. | UK |
| Reiner and Hofmann (2006) | Manufacturing SC | Authors present an integrated benchmarking approach for analysing the efficiency in the SC process. They analyse the performance using DEA approach and found that make-to-stock is still the predominating manufacturing strategy. | USA |

| | | | |
|---|---|---|---|
| Rytila and Spens (2006) | Blood Supply Chain | Research study in the blood supply chain in Finland to enhance efficiency. The study aims to enhance efficiency in blood SCM considering the fact that blood is scarce. | Finland |
| Borgstrom (2005) | Manufacturing SC | Author describes and evaluates effectiveness and efficiency as concepts relying on activity based systems in the manufacturing industry of Sweden. The framework suggested that effectiveness and efficiency should be viewed separately in the context of supply chain. | Sweden |
| Fairchild (2005) | Financial Services Industry | Developed a framework of SCM in the financial services industry of Netherlands by exploring the role of flow of ideas in developing efficiency through intelligent matching. | Netherlands |
| Park and King (2004) | Food Retailing | Authors have evaluated efficiency impact of the use of Information Technology in Food Retailing. Store organisation and the adoption of data sharing and decision sharing technologies were found the significant factors influencing efficiency. | Georgia |
| Karkkainen (2003) | Short Self Life Product | Research on enhancing efficiency in SCM of lesser shelf-life products by the usage of RFID tagging in Finland. It was inferred that an effective data capturing mechanism could assist in solving the issues of lesser shelf-life products. | Finland |
| Prasad and Sounderpandian (2003) | Information System | Author provides a checklist of reasons having an impact upon international supply chain efficiency in USA. The study focused on three aspects i.e. sourcing, processing and distribution | USA |
| Stephens (2001) | SCOR Model | Discussed the Supply Chain Operations Reference (SCOR) Model, its expansion, and its implementation to enhance efficiency in supply chain. | USA |
| Hewitt (1994) | Manufacturing SC | The concept of efficiency and effectiveness of the process are evaluated by author, in connection with redesigning of supply chain of various companies. | England |
| Horscroft and Braithwaite (1990) | Manufacturing SC | Paper describes the strategic lead-time approach to improve efficiency in supply chain and improve the performance of customer service in the manufacturing supply chain. | UK |

### 3.6. Theme 6: Measuring Supply Chain Efficiency

This theme discusses the measures for supply chain efficiency. The measures are discussed and highlighted below, and the summary of the same is presented in Table 3.9.

The studies show that quantitative efficiency measurement may be classified as profit or cost, productivity, and customer responsiveness whereas qualitative efficiency measurement may be classified as consumer satisfaction, goods flow and information integration, flexibility, efficient supplier, and managing risk. Higher efficiency in supply chain can be attained by selecting minimum price that the supplier is ready to take or the maximum price the manufacturer is ready to pay for semi-finished goods (Mishra, 2012). Aramyan et al. (2007) identified four basic evaluative methods of performance (flexibility, food quality, efficiency and responsiveness) as facilitating factors of performance evaluation system in supply chain.

IT utilisation, SCM flexibility, and responsiveness also constitute the efficient supply chain operational performance. It is also reported that better financial performance is a byproduct of efficient and effective supply chain. The past studies study also reported that the main difficulties in analysing efficiency and effectiveness are time, boundaries, and interdependencies. A model (in manufacturing) was also proposed in the literature to improve supply chain efficiency and effectiveness based on four criteria namely: lead-time, profit, quick delivery, waste eradication. The best measure for enhancing the supply chain efficiency is the least cost measures that yield maximum benefit to the end consumers.

**Table 3.9: Summary of Measures for Supply Chain Efficiency**

| Author (Year) | Inference |
|---|---|
| • Janvier-James Assey Mbang (2013);<br>• Mishra (2012);<br>• Hamalainen and Tapaninen (2011);<br>• Chang and Chiu (2010);<br>• Pandey et al. (2009);<br>• Aramyan et al. (2007),<br>• Tippayawong et al. (2010);<br>• Reiner and Hofmann (2006); | • Quantitative efficiency measurement may be classified as **profit or cost**, **productivity**, and **customer responsiveness**. Qualitative efficiency measurement may be classified **as Consumer satisfaction, Flexibility, Material flow and Information integration, Effective risk management, Supplier Efficiency**.<br>• Higher efficiency in supply chain can be attained by selecting minimum price that the supplier is ready to take or the maximum price the manufacturer is ready to pay for semi-finished goods<br>• Four basic evaluative methods of performance (**flexibility, food quality, efficiency** and **responsiveness**) are facilitating factors of evaluation system in supply chain.<br>• The factor determined from the study are **IT utilisation**, **SCM flexibility** and **responsiveness**, which constitute efficiency in operations of supply chain in low and high technology intensive groups. |

| | |
|---|---|
| • David Walters (2006)<br>• Liang et al. (2006)<br>• Borgstrom (2005)<br>• Karkkainen (2003);<br>• Li and O'Brien (1999)<br>• Chen (1997) | • It is reported better **performance on financial** grounds is the byproduct of efficient supply chain.<br>• The study reported that while SCM is to a degree **customer-focused**, the emphasis is on efficiency.<br>• The study reported that while analysing the efficiency, supply chain encounters difficulties, such as, dependency, boundaries, and time factors.<br>• Proposed a model (in manufacturing) to improve supply chain effectiveness and efficiency based on criteria, such as, **lead-time, waste eradication, quick delivery,** and **profit.**<br>• The best measure for enhancing the supply chain efficiency is the **least cost** measures that yield maximum benefit to the end consumers. |

### 3.7. Theme 7: Measures to Improve Supply Chain Efficiency

This theme discusses some of the measures, which have been suggested and highlighted in the past studies for improving level of efficiency of supply chain in general. The suggested measures are discussed and highlighted below. Moreover, the summary of the same is presented in Table 3.10.

Product quality control and management, adoption of pull based supply chain model, communications, use of ICT for better information sharing, strategic alliances, trust and collaboration among stakeholders, volume growth, constant investment, technology based data capture system like RFID, innovations, well equipped man power, operational scale, flexibility in production, cost control, vertical co-ordination, continuous supply, minimum costs of production, minimum transportation cost, minimum inventory holding, and use of technology are some of the important measures suggested by various authors to improve supply chain efficiency.

**Table 3.10: Summary of Measures to Improve Supply Chain Efficiency**

| Author (Year) | Inference |
|---|---|
| Jraisat and Sawalha (2013) | The study showed that quality control in supply chain plays the role of key strategy to deal with challenges in supply chain. |
| Xiao and Chen (2012) | Adoption of pull model will enhance the performance of producers and distributors, hence, the entire supply chain. |
| Pandey et al. (2009) | The ICT system provides a platform for sharing information which is common for growers and buyers. This makes the value chain of apple more efficient in terms of delivery. |

| | |
|---|---|
| Ali et al. (2009) | Technology is considered to play a significant role in the food sector with respect to cost efficiency and growth. |
| Matopoulos et al. (2007); Cadilhon et al. (2003) | The research highlighted the role and importance of collaboration and trust issues between various stakeholders in the vegetables marketing system. |
| Vasileiou and Morris (2006) | Social factor and environmental factors are the indicators of business performance. |
| Karkkainen (2003) | RFID based technology that helps to capture the data, assists in providing solutions to issues involved in logistics and supply chain of product having low shelf life. |
| Fearne and Hughes (2000) | The key attributes for success in perishable food supply chain are better manpower, constant investment, cost control, growth of the volume, and innovation. |
| Mowat and Collin (2000) | The entire supply chain performance can be enhanced by greater product quality. |
| Folkerts and Koehorst (1997) | Vertical coordination is essential to improve the competitive position. |
| Fisher (1997) | Functional products require an efficient supply chain in which the costs of production, transportation and inventory holding are minimised. |
| Grimsdell (1996) | Strategic associations, continous supply, communication, operational scale, and quality control are the requirements of efficient supply chain. |

## 3.8. Theme 8: Significance of Efficient Supply Chain in F&V Sector

This theme discusses and highlighted the importance of efficient supply chain in F&V sector in India. Several researchers have highlighted the need of efficiency in supply chain and its importance for the stakeholders involved indirectly or directly in catering to the requirements of the consumer and to the Indian economy as a whole. The importance is highlighted and discussed below, and the summary of the same is presented in Table 3.11.

In order to increase the profitability of stakeholders, efficiency in supply chain is highly essential in F&V sector, which would also help in reduction of wastages and losses incurred in this sector. Further, this would help in maintaining the value and quality of F&V, therby resulting in a reliable and timely delivery to the customers at appropriate time by maintaing proper quality at reasonable prices. It can be inferred that efficiency in supply chain is the need of the hour in F&V sector, hence, it exhibits an essentiality for further research in the area of SCM.

**Table 3.11: Significance of Efficient Supply Chain in F&V Sector**

| Author (Year) | Significance | Inference |
|---|---|---|
| Negi and Anand (2015) | As Indian economy is based on agriculture, there is a need to develop proper supply chain models, which may play an important role in increasing the shelf life and in turn reduce the losses and wastages in | |

| | | |
|---|---|---|
| | F&V. | Importance of efficient supply chain in F&V has been highlighted. |
| Rais and Sheoran (2015) | In case of many F&V, India happens to be the leading producer in the world, but the existence of a higher gap between per capita demand and supply is due losses during the post-harvest supply chain (poor handling and storage issues) and it amount to significant losses for the country. Therefore, there is a requirement of robust and efficient SCM in F&V sector and considerable improvements are needed in all the phases through best practices followed globally. | |
| Shukla and Jharkharia (2013) | In developing nations like India and China, the consumption pattern will be subject to massive changes, which will demand the need of higher efficiency in supply chain. The extent of wastage can be reduced only by the proper and efficient supply chain. | |
| Halder & Pati (2011) | India being an agrarian economy requires proper measures and efficient supply chain for playing a major role in minimising wastages and losses during several phases of supply chain. | |
| Veena et al. (2011) | Higher degree of efficiency in supply chain happens to increase the profits generated and retailer's efficiency alongwith adding greater value to various stakeholders involved in supply chain process (farmers, aggregators, and end users). | |
| Bhardwaj et al. (2011) | In order to reduce losses pertaining to tomato during post-harvest, there is a requirement of efficient food supply chain. There are significant inefficiencies witnessed in tomato value chain, which if taken care of will result in proseperity of farmers. | |
| Reddy et al. (2010) | Efficiency in F&V supply chain will add significant value to the perishable food products and assist in bringing the same to the market. | |
| Rathore et al. (2010) | F&V are highly perishable in nature, and because of the high level of wastage and inefficiency in this sector, efficient supply chain after the farm gate to the final consumer has become an absolute necessity. Therefore, there is an urgent need to develop intelligent supply chains to curb losses, increase the shelf life of F&V, and ensure safety and desired quality. | |
| Murthy et al. (2009) | Efficient Supply chain would help largely to reduce losses occurring during various stages of the supply chain. | |
| Dharni and Sharma (2008) | Efficiency in the distribution channel and supply chain are vital approaches for enhancing revenue for the growers and simultaneously ensuring an increase in affordability. | |
| Viswanadham (2007) | By developing an effective and efficient supply chain using technical approaches, chances are likely to feed the Indian population with the help of value addition in food, ensuring better prices for growers. | |
| Karkkainen, (2003); Raman et al. (2001); Bubny (2000); Toyryla (1999); Kantor et al. (1997) | SCM is vital in the field of the products having lesser shelf life because of larger product varieties, perishable nature, controlled temperature, and strict monitoring. Hence, attaining efficiency throughout the supply chain is of vital necessity for perishable goods. | |

Improved efficiency and performance of F&V supply chain are expected to significantly reduce the perishable food wastage and increase the income of farmers and other stakeholders. Further, the importance of efficient supply chain is graphically represented in Figure 3.2.

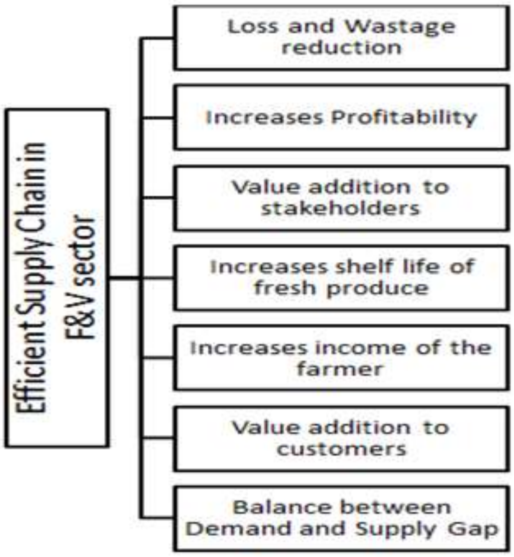



**Figure 3.2: Significance of Efficient Supply Chain in F&V Sector**

## 3.9. Theme 9: Goldratt's "Theory of Constraints" Thinking Processes

This theme discusses the literature available on the past studies conducted on Goldratt's "Theory of Constraints" Thinking Processes. Authors have carried out an extensive literature review and discussed the past studies conducted globally and in Indian perspectives (as shown Table 3.12).

**Table 3.12: Summary of Past studies on Goldratt's "Theory of Constraints" Thinking Processes**

| Author (Year) | Context | Objective | Country |
|---|---|---|---|
| El-Sakty and Beheiry (2014) | *General SC* | This paper aims to address a series of tools and instruments that facilitate trade using TSC, and it proposes a Thinking Process Framework that could support global supply chain growth. | Global |
| Nowakowska-Grunt and Moroz (2013) | | Authors documented the application of Theory of Constraints approach to overcome distinctive strategic encounters in SCM. It presents how the philosophy of TOC can be used to expand the general framework for cooperation in SCM. | Global |
| Souza and Pires (2010) | | Authors thoroughly define the key concrete contributions of the theory to distribution and outbound logistics. They describe the real functional features of the tactic proposed by TOC to the logistics of outbound operations. | Brazil |
| Simatupang, Wright, and Sridharan (2004) | | This study applied the approach of TOC to counter the problems in understanding the possible benefits of collaboration in supply chain. Precisely, it demonstrated how the approach can be adopted to represent an intrinsic dilemma of collaborative performance metrics and collaboration. | New Zealand |
| Taylor and Ortega (2003) | | This paper detailed the use elements of the Thinking Process in an attempt to elicit a logical, comprehensive solution to a multifaceted, intricate problem. | Global |

| | | | |
|---|---|---|---|
| Rahman (2002) | | Authors describe an application of a thinking process to determine the key success reasons in SCM and to comprehend underlying associations among these reasons. | Australia |
| Mabin (1999) | | This study concisely summarise the TOC approach and deliberates the comparisons between other existing methods (specifically, Rational Model of decision-making) and TOC. | New Zealand |
| Rahman (1998) | | Author conducted an investigation of a complete publications list with respect to TOC. The explored themes are categorised as theoretical description and development of the methodology, evaluation with other methods based on its philosophy, and applications in fields such as education management, administration, procurement, manufacturing, finance & accounting, and managing quality. | Global |
| Simsita et al., (2014) | ***LR*** | This research delivers a literature review on TOC development through its five eras- "the optimized product technology era, the goal era, the haystack syndrome era, it's not luck era and the critical chain era". The historic context and basic theories of TOC purpose is to see the evolvement of this philosophy over the period and changes, which took place in TOC researches. | Global |
| Kim et al., (2008) | | Authors reviewed the expansions to the knowledge of TOC. The study mainly focused on "TOC thinking processes" to investigate the characteristics of the thinking processes and their advancement in terms of methodology and application. | Global |
| Wolniak et al. (2017) | ***Manufacturing*** | The study presents the example of practical application of TOC to improve production process in the case of the company producing electrical equipment for the mining industry. | Poland |
| Taylor and Asthana (2016) | | Authors studied a segment of a manufacturing company facing inventory control problems. This research pursued using Goldratt's Thinking Process, with the intent of investigating solutions to the problem faced by the company. | USA |
| Pegels and Watrous (2005) | | Study describes the methodology for successful application of TOC with reference to a problem related to manufacturing operations. | Global |
| Ehie and Sheu (2005) | | Authors investigate the prospective of integrating six sigma and TOC to enhance performance of production system. Study also suggests a combined TOC/SS framework and implemented to the production system of a company to enhance its operation. | USA |
| Mabin and Balderstone (2003) | | Authors present a literature review investigating the outcomes of applying TOC as reported in the literature. This study exhibits that financial and operational performance can be significantly improved by the application of TOC. | Australia |
| Taylor and Jenny (2008) | ***Human Resource Management*** | The article discusses the implication of glass ceiling approach on the employment of women and minorities in the business world. | USA |
| Taylor and Poyner (2008) | | The authors investigate the issue of retention of skilled manpower in an extremely competitive labour market for a production plant in the oilfields of West Texas. They evaluates that how a skilled employee can be retained using the thinking process logic. | USA |
| Walker and Cox (2006) | | The aim of this study is to describe the usage of Current Reality Tree, which is one of the tool of TOC thinking process. The aim of the tool is to determine the reason for undesirable effects or | USA |

| | | | |
|---|---|---|---|
| | | surface problems that occurs in a company. | |
| Reid (2007) | ***Banking*** | This study presents a complete descriptive investigation of the application of TOC five-step focusing process in enhancing the efficiency of a service process that was affecting the performance of an overall system. | USA |
| Taylor and Miller (2004) | | Authors used "Goldratt's Theory of Constraints and Thinking Process" in Banks M&A (Mergers and Acquisitions) with an aim to create beneficial information essential to identify means that improve the present scenario. | USA |
| Lacerda et al. (2010) | ***Education*** | This research presented a study of amalgamation of thinking process of TOC and process engineering with reference to the processes of an academic organisation. Study shows the matching characteristics among the theories and their advantages for the organisation. | Brazil |
| Cooper and Loe (2000) | | This study proposed instructors tools that impart skills to the students related to identification of problems and analysis of the situations. "Goldratt's theory of constraints thinking processes" is delivered as a model beside with procedures for applying this approach in marketing. | Global |
| Amonge (2015) | ***Hospital*** | The focus of this study is at an ED center in Bowling Green Kentucky, using theory of constraints (TOC) thinking process application tools to capture in detail the core and apply TOC to resolve the problems identified. | USA |
| Taylor and Churchwell (2004) | | In this paper, authors used Thinking Process to determine and answer the issues with reference to "General Medical Department of an MHMR State Hospital" in Texas (USA). | USA |
| Singh and Misra (2017) | ***FMCG*** | Through case-study method, this study discover the current operational model of TOC particularly in outbound supply chain and exposes the related bottlenecks that occurs during application. | India |
| Taylor and Jonathan (2016) | ***Media*** | This paper identifies, which undesirable effect is the core problem to Digital Rights Management brings to the market. With Goldratt's thinking process, an injection is created that solves this core problem and creates a solution that satisfies all parties. | USA |
| Brzozowska et al. (2016) | ***Agribusiness*** | Authors identify the manners for improving the logistics information management system in an agribusiness enterprise, based on methods for projects management, encountered in the Theory of Constraints. | Global |
| Banerjee and Mukhopadhyay (2016) | ***Business Functional Department*** | This research adopts Theory of Constraints (ToC) methodology and amalgamates it with design thinking process, people's opinion and mathematical approach to help achieve supply chain leagility. | India |
| Zivaljevic (2015) | ***Transportation (Traffic Congestion)*** | This study explores the use of TOC approach in solving the congestion problem in road transportation system, which is the key obstacle in improving the effectiveness of the road transportation. | New Zealand |
| Librelato et al. (2014) | ***Automotive Industry*** | This study presents an example of process modelling integration by applying the "Value Stream Mapping and the Thinking Process of the TOC" by analysing organisational process. This study also highlighted the characterstics and benefits of these approaches to the automotive industry. | Brazil |

| | | | |
|---|---|---|---|
| Oglethorpe and Heron (2013) | ***Food Supply chain*** | This study identified the noticeable supply chain and operations limitations that happen in the supply chains of local foods, particularly with marginal producers, as there aim is to enhance market diffusion in a broader geographical region. | UK |
| Taylor and Esan (2012) | ***Fruits & Vegetables SC*** | Authors used "Goldratt's Theory of Constraints and Thinking Process" to identify the central factor for the wastage and losses with an aim to generate essential information to enhance the current scenario and minimise losses. This study was related to Transport modes, Storing, and Sales of fresh F&V. | Nigeria |
| Taylor and Thomas (2008) | ***Oil & Gas*** | Authors apply "Goldratt's thinking process" to complications related to the invoicing system of a consulting firm in order to enhance efficiency. By detecting the central issue, authors determined "what to change, what to change to, and how to cause the change". | USA |
| Taylor et al. (2007) | ***Business Start-ups*** | This study presents the "Goldratt's Theory of Constraint and Thinking Process" as decision making modeling tool. Both the the theory and the process are defined and described with the help of a simulation of small business startup. | USA |
| Polito et al. (2006) | ***Airline Industry*** | Authors illustrate the application of a particular method "The Thinking Processes" to solve the case of an airline industry for improving and enhancing competitive outcomes. | Global |
| Taylor et al. (2006) | ***Police & Fire Dept.*** | This study investigates the features and degree of employee retainment and throughput for metropolitan police and fire departments. This study exposes how the thinking process approach by Goldratt's can be used to the problems in business that have numerous variables. | USA |
| Reid and Cormier (2003) | ***Service Industry*** | This study shows that how a TOC thinking process approach can be applied by a manager to identify the answers for the following questions in a small service organisation: "What to change? and What to change to?". The new technique, which is known as three-cloud approach was used in this study to identify the central problem accountable for the major issues presently encountered by organisations. | USA |
| Taylor and Sheffield (2002) | ***Health Insurance*** | This study focuses on the application of "Goldratt's Thinking Process" in a "claims processing center" in USA. They defines the processes related to claim registering and its settlement, apply "Goldratt's Thinking Process" to that situation, and give suggestions for the improvement. | USA |

It has been observed by the researcher that this theory has been broadly used in manufacturing and service sector but hardly found any evidence for the application in the supply chain for F&V sector. A researcher could find a study, which was conducted in Nigerian F&V supply chain, but that is also limited to only transportation and storage problem.

## 3.10. Research Gap

Based on the above literature review, a gap was identified as though various studies are available on supply chain efficiency of agri and other products, but hardly any study could be found on suggesting a framework for improving supply chain efficiency at various stages of F&V sector. The research gap identified in each theme is shown in Table 3.13.

**Table 3.13: Theme wise Research Gap**

| Theme | Research Gap |
|---|---|
| Theme 1 | There is inadequate literature available on reasons for supply chain inefficiency in various activities across the stages with reference to F&V. |
| Theme 2 | The most inefficient supply chain is a significant challenge on the roads of speedy development of Indian agriculture sector. Hence, there is a need to identify the activities leading to inefficiency across the stages of F&V supply chain and the major reasons behind that. |
| Theme 3 | To the best of author's knowledge, there is a lack of study on identifying the most significant activities leading to supply chain inefficiency with reference to cost, time, and quality across the stages of the supply chain, which is ultimately resulting to losses and wastage, and the reasons for that inefficiency. |
| Theme 5, 6, and 7 | To the best of author's knowledge, enough study has not been conducted on supply chain efficiency specifically to F&V sector in India. |
| Theme 8 | It can be inferred based on the available literature that efficient supply chain is the need of the hour for F&V sector, which arises a need for research in this area. |
| Theme 9 | The author hardly found any study on TOC thinking process related to supply chain efficiency of F&V sector in the Indian scenario. |

## 3.11. Theoretical Premises

The approach of Goldratt's "Theory of Constraints" Thinking Processes has been used in this study for process improvement of F&V supply chain.

Various theories like Stakeholders theory, Organisational theory, Transaction Cost Economies theory, Agents Theory, Theory of Constraints, and Resource-based view theory were studied to deliberate the theoretical premise for this study (Sanderson et al., 2015; Halldorsson et al., 2007). After due deliberation, it has been observed that Goldratt's Theory of Constraints Thinking Process is the most relevant for this study.

***The Thinking Process and the Theory of Constraints (TOC)***

Goldratt [1992] in his book narrates the evidence of a manager of a plant who struggles to manage his plant, searching for a way to improve the plant's performance. With the help of an academician, the manager learned the skills to enhance the performance issues of the plant thereby also gaining the knowledge of finding out solution to the potential problems resulting in win-win situation.

According to (Taylor and Esan, 2012), "Goldratt's Theory of Constraints (TOC) focuses on the efficiency of all the processes as a whole rather than the efficiency of any one single process."

In Goldratt's ToC, a given group of processes will have the weakest link controlling the entire system. To facilitate a better performance, the challenges in weakest link and the speed controlling the link must be identified and improved. Considering the fact that, the major constraints come from the weakest link, hence, all the processes involved must be evaluated to understand the constraints and central problems to be given a potential solution (Taylor and Esan, 2012).

Since, TOC is popular for overcoming the bottlenecks involved in the management of supply chain, the term also denotes to a variety of other related productivity concepts put forward by Dr. Goldratt or other supporters of his philosophy (Polito et al., 2006).

While TOC was developed for manufacturing through Goldratt's Thinking Process, the Thinking process system is true to all constraints and processes; whatever the case may be (Taylor and Ortega, 2003). TOC thinking process is not taken into account by system modelers to be a part of the system's literature, but the system methodology tries to make the changes undertaken as a component of a process involved for the enhancement, which will benefit the entire system rather than just a minor part of the system (Mabin, 1999).

Because of the fact that, the constraint is not often evident, Goldratt (1992) developed the Thinking Process, which is a series of following steps:

| | |
|---|---|
| • What to Change? | Locate the constraint |
| • What to change to? | Determine the solution |
| • How to make the change? | How to implement the solution |

The above steps are refereed as Thinking Process. Goldratt's Theory of Constraints and Thinking Process has been used in several cases for performance enhancement and resolutions to business process related problems and to figure out the core problem.

It has been observed by the researcher that this theory has been broadly used in manufacturing and service sector but hardly found any evidence for the application in the supply chain for F&V sector (refer Table 12). A researcher could find a study, which has been conducted in Nigerian F&V supply chain, but that is also limited to only transportation and storage problem. This study has been carried out specifically for supply chain efficiency in different stages of F&V sector in India for which this theory of constraints thinking process has been considered as a theoretical base for the research work.

**Concluding Remarks**

This chapter concludes the discussion on literature available in the domain of supply chain relating to fresh produce. Extensive literature review has been conducted under different themes to identify the research gap in the past available literature. The next chapter describes the research questions, research objectives in detail and the methodology adopted to attain the results.

# 4. RESEARCH METHODOLOGY

*Research method is the framework that gives the blueprint of the study to be conducted and ensures that the present research is relevant to the problem. This chapter presents the rationale for the study, problem statement, research questions, research objectives and the research design adopted for data collection and get the results. Further, this chapter discusses the sampling process, administration of survey and statistical tools used for data analysis.*

## 4.1. Rationale of the Study

The supply chain of F&V sector in India is suffering from maximum inefficiencies, which are leading to the massive amount of losses, and wastage in F&V. India, the world's second largest F&V producer, is also one of the biggest wasters in the world, which is a high matter of concern for the nation. Each year, billions of tons of fresh food items with millions of dollars' worth lost due to inadequate supply chain system. Therefore, there is a comprehensive requirement of research in the area not only to fully understand the challenges in supply chains management but also to identify the opportunities for improvement and to reduce several inefficiencies in the supply chains. F&V are highly perishable in nature; and because of the high level of wastage due to inefficiency in this sector, efficient supply chain from the farm gate to the final consumer has become an absolute necessity, hence there is an urgent need to develop an intelligent supply chain to curb losses and increase the shelf life of F&V and ensure safety and desired quality. This study emphases on identifying the activities contributing to supply chain inefficiencies across the stages of F&V supply chain starting from farm gate to the commission agent/pre-harvest contractor to local traders and then finally to wholesale market usually known as Mandi, and the factors leading to supply chain inefficiency in the identified activities across the stages. Based on these identified activities and factors a framework has been developed for improving supply chain efficiency of F&V sector in India.

## 4.2. Problem Statement

Although in the existing literature, various studies have been conducted on F&V supply chain in general but there is a lack of study on supply chain efficiency specifically to F&V sector. Also, the weak links and constraints responsible for supply chain inefficiency in different stages of F&V sector and the measures to improve supply chain efficiency are not known. Further, it has been observed that there is a lack of a framework for improving supply chain efficiency of F&V (specifically mango and tomato) sector in India.

## 4.3. Research Questions

To address the gaps in the existing literature of F&V supply chain, few vital research questions are considered. They are as follows:

- What are the most significant activities contributing to supply chain inefficiency in different stages of fruits and vegetables supply chain with specific reference to mango and tomato?
- What are the factors leading to supply chain inefficiency in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato?
- How to develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato?

## 4.4. Research Objectives

The objectives of the present research are mentioned below:

- To identify the most significant activities contributing to supply chain inefficiency (*with respect to cost, time and quality)* in different stages of F&V supply chain with specific reference to mango and tomato
- To identify the factors leading to supply chain inefficiency *(with respect to cost, time and quality)* in the identified activities in different stages of F&V supply chain with specific reference to mango and tomato
- To develop a framework for improving supply chain efficiency of F&V sector with specific reference to mango and tomato

### 4.5. Research Design

According to Kinnear and Taylor (1996), "Research design is a blueprint that is followed to complete the study and it ensures that the study is relevant to the problem and use economic procedures". The research design used in this study can be categorised into two major categories i.e. exploratory research, for first two objectives and conclusive research, for third objective.

#### 4.5.1. Research Process

The framework followed to obtain answers to the research questions is represented diagrammatically in below Figure 4.1.

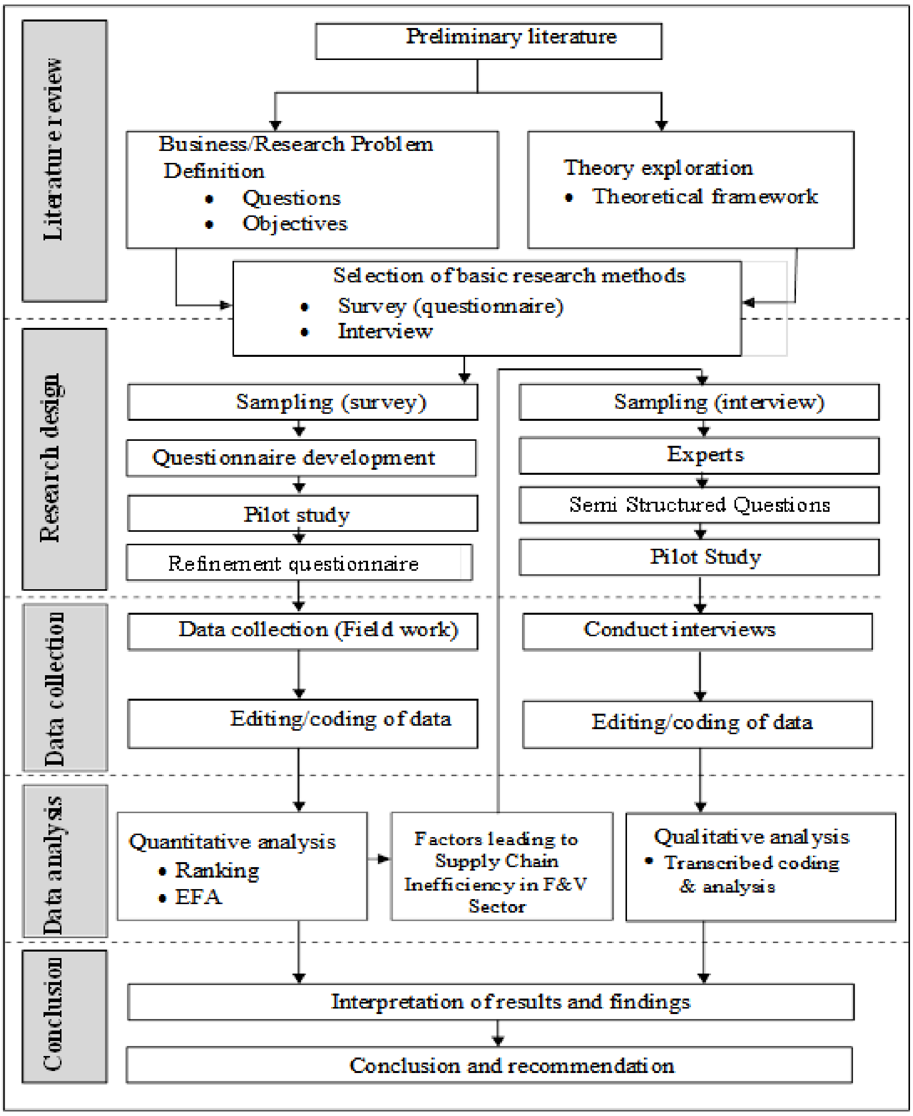
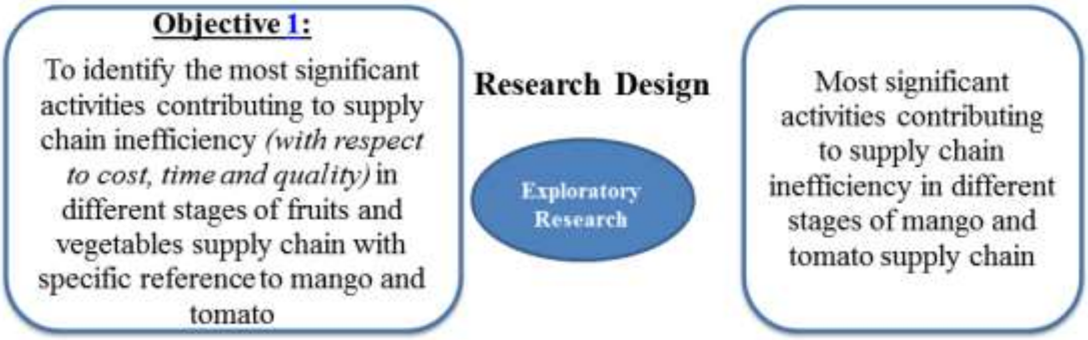



**Figure 4.1: The Research Process Flow Chart**

The research design and necessary steps followed to accomplish Research objective 1, 2 and 3 have been shown separately.

***Process/Steps for Research Objective 1:***



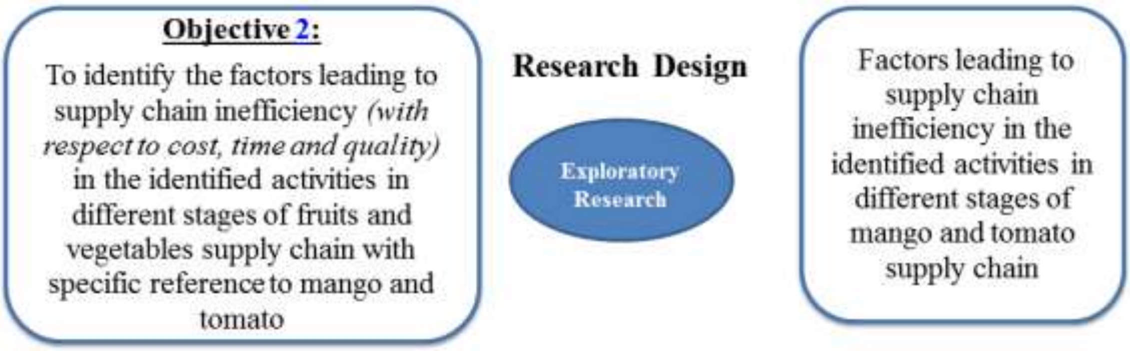

**Steps:**

**1.** Mapping/Listing of activities at each stages of the Mango and Tomato supply chain through Supply Chain Mapping.
**2.** Preparation of Questionnaire based on the mapped/listed activities.
**3.** 5 point Likert scale used.
**4.** Finalize the questionnaire after the pilot study
**5.** Reliability test of the Questionnaire followed by Cronbach alpha.

**Sample Size**- 5-8 times of items

**<u>Tool:</u> Ranking Method**

***Process/Steps for Research Objective 2:***



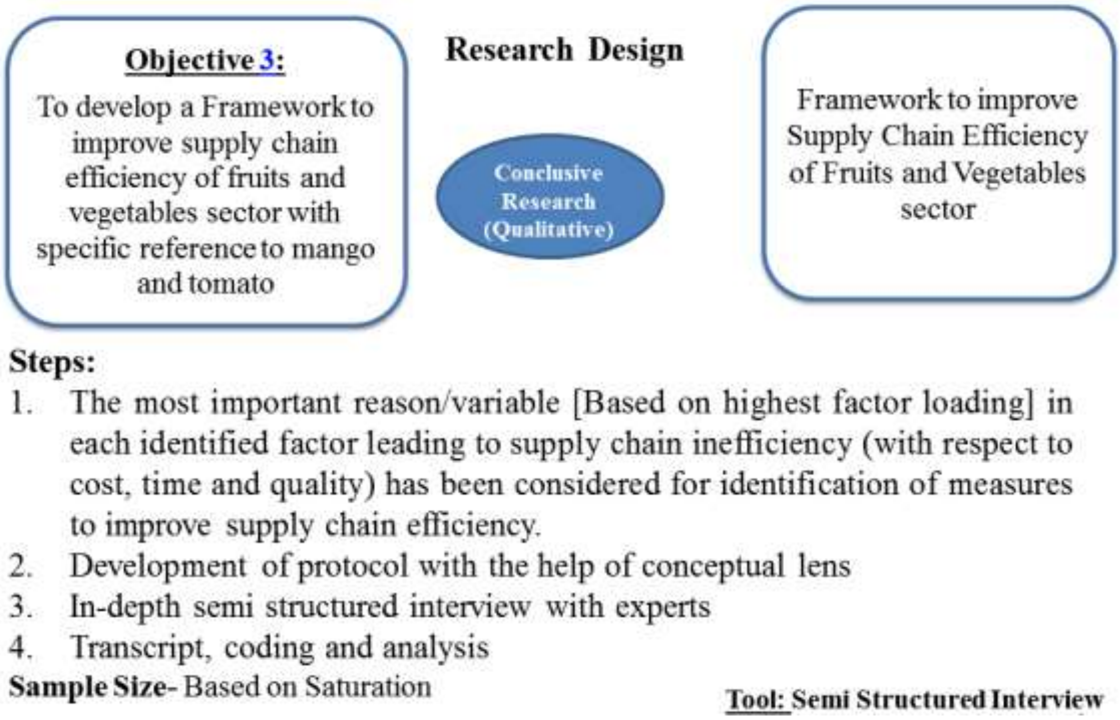

**Steps:**

**1.** Preparation of Questionnaire for identifying the factors (Identification of variables for supply chain inefficiency in the identified activities from RO 1 listed through extensive literature review)
**2.** 5 point Likert scale used.
**4.** Finalize the questionnaire after the pilot study
**5.** Reliability test of the Questionnaire followed by Cronbach alpha
**6.** KMO and Bartlett's Test to carry Factor Analysis.

**Sample Size**- 5-8 times of *K* (variables)

**<u>Tool:</u> Factor Analysis**

*Process/Steps for Research Objective 3:*




**4.6. For Research Objective 1-** *To identify the most significant activities contributing to supply chain inefficiency (with respect to cost, time and quality) in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

### 4.6.1. Questionnaire Development

On the basis of activities listed with the help of activity mapping *(discussed in next chapter)* and brainstorming among the experts and stakeholders, the questionnaire is designed for each stakeholder across the stages of F&V supply chain i.e. the farmer, local trader, local commission agent, wholesaler, and transporter. For each questionnaire, the respondents had to response on the level of supply chain inefficiency for each activity in three aspects i.e. with respect to cost, time, and quality. A five point Likert scale was used for developing the questionnaire ("1" as not significant to "5" represents highly significant) (Brown, 2010; Vagias, 2006; Vogt, 1999). The respondents can respond to the degree of significant or non-significant *(Refer to Appendix I)*. The data was fed into the SPSS: Statistical Package for the Social Sciences (version 21) for further analysis.

### 4.6.2. Pilot Testing

Based on the final list of activities, the questionnaires were prepared and pretested with total 119 stakeholders in fruits (mango) supply chain and 105 stakeholders in vegetables (tomato) supply chain, including 32 farmers, 21 local traders, 19 wholesaler/commission agents, 22 mashakhor/local traders, and 25 transporters in fruits (mango) supply chain, and 34 farmers, 15 local commission agents, 25 wholesaler/commission agents, and 31 transporters in vegetables (tomato) supply chain, as suggested by Hair et al. (2010) and Bryman and Bell (2007). The same can be seen in Table 4.1 and Table 4.2. Before beginning the field work, the questionnaire was vividly discussed with the stakeholders, industry and scholarly experts in the area of logistic and supply chain. Ambiguous and vague questions were removed and more specific and relevant questions were included. Feedback received from the above mentioned experts were of great help in nature to prepare the questionnaire into a concise one corresponding to the desired objectives.

**Table 4.1: Pilot Testing-Fruits Supply Chain**

| S. No. | Stage | Respondents | No. of Respondents |
|---|---|---|---|
| 1 | Stage I-Farm Stage | Farmers | 32 |
| 2 | Stage II-Local Trader/Middlemen Stage | Local Trader | 21 |
| 3 | Stage III-Wholesale/Mandi Stage | Wholesaler/Commission Agents | 19 |
| 4 | Stage IV-Local Trader/Mashakhor Stage | Mashakhor/Local Trader | 22 |
| 5 | Stage V-Transportation Stage | Transporter | 25 |

**Table 4.2: Pilot Testing-Vegetables Supply chain**

| S. No. | Stage | Respondents | No. of Respondents |
|---|---|---|---|
| 1 | Stage I-Farm Stage | Farmers | 34 |
| 2 | Stage II-Local Mandi Stage | Local Commission Agent | 15 |
| 3 | Stage III-Wholesale/Mandi Stage | Wholesaler/Commission Agents | 25 |
| 4 | Stage IV-Transportation Stage | Transporter | 31 |

### 4.6.3. Administration of Survey

The questionnaire was administered to the different stakeholders in F&V supply chain, i.e. farmers (based on the primary production areas of Mango in UP & Tomato in HP & UK), local traders (nearby major production areas), wholesaler/commission agents (Asia's largest F&V wholesale market), mashakhor (Asia's largest F&V wholesale market), and transporters (major production areas & wholesale market). The researcher adopted a Multi-stage sampling technique to collect the data from the respondents. Later on, based on initial contacts, the snowball sampling technique was also used in some cases to identify further respondents. In total, 1180 valid and complete responses were received against 1345 questionnaires distributed to the fruits (mango) supply chain stakeholders' and 860 valid responses were received against 947 questionnaires distributed to the vegetables (tomato) supply chain stakeholders', giving a high response rate of 88% and 91% as most of the data was collected through scheduling method wherein, the researcher directly visited the field and interacted with the respondents. This method of data collection is beneficial for extensive inquiries and can lead to reasonably reliable results (Gangrade, 2006; Shah, 1972; Pauline 1968). The total number of a questionnaire administered (individual stakeholder wise) and the response received is shown in Table 4.3 and Table 4.4.

**Table 4.3: Number of questionnaires administered and response rate-Fruits Supply Chain**

| **Stage I** | **Respondent** | **Questionnaire Administered** | **Final Response Received** | **Response Rate %** |
|---|---|---|---|---|
| Stage I-Farm Stage | Farmers | 390 | 360 | 92.31% |
| Stage II-Local Trader/Middlemen Stage | Local Trader | 265 | 230 | 86.79% |
| Stage III-Wholesale/Mandi Stage | Wholesaler/ Commission Agents | 190 | 180 | 94.74% |
| Stage IV-Local Trader/Mashakhor Stage | Mashakhor/Local Trader | 165 | 140 | 84.85% |
| Stage V-Transportation Stage | Transporter | 335 | 270 | 80.60% |
| **Total** | | **1345** | **1180** | **87.73%** |

**Table 4.4: Number of questionnaires administered and response rate-Vegetables Supply Chain**

| **Stage I** | **Respondent** | **Questionnaire Administered** | **Final Response Received** | **Response Rate %** |
|---|---|---|---|---|
| Stage I-Farm Stage | Farmers | 372 | 340 | 91.40% |
| Stage II-Local Mandi Stage | Local Commission Agent | 185 | 170 | 91.89% |
| Stage III-Wholesale/Mandi Stage | Wholesaler/Commission Agents | 140 | 130 | 92.86% |
| Stage IV-Transportation Stage | Transporter | 250 | 220 | 88.00% |
| **Total** | | **947** | **860** | **90.81%** |

The detailed sample distribution of respondents from the primary production areas are shown in Table 4.5 and Table 4.6.

**Table 4.5: Detailed Sample Distribution of Respondents-Stage Wise (Fruits supply chain)**

| District (State) | Place Visited | Stage I | Stage II | | Stage III | Stage IV | Transporter |
|---|---|---|---|---|---|---|---|
| | | **Farmers** | **Local Commission Agent** | **Local Trader** | **Commission Agent in Azadpur Mandi** | **Local Trader in Azadpur Mandi** | |
| Saharanpur (UP) | Behat | 54 | - | 22 | | | 34 |
| | Gangoh | 15 | - | - | | | 8 |
| Amroha (UP) | Amroha | 42 | 12 | 15 | | | 26 |
| | Hasanpur | 18 | - | 7 | | | 12 |
| | Joya | 12 | - | - | | | 7 |
| | Garh | 16 | - | - | | | 8 |
| Lucknow (UP) | Mal | 11 | 5 | 9 | | | 9 |
| | Malihabad | 62 | 21 | 32 | | | 36 |
| | Kakori | 15 | 5 | 8 | | | 7 |
| | Baxi ka Talab | 9 | 5 | - | | | 5 |
| Unnao (UP) | Farhatpur Puliya | 58 | - | 48 | | | 38 |
| | Miyaganj | 21 | - | 15 | | | 11 |
| Barabanki (UP) | Banki | 16 | 6 | 7 | | | 9 |
| Hardoi (UP) | Shahabad | 11 | 6 | 7 | | | 7 |
| Azadpur (Delhi) | | | | | 180 | 140 | 53 |
| | ***TOTAL*** | **360** | **60** | **170** | **180** | **140** | **270** |

**Table 4.6: Detailed Sample Distribution of Respondents-Stage Wise (Vegetables supply chain)**

| District (State) | Place Visited | Stage I | Stage II | Stage III | Transporter |
|---|---|---|---|---|---|
| | | **Farmers** | **Local Trader** | **Commission Agent in Azadpur Mandi** | |
| Solan (HP) | Basaal | 24 | 40 | | 10 |
| | Kandaghat | 38 | | | 16 |
| | Salogurah | 12 | | | 10 |
| | Vakunaghat | 9 | | | 8 |
| | Chail | 14 | | | 10 |
| | Baniya village, Dharampur | 10 | | | 6 |
| | Dewathi | 8 | | | 5 |
| Sirmaur (HP) | Rajgarh | 15 | 31 | | 10 |
| | Sirmaur | 28 | | | 14 |
| | Sargaun | 10 | | | 6 |
| Uttarkashi (UK) | Naugaun | 36 | 13 | | 14 |
| | Purola | 38 | | | 12 |
| Nainital (UK) | Nainital | 46 | 48 | | 34 |
| | Gaula Par, Haldwani | 28 | | | 30 |
| Dehradun (UK) | Chakrata | 24 | 38 | | 15 |
| Delhi | Azadpur Mandi | - | - | 130 | 20 |
| | ***TOTAL*** | **340** | **170** | **130** | **220** |

The final sample size for RO 1 is 1180 and 860. The sample size should be ten times larger than the number of items being considered (Hair et al., 2008; Bartlett et al., 2001; Hinkin, 1995; Schwab, 1980). Bryant and Yarnold (1995) stated that one's sample should be at least five times the number of items. The subjects-to-item ratio should be no lower than 5 (Garson, D, 2008; MacCallum et al., 1999; Arrindell and van der Ende, 1985; Gorsuch, 1983; Everitt, 1975). All the cases are satisfied in this study. The required sample size as per the subjects-to-item ratio and the sample size used in this study are shown in Table 4.7 and Table 4.8.

**Table 4.7: Required sample size (Minimum) as per the subjects-to-items ratio and Actual Sample size in the study-Fruit Supply Chain**

| Stage | No. of items | Required sample size (Minimum) as per the subjects-to-item ratio (If, ten times larger than no. of items) | Actual Sample Size in the study | Appropriate Sample Size |
|---|---|---|---|---|
| Stage I-Farm Stage | 9 | 90 | 360 | ✓ |
| Stage II-Local Trader/Middlemen Stage | 9 | 90 | 230 | ✓ |
| Stage III-Wholesale/Mandi Stage | 7 | 70 | 180 | ✓ |
| Stage IV-Local Trader/Mashakhor Stage | 7 | 70 | 140 | ✓ |
| Stage V-Transportation Stage | 3 | 30 | 270 | ✓ |

**Table 4.8: Required sample size (Minimum) as per the subjects-to-items ratio and Actual Sample size in the study-Vegetables Supply Chain**

| Stage | No. of items | Required sample size (Minimum) as per the subjects-to-item ratio (If, ten times larger than no. of items) | Actual Sample Size in the study | Appropriate Sample Size |
|---|---|---|---|---|
| Stage I-Farm Stage | 11 | 110 | 340 | ✓ |
| Stage II-Local Mandi Stage | 9 | 90 | 230 | ✓ |
| Stage III-Wholesale/Mandi Stage | 9 | 90 | 180 | ✓ |
| Stage V-Transportation Stage | 2 | 20 | 270 | ✓ |

**4.7. For Research Objective 2**: *To identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

### 4.7.1. Questionnaire Development

On the basis of variables extracted *(Refer to Appendix II)* through literature review and suggestions by the F&V supply chain experts, stakeholders, and academicians, the questionnaire was designed for each stakeholder across the stages of F&V supply chain such as the farmer, local trader, local commission agent, wholesaler, and transporter. The questionnaire was broadly divided into two sections and confined open-ended and close-ended questions. Respondents' socio-demographic characteristics were asked in the first section (e.g., age, education level, and experience). The second section consisted of close-ended questions concerning the reasons leading to supply chain inefficiency.

For each stage, the questionnaire was further divided into three sections on the basis of reasons for supply chain inefficiency with respect to cost, time and quality. All the questions were developed on a five-point Likert scale ("1" as strongly disagree to "5" represents strongly agree) (Brown, 2010; Vagias, 2006; Vogt, 1999). The respondents could answer to the degree of agreement or disagreement *(Refer to Appendix III)*. The data was fed into the SPSS (version 21) for further analysis.

### 4.7.2. Pilot Testing

Based on the final list of variables, the questionnaire was prepared and pretested with total 108 stakeholders in fruits (mango) supply chain and 97 stakeholders in vegetables (tomato) supply chain. This pre-testing included 22 farmers, 14 local traders, 17 wholesaler/commission agents, 20 mashakhor/local traders, and 35 transporters in fruits (mango) supply chain; and 21 farmers, 12 local commission agents, 36 wholesaler/commission agents, and 28 transporters in case of vegetables supply chain as suggested by Hair et al. (2010) and Bryman and Bell (2007). The same can be seen in Table 4.9 and Table 4.10.

Before beginning the field work, the questionnaire was vividly discussed with the stakeholders, industry and scholarly experts in the area of logistic and supply chain. Ambiguous and vague questions were removed, some of the questions were re-ordered, repetitive questions were deleted, and more specific and relevant questions were included. Feedback received from the above mentioned experts were of great help in nature to prepare the questionnaire into a concise one corresponding to the desired objectives.

**Table 4.9: Pilot Testing-Fruits Supply Chain**

| S. No. | Stage | Respondents | No. of Respondents |
|---|---|---|---|
| 1 | Stage I-Farm Stage | Farmers | 22 |
| 2 | Stage II-Local Trader/Middlemen Stage | Local Trader | 14 |
| 3 | Stage III-Wholesale/Mandi Stage | Wholesaler/Commission Agents | 17 |
| 4 | Stage IV-Local Trader/Mashakhor Stage | Mashakhor/Local Trader | 20 |
| 5 | Stage V-Transportation Stage | Transporter | 35 |

**Table 4.10: Pilot Testing-Vegetables Supply chain**

| S. No. | Stage | Respondents | No. of Respondents |
|---|---|---|---|
| 1 | Stage I-Farm Stage | Farmers | 21 |
| 2 | Stage II-Local Mandi Stage | Local Commission Agent | 12 |
| 3 | Stage III-Wholesale/Mandi Stage | Wholesaler/Commission Agents | 36 |
| 4 | Stage IV-Transportation Stage | Transporter | 28 |

### 4.7.3. Administration of Survey

The questionnaire was administered to the different stakeholders in F&V supply chain, i.e., farmers (based on the primary production areas of Mango in UP & Tomato in HP & UK), local traders (nearby major production areas), wholesaler/commission agents (Asia's largest F&V wholesale market), mashakhor (Asia's largest F&V wholesale market), and transporters (major production areas & wholesale market). Multi-stage sampling technique was used to collect the data from the respondents. Later on, based on initial contacts, the snowball sampling technique was also used in some cases to identify further respondents. In total, 912 valid and complete responses were received against 1055 questionnaires distributed to the fruits supply chain stakeholders' and 600 valid responses were received against 735 questionnaires distributed to the vegetables supply chain stakeholders', giving a high response rate of 86% and 82% as most of the data was collected through scheduling method wherein, the researcher directly visited the field and interacted with the respondents. This method of data collection is beneficial for extensive inquiries and can lead to reasonably reliable results (Gangrade, 2006; Shah, 1972; Pauline 1968). The total number of a questionnaire administered (individual stakeholder wise) and the response received is shown in Table 4.11 and Table 4.12.

**Table 4.11: Number of questionnaires administered and response rate-Fruits Supply Chain**

| S. No. | Stage I | Respondent | Questionnaire Administered | Final Response Received | Response Rate % |
|---|---|---|---|---|---|
| 1 | Stage I-Farm Stage | Farmers | 295 | 260 | 88.14% |
| 2 | Stage II-Local Trader/Middlemen Stage | Local Trader | 170 | 140 | 82.35% |
| 3 | Stage III-Wholesale/Mandi Stage | Wholesaler/ Commission Agents | 175 | 160 | 91.43% |
| 4 | Stage IV-Local Trader/Mashakhor Stage | Mashakhor/Local Trader | 190 | 180 | 94.74% |
| 5 | Stage V-Transportation Stage | Transporter | 225 | 172 | 76.44% |
| **Total** | | | **1055** | **912** | **86.44%** |

**Table 4.12: Number of questionnaires administered and response rate-Vegetables Supply Chain**

| S. No. | Stage I | Respondent | Questionnaire Administered | Final Response Received | Response Rate % |
|---|---|---|---|---|---|
| 1 | Stage I-Farm Stage | Farmers | 255 | 200 | 78.43% |
| 2 | Stage II-Local Mandi Stage | Local Commission Agent | 172 | 140 | 81.40% |
| 3 | Stage III-Wholesale/Mandi Stage | Wholesaler/Commission Agents | 140 | 120 | 85.71% |
| 4 | Stage IV-Transportation Stage | Transporter | 168 | 140 | 83.33% |
| **Total** | | | **735** | **600** | **81.63%** |

The detailed sample distribution of respondents from the primary production areas are shown in Table 4.13 and Table 4.14.

**Table 4.13: Detailed Sample Distribution of Respondents-Stage Wise (Fruits supply chain)**

| District (State) | Place Visited | Stage I | Stage II | | Stage III | Stage IV | Transporter |
|---|---|---|---|---|---|---|---|
| | | Farmers | Local Commission Agent | Local Trader | Commission Agent in Azadpur Mandi/Adarsh Nagar | Local Trader in Azadpur Mandi | |
| Saharanpur (UP) | Behat | 35 | - | 14 | | | 21 |
| | Gangoh | 10 | - | - | | | 6 |
| Amroha (UP) | Amroha | 30 | 8 | 6 | | | 18 |
| | Hasanpur | 15 | - | 5 | | | 12 |
| | Joya | 10 | - | - | | | 5 |
| | Garh | 13 | - | - | | | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lucknow (UP) | Mal | 12 | 5 | 8 | | | 8 |
| | Kakori | 10 | 5 | 5 | | | 9 |
| | Baxi ka Talab | 6 | 5 | - | | | 5 |
| | Malihabad | 40 | 15 | 12 | | | 20 |
| Unnao (UP) | Farhatpur Puliya | 35 | - | 22 | | | 15 |
| | Miyaganj | 20 | - | 9 | | | 4 |
| Barabanki (UP) | Banki | 10 | 6 | 5 | | | 3 |
| Hardoi (UP) | Shahabad | 14 | 5 | 5 | | | 5 |
| Azadpur (Delhi) | | | | | 160 | 180 | 36 |
| | ***TOTAL*** | **260** | **49** | **91** | **160** | **180** | **172** |

**Table 4.14: Detailed Sample Distribution of Respondents-Stage Wise (Vegetables supply chain)**

| **District (State)** | **Place Visited** | **Stage I** | **Stage II** | **Stage III** | **Transporter** |
|---|---|---|---|---|---|
| | | **Farmers** | **Local Trader** | **Commission Agent in Azadpur Mandi/Adarsh Nagar** | |
| Solan (HP) | Basaal | 18 | 45 | | 10 |
| | Kandaghat | 15 | | | 10 |
| | Vakunaghat | 10 | | | 6 |
| | Chail | 12 | | | 9 |
| | Baniya village, Dharampur | 8 | | | 6 |
| Sirmaur (HP) | Rajgarh | 12 | 25 | | 12 |
| | Sirmaur | 16 | | | 11 |
| | Sargaun | 8 | | | 5 |
| Uttarkashi (UK) | Naugaun | 20 | - | | 6 |
| | Purola | 22 | | | 7 |
| Nainital (UK) | Nainital | 26 | 38 | | 7 |
| | Gaula Par, Haldwani | 18 | | | 17 |
| Dehradun (UK) | Chakrata | 15 | 32 | | 9 |
| Delhi | Azadpur Mandi | - | | 120 | 25 |
| | ***TOTAL*** | **200** | **140** | **120** | **140** |

The final sample size for research objective 2 is 912 and 600. As the general norm to conduct factor analysis is to have five respondents for each variable (Hair et al., 2008). Bryant and Yarnold (1995) also stated that one's sample should be at least five times the number of variables. The subjects-to-variables ratio should be no lower than 5 (Garson, 2008; MacCallum et al., 1999; Arrindell and van der Ende, 1985; Gorsuch, 1983; Everitt, 1975), it is satisfied in this study. The required sample size as per the subjects-to-variables ratio and the sample size used in this study are shown in Table 4.15 and Table 4.16.

**Table 4.15: Required sample size (Minimum) as per the subjects-to-variables ratio and Actual Sample size in the study-Fruit Supply Chain**

| Stage | Cost/Time/Quality | No. of Variables | Required sample size (Minimum) as per the subjects-to-variables ratio | Sample Size in the study | Appropriate Sample Size |
|---|---|---|---|---|---|
| Stage I-Farm Stage | Cost | 18 | 90 | 260 | ✓ |
| | Time | 22 | 110 | | ✓ |
| | Quality | 40 | 200 | | ✓ |
| Stage II-Local Trader/Middlemen Stage | Cost | 20 | 100 | 140 | ✓ |
| | Time | 18 | 90 | | ✓ |
| | Quality | 25 | 125 | | ✓ |
| Stage III-Wholesale/Mandi Stage | Cost | 15 | 75 | 160 | ✓ |
| | Time | 17 | 85 | | ✓ |
| | Quality | 26 | 130 | | ✓ |
| Stage IV-Local Trader/Mashakhor Stage | Cost | 20 | 100 | 180 | ✓ |
| | Time | 18 | 90 | | ✓ |
| | Quality | 30 | 150 | | ✓ |
| Stage V-Transportation Stage | Cost | 10 | 50 | 172 | ✓ |
| | Time | 11 | 55 | | ✓ |
| | Quality | 10 | 50 | | ✓ |

**Table 4.16: Required sample size (Minimum) as per the subjects-to-variables ratio and Actual Sample size in the study-Vegetables Supply Chain**

| Stage | Cost/Time/Quality | No. of Variables | Required sample size (Minimum) as per the subjects-to-variables ratio | Sample Size in the study | Appropriate Sample Size |
|---|---|---|---|---|---|
| Stage I-Farm Stage | Cost | 19 | 95 | 200 | ✓ |
| | Time | 23 | 115 | | ✓ |
| | Quality | 25 | 125 | | ✓ |
| Stage II-Local Mandi Stage | Cost | 16 | 80 | 140 | ✓ |
| | Time | 18 | 90 | | ✓ |
| | Quality | 22 | 110 | | ✓ |
| Stage III-Wholesale/Mandi Stage | Cost | 15 | 75 | 120 | ✓ |
| | Time | 18 | 90 | | ✓ |
| | Quality | 22 | 110 | | ✓ |
| Stage IV-Transportation Stage | Cost | 10 | 50 | 140 | ✓ |
| | Time | 12 | 60 | | ✓ |
| | Quality | 10 | 50 | | ✓ |

**4.8. For Research Objective 3:** *To develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato*

As it was not possible for an individual researcher to cover all the issues discovered through RO 2, the researcher tries to find out the measures only for the major reasons/variables under each factor leading to supply chain inefficiency. The factor loading of each variable across the stages of the F&V supply chain has been looked out. After that, the important variable under each dimension/factor has been classified based upon the highest factor loading (Negi and Anand, 2018 (a); Negi and Anand, 2018 (b); Tiwari, 2012). The higher the value of factor loading, the higher the variable has contributed to that factor (Hair et al., 2010; Field, 2009; Malhotra, 2007; Harman, 1976). The variable with highest factor loading is the reasons, which are highly contributing to the factors leading to supply chain inefficiency with respect to cost, time and quality. Factor loadings are very similar to weights, and signify the correlation's strength between the factor and the variable (Kline, 1994). This also provides the directions, to decide which of these reasons requires to be given attention on an immediate basis to improve the supply chain.

Therefore, it can be inferred that the variables with highest factor loading are the most important reasons/major reasons, which are highly contributing to the factors leading to supply chain inefficiency and need higher consideration for improving supply chain efficiency (Tiwari, 2012; Hair et al., 2010; Field, 2009; Malhotra, 2007; Harman, 1976).

Qualitative research has been used to find the measures and suggesting a framework to improve supply chain efficiency of F&V sector. It is a tool that helps to collect, analyse, and understand the raw data by perceiving participants' reactions (Creswell, 1994). Qualitative research is used within the interpretivist philosophy, which is designed in such a manner that it helps in understanding the diverse and complex nature of human actions. The nature of qualitative data is in-depth inquiry, detailed description, direct quotations tapping experiences and personal viewpoints of respondents (Patton, 1990). It involves observations, focus group discussions, and interviews (Cavana et al., 2008).

In this study, the in-depth semi-structured interview was conducted to identify the measures for these reasons. Measures for rest of the reasons are out of the purview and one of the limitation of this study. Pre-formulated questions are inducted in the semi-structured interviews, but no measures are adopted to strictly adhere them as chances are likely that new questions may emerge during the conversation (Myers, 2009, p. 124). Hence, it gives liberty to the interviewee to add meaningful insights.

### 4.8.1. Conceptualization and Protocol Designing

Based on the highest factor loading obtained from RO 2, the only variable, which has been found as the most critical reason for supply chain inefficiency in each factor across the stages were used for conceptualization *(Refer to Appendix IV)* and accordingly, protocols/questions were designed for each stage in F&V supply chain to identify the measures for improving supply chain efficiency *(Refer to Appendix V).* A protocol is a valid document, which comprises a questionnaire, which is used for collecting data and includes the thumb rules, which are followed while the protocol is in use. During the stage of data collection, construct validity was determined with the help of manifold sources of the evidence and with the help of protocol, reliability was ensured (Yin, 2003). These questions in a protocol were formulated based on the input gained from the RO 2.

A pilot study was conducted with F&V supply chain experts to understand if the interview questions are easy to be comprehended by the respondents and also to test the rationality of the said questionnaire. The pilot study aimed to probe into the narrowness or broadness of the questions and also tested the illustrative questions. In a nutshell, the validity of all the proposed questions were tested in this pilot study.

### 4.8.2. Sampling Design

One of the most vital component of qualitative research study is the selection of respondents to make sure the responses are voluntary in nature and people are more than willing to provide the desired information, which is a true representation of the targeted population (Cavana et al., 2008). On the other hand, Bryman and Bell (2007) claimed that a representativeness should not be the primary focus in a qualitative research, pertaining to the fact that it is making a thorough analysis

According to Cavana et al. (2008, p. 137), usage of non-probability methods have a positive edge of extracting quality information from the respondents at a rapid rate. Therefore, judgement-sampling methods was adopted to elicit information from the respondent using in-depth interviews. In this approach, the researcher is amply clear about the information to be extracted for which the respondents are finalized; the ones who are ready to deliver the information which they have accumulated over a point of time by the virtue of their experience (Bernard, 2002). It is specifically used to figure out the cases, which are rich in information and the same is processed to make good use of the resources available at the disposal of the researcher (Patton, 2002). Choosing the respondents in qualitative research is a tricky affair, as they need to be highly knowledgeable with a greater degree of expertise in the respective field (Cresswell and Plano Clark, 2011). Apart from their expertise and knowledge, Bernard (2002) and Spradley (1979) highlighted the significance of willingness of respondents to participate, capability to communicate their real life experiences and thoughts in a critical, expressive and insightful manner. Above all, the availability of respondents is also a crucial factor, which cannot be discounted under any circumstances.

For this reason, the judgmental method is selected as the best suited approach, as the objective is to explore the measures, which need to be taken to improve supply chain efficiency of F&V sector. Judgment sampling approach give due emphasis on data saturation (i.e. gaining a full-fledged information until a stage where the researcher feels that no new essential information is available) (Mile and Huberman, 1994). Therefore, during this stage of research, the determination of sample size was based on the issue like data saturation and absence of extra participants. The particular sample size in different stages is shown below in Table 4.17 and Table 4.18.

**Table 4.17: Sample Size based on Saturation-Fruits (Mango) Supply Chain**

| Stage | No. of experts |
|---|---|
| Stage I-Farm Stage | 07 |
| Stage II-Local Trader/Middlemen Stage | 05 |
| Stage III-Wholesale/Mandi Stage | 06 |
| Stage IV-Local Trader/Mashakhor Stage | 05 |
| Stage V-Transportation Stage | 07 |

**Table 4.18: Sample Size based on Saturation-Vegetables (Tomato) Supply Chain**

| Stage | No. of experts |
|---|---|
| Stage I-Farm Stage | 06 |
| Stage II-Local Mandi Stage | 05 |
| Stage III-Wholesale/Mandi Stage | 07 |
| Stage V-Transportation Stage | 07 |

Prior to the conduct of interview, the interviewee was given an explanation that the data collected through interview will be fully confidential and would be used by the researcher for academic purpose only. After data collection through a semi-structured interview, the responses were recorded, transcribed and codes were generated. The sample of transcribed conversation and list of codes are attached as an appendix *(Refer to Appendix VI and VII)*. Based on transcribed conversation and codes, measures were taken out, as suggested by the experts. Finally, based on the output, a framework was developed.

The findings were reviewed by an expert as suggested by Yin (2003) who resonated with the findings of this study. In addition, the following measures were also taken to enhance the quality of this study: Triangulation has been attempted by getting the findings of this study vetted by the expert, and obtaining data from varied persons to get different perspectives on the phenomenon, using interview protocol to guide the research process to bring in the elements of reliability (Yin, 2003).

The steps followed for this objective are as follows:

1. Experts based on judgment sample consisting of:
    a) F&V supply chain expert
    b) Cold chain expert
    c) Logistics expert
    d) Horticulture Supply Chain expert
    e) Agribusiness experts
    f) Experts from Academia (Agricultural/Supply Chain)
2. Semi-structured interview with the experts
3. Transcribe the conversation
4. Coding
5. Measures to improve supply chain efficiency of F&V sector
6. Framework development based on the output

## 4.9. Scope of the Study

The scope of the study is limited to supply chain of F&V with specific reference to mango and tomato, as the highest amount of losses in F&V were found in these two categories. The supply chain from farm to wholesale mandi was selected because maximum inefficiency has been found between these stages. For Mango, state of Uttar Pradesh (UP) was selected as the origin point (farm), as it has the highest production of mango in India. For Tomato, Himachal Pradesh, and Uttarakhand was selected as the origin point (farm), as it has the high potential to serve the needs during offseason and the livelihood of the people in these states is largely dependent on the agriculture. For destination point/wholesale level, Azadpur Mandi was selected. Azadpur wholesale mandi is the Asia's largest mandi and world's second largest mandi, which has the highest amount of arrival among any wholesale mandi across the country.

## Concluding Remarks

This chapter concludes the discussion on research methodology adopted by the researcher to attain the objectives. Both, exploratory and conclusive research have been used in this study. To collect and analyse the data, the researcher has used mixed method research combining quantitative and qualitative research. Also, this chapter discusses the rationale for the study and scope of the study. Next chapter discusses the data analysis and findings of the study in detail.

# 5. DATA ANALYSIS AND FINDINGS

*This chapter discusses the sample profile of the respondents and analysis of data collected to attain research objectives. This chapter aims to answer the three questions reflected through the research objectives, to identify the activities contributing to supply chain inefficiency, factors leading to supply chain inefficiency and the measures to improve supply chain efficiency of F&V sector. The data was analysed using the ranking method, factor analysis and interview method to attain these three objectives. In this chapter, the results obtained from the above-mentioned methods are presented, and the finding with respect to each objective is discussed in detail.*

## 5.1. Sample Profile

The sample profile consists of farmers, local traders, wholesalers, local traders at Mandi, and transporters who are involved in F&V business. These stakeholders were selected with the trust that they are familiar to operational conditions of their businesses. It is also believed that the respondents are completely aware of the operations related to supply chain management, such as grading, packaging, distribution, and storage.

**5.1.1. Sample Profile- Research Objective 1:** *To identify the most significant activities contributing to supply chain inefficiency (with respect to cost, time and quality) in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

Total 1180 respondents in fruits (mango) supply chain and 860 respondents in the vegetables (tomato) supply chain have been taken for the study as shown in Table 5.1 and Table 5.2. The description of the profile on the basis of age, educational qualifications, and experience are discussed in this section.

**Table 5.1: Sample Distribution of Respondents-Stage Wise (Fruits supply chain)**

| Stage | Respondent | Total | Percentage |
|---|---|---|---|
| Farm Stage | Farmer | 360 | 31% |
| Local Trader/Middlemen Stage | Local Trader/LCA | 230 | 19% |
| Wholesale/Mandi Stage | Commission Agents | 180 | 15% |
| Local Trader Stage at Azadpur | Local Trader (Mashakhor) | 140 | 12% |
| Transportation Stage | Transporter | 270 | 23% |
| **Grand Total** | | **1180** | **100%** |

**Table 5.2: Sample Distribution of Respondents-Stage Wise (Vegetables supply chain)**

| Stage | Respondent | Total | Percentage |
|---|---|---|---|
| Farm Stage | Farmer | 340 | 40% |
| Local Mandi Stage | Local Trader/LCA | 170 | 20% |
| Wholesale/Mandi Stage | Commission Agents | 130 | 15% |
| Transportation Stage | Transporter | 220 | 25% |
| **Grand Total** | | **860** | **100%** |

### 5.1.1.1 Sample Distribution of Respondents on the Basis of Age

The sample distributions of respondents (across the stages of F&V supply chain) on the basis of age are shown in Table 5.3 - Table 5.6.

**Table 5.3: Sample Distribution of Respondents (across the stages of fruits supply chain) on the Basis of Age**

| Stage | Respondent | Age (Yrs) | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 20-35 | 80 | 22% |
| | | 36-50 | 153 | 43% |
| | | 51-above | 127 | 35% |
| | **Grand Total** | | **360** | **100%** |
| Local Trader/Intermediaries Stage | Local Trader/LCA | 20-35 | 71 | 31% |
| | | 36-50 | 108 | 47% |
| | | 51-above | 51 | 22% |
| | **Grand Total** | | **230** | **100%** |
| Wholesale/Mandi Stage | Commission Agents | 20-35 | 36 | 20% |
| | | 36-50 | 63 | 35% |
| | | 51-above | 81 | 45% |
| | **Grand Total** | | **180** | **100%** |
| Local Trader Stage at Azadpur | Local Trader (Mashakhor) | 20-35 | 42 | 30% |
| | | 36-50 | 68 | 49% |
| | | 51-above | 30 | 21% |
| | **Grand Total** | | **140** | **100%** |
| Transportation/ In Transit Stage | Transporter | 20-35 | 147 | 54% |
| | | 36-50 | 110 | 41% |
| | | 51-above | 13 | 5% |
| | **Grand Total** | | **270** | **100%** |

**Table 5.4: Composite Age Distribution of Respondents (across the stages of fruits supply chain)**

| Age (Yrs) | Total | Percentage |
|---|---|---|
| 20-35 Yrs | 376 | 32% |
| 36-50 Yrs | 502 | 43% |
| 51 Yrs-above | 302 | 25% |
| **Grand Total** | **1180** | **100%** |

**Table 5.5: Sample Distribution of Respondents (across the stages of vegetables supply chain) on the Basis of Age**

| Stage | Respondent | Age (Yrs) | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 20-35 | 122 | 36% |
| | | 36-50 | 170 | 50% |
| | | 51-above | 48 | 14% |
| | **Grand Total** | | **340** | **100%** |
| Local Trader/Intermediaries Stage | Local Trader/LCA | 20-35 | 62 | 36% |
| | | 36-50 | 89 | 52% |
| | | 51-above | 19 | 11% |
| | **Grand Total** | | **170** | **100%** |
| Wholesale/Mandi Stage | Commission Agents | 20-35 | 24 | 18% |
| | | 36-50 | 61 | 47% |
| | | 51-above | 45 | 35% |
| | **Grand Total** | | **130** | **100%** |
| Transportation/ In Transit Stage | Transporter | 20-35 | 119 | 54% |
| | | 36-50 | 88 | 40% |
| | | 51-above | 13 | 6% |
| | **Grand Total** | | **220** | **100%** |

**Table 5.6: Composite Age Distribution of Respondents (across the stages of vegetables supply chain)**

| Age (Yrs) | Total | Percentage |
|---|---|---|
| 20-35 Yrs | 327 | 38% |
| 36-50 Yrs | 408 | 47% |
| 51 Yrs-above | 125 | 15% |
| **Grand Total** | **860** | **100%** |

The charts below (Figure 5.1 and Figure 5.2) show the composite frequency distribution of the ages of all the respondents in F&V supply chain. Most of the respondents (43%) were between the age group of 36 and 50 in case of fruits supply chain and about to one-half of the respondents (47%) were between the ages of 36 and 50 years in vegetables supply chain.

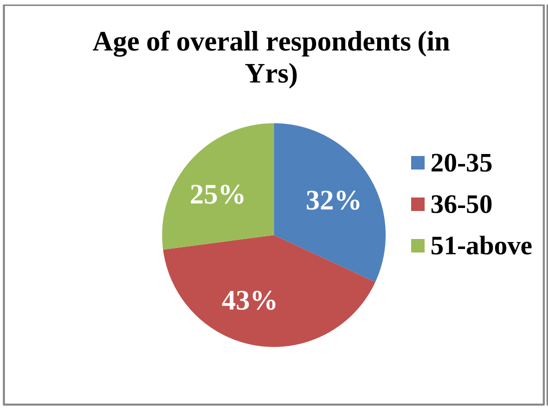



**Figure 5.1: Sample Distribution of Overall Respondents (Fruits Supply Chain) on the Basis of Age**

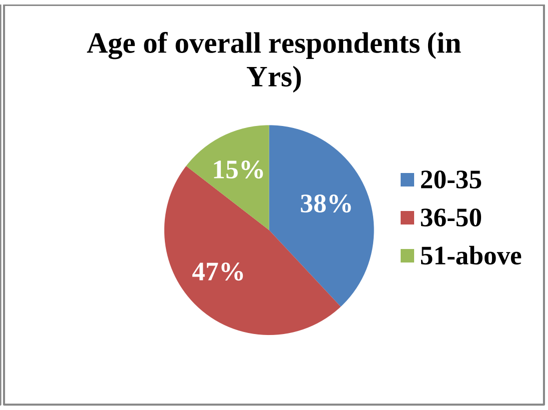



**Figure 5.2: Sample Distribution of Overall Respondents (Vegetables Supply Chain) on the Basis of Age**

### 5.1.1.2. Sample Distribution of Respondents on the Basis of Educational Qualifications

The sample distributions of respondents (across the stages of F&V supply chain) on the basis of Educational Qualifications are shown in Table 5.7 to Table 5.10.

**Table 5.7: Sample Distribution of Respondents (across the stages of fruits supply chain) on the Basis of Educational Qualifications**

| Stage | Respondent | Level of Qualifications | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | No Education | 53 | 15% |
| | | Primary | 145 | 40% |
| | | Secondary | 97 | 27% |
| | | Tertiary education | 65 | 18% |
| | **Grand Total** | | **360** | **100%** |
| Local Trader/Intermediaries Stage | Local Trader/LCA | No Education | 20 | 9% |
| | | Primary | 62 | 27% |
| | | Secondary | 82 | 36% |
| | | Tertiary education | 66 | 29% |
| | **Grand Total** | | **230** | **100%** |
| Wholesale/Mandi Stage | Commission Agents | No Education | 5 | 3% |
| | | Primary | 18 | 10% |
| | | Secondary | 85 | 47% |
| | | Tertiary education | 72 | 40% |
| | **Grand Total** | | **180** | **100%** |
| Local Trader Stage at Azadpur | Local Trader (Mashakhor) | No Education | 7 | 5% |
| | | Primary | 61 | 44% |
| | | Secondary | 49 | 35% |
| | | Tertiary education | 23 | 16% |
| | **Grand Total** | | **140** | **100%** |
| Transportation/ In Transit Stage | Transporter | No Education | 28 | 10% |
| | | Primary | 207 | 77% |
| | | Secondary | 27 | 10% |
| | | Tertiary education | 8 | 3% |
| | **Grand Total** | | **270** | **100%** |

**Table 5.8: Composite Educational Qualifications of Respondents (across the stages of fruits supply chain)**

| Level of Qualifications | Total | Percentage |
|---|---|---|
| No Education | 113 | 9% |
| Primary *(I-VIII)* | 493 | 42% |
| Secondary *(VIII-XII)* | 340 | 29% |
| Tertiary education *(college/university)* | 234 | 20% |
| **Grand Total** | **1180** | **100%** |

**Table 5.9: Sample Distribution of Respondents (across the stages of vegetables supply chain) on the Basis of Educational Qualifications**

| Stage | Respondent | Level of Qualifications | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | No Education | 82 | 24% |
| | | Primary | 214 | 63% |
| | | Secondary | 34 | 10% |
| | | Tertiary education | 10 | 3% |
| | **Grand Total** | | **340** | **100%** |

| | | | | |
|---|---|---|---|---|
| Local Trader/Intermediaries Stage | Local Trader/LCA | No Education | 10 | 6% |
| | | Primary | 31 | 18% |
| | | Secondary | 83 | 49% |
| | | Tertiary education | 46 | 27% |
| | **Grand Total** | | **170** | **100%** |
| Wholesale/Mandi Stage | Commission Agents | No Education | 0 | 0% |
| | | Primary | 17 | 13% |
| | | Secondary | 61 | 47% |
| | | Tertiary education | 52 | 40% |
| | **Grand Total** | | **130** | **100%** |
| Transportation/ In Transit Stage | Transporter | No Education | 33 | 15% |
| | | Primary | 146 | 66% |
| | | Secondary | 37 | 17% |
| | | Tertiary education | 4 | 2% |
| | **Grand Total** | | **220** | **100%** |

**Table 5.10: Composite Educational Qualifications of Respondents (across the stages of vegetables supply chain)**

| Level of Qualifications | Total | Percentage |
|---|---|---|
| No Education | 125 | 15% |
| Primary *(I-VIII)* | 408 | 47% |
| Secondary *(VIII-XII)* | 215 | 25% |
| Tertiary education *(college/university)* | 112 | 13% |
| **Grand Total** | **860** | **100** |

The chart below (Figure 5.3 and Figure 5.4) shows the composite frequency distribution of the educational qualifications of all the respondents in F&V supply chain. Most of the respondents (42%) had primary education in case of fruits supply chain and (47%) had primary education in case of the vegetables supply chain.

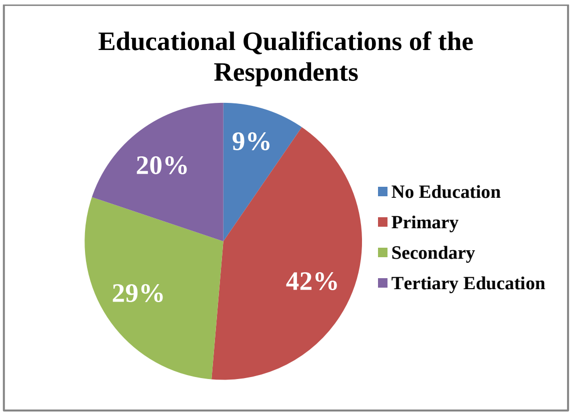



**Figure 5.3: Sample Distribution of Overall Respondents (Fruits Supply Chain) on the Basis of Educational Qualifications**

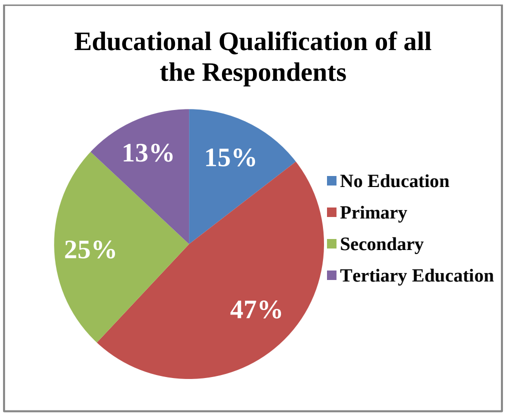



**Figure 5.4: Sample Distribution of Overall Respondents (Vegetables Supply Chain) on the Basis of Educational Qualifications**

### 5.1.1.3. Sample Distribution of Respondents on the Basis of Experience

The sample distributions of respondents (across the stages of F&V supply chain) on the basis of the level of experience are shown in Table 5.11 to Table 5.14.

**Table 5.11: Sample Distribution of Respondents on the Basis of Experience**

| Stage | Respondent | Experience | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 0-5 Yrs | 27 | 8% |
| | | 5-10 Yrs | 54 | 15% |
| | | 10-15 Yrs | 96 | 27% |
| | | 15-20 Yrs | 108 | 30% |
| | | 20< above | 75 | 21% |
| | **Grand Total** | | **360** | **100%** |
| Local Trader/Intermediaries Stage | Local Trader/LCA | 0-5 Yrs | 36 | 16% |
| | | 5-10 Yrs | 54 | 23% |
| | | 10-15 Yrs | 72 | 31% |
| | | 15-20 Yrs | 46 | 20% |
| | | 20< above | 22 | 10% |
| | **Grand Total** | | **230** | **100%** |
| Wholesale/Mandi Stage | Commission Agents | 0-5 Yrs | 8 | 4% |
| | | 5-10 Yrs | 17 | 9% |
| | | 10-15 Yrs | 30 | 17% |
| | | 15-20 Yrs | 53 | 29% |
| | | 20< above | 72 | 40% |
| | **Grand Total** | | **180** | **100%** |
| Local Trader Stage at Azadpur | Local Trader (Mashakhor) | 0-5 Yrs | 11 | 8% |
| | | 5-10 Yrs | 27 | 19% |
| | | 10-15 Yrs | 32 | 23% |
| | | 15-20 Yrs | 28 | 20% |
| | | 20< above | 42 | 30% |
| | **Grand Total** | | **140** | **100%** |
| Transportation/ In Transit Stage | Transporter | 0-5 Yrs | 38 | 14% |
| | | 5-10 Yrs | 52 | 19% |
| | | 10-15 Yrs | 84 | 31% |
| | | 15-20 Yrs | 66 | 24% |
| | | 20< above | 30 | 11% |
| | **Grand Total** | | **270** | **100%** |

**Table 5.12: Composite-Level of Experience of Respondents (across the stages of fruits SC)**

| Level of Experience | Total | Percentage |
|---|---|---|
| 0-5 Yrs | 120 | 10% |
| 5-10 Yrs | 204 | 17% |
| 10-15 Yrs | 314 | 27% |
| 15-20 Yrs | 301 | 26% |
| 20< above | 241 | 20% |
| **Grand Total** | **1180** | **100%** |

**Table 5.13: Sample Distribution of Respondents (across the stages of vegetables supply chain) on the Basis of Experience**

| Stage | Respondent | Level of Qualifications | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 0-5 Yrs | 43 | 13% |
| | | 5-10 Yrs | 58 | 17% |
| | | 10-15 Yrs | 46 | 14% |
| | | 15-20 Yrs | 110 | 32% |
| | | 20< above | 83 | 24% |

| | | | | |
|---|---|---|---|---|
| | **Grand Total** | | **340** | **100%** |
| Local Trader/Intermediaries Stage | Local Trader/LCA | 0-5 Yrs | 12 | 7% |
| | | 5-10 Yrs | 26 | 15% |
| | | 10-15 Yrs | 42 | 25% |
| | | 15-20 Yrs | 52 | 31% |
| | | 20< above | 38 | 22% |
| | **Grand Total** | | **170** | **100%** |
| Wholesale/Mandi Stage | Wholesaler/ Commission Agents | 0-5 Yrs | 7 | 5% |
| | | 5-10 Yrs | 22 | 17% |
| | | 10-15 Yrs | 34 | 26% |
| | | 15-20 Yrs | 48 | 37% |
| | | 20< above | 19 | 15% |
| | **Grand Total** | | **130** | **100%** |
| Transportation/ In Transit Stage | Transporter | 0-5 Yrs | 22 | 10% |
| | | 5-10 Yrs | 40 | 18% |
| | | 10-15 Yrs | 75 | 34% |
| | | 15-20 Yrs | 52 | 24% |
| | | 20< above | 31 | 14% |
| | **Grand Total** | | **220** | **100%** |

**Table 5.14: Composite Experience of Respondents (across the stages of vegetables supply chain)**

| Level of Experience | Total | Percentage |
|---|---|---|
| 0-5 Yrs | 84 | 10% |
| 5-10 Yrs | 146 | 17% |
| 10-15 Yrs | 197 | 23% |
| 15-20 Yrs | 262 | 30% |
| 20< above | 171 | 20% |
| **Grand Total** | **860** | **100.00%** |

The chart below (Figure 5.5 and Figure 5.6) shows the composite frequency distribution of the experience of all the respondents in F&V supply chain. About to one-half of the respondents (46%) have an experience of more than 15 years in fruits agribusiness. In case of the vegetables supply chain, most of the respondents (30%) have 15-20 years of experience. 20% of the respondents have experience of more than 20 years.

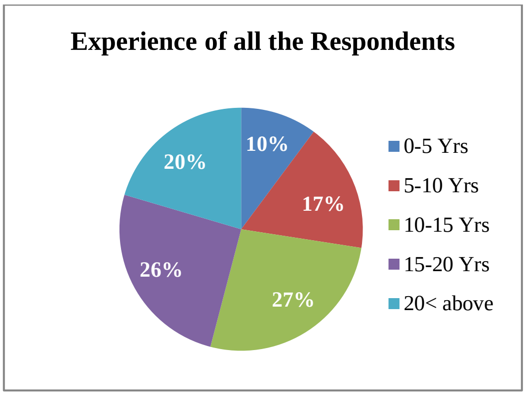



**Figure 5.5: Sample Distribution of Overall Respondents (Fruits Supply Chain) on the Basis of Experience**

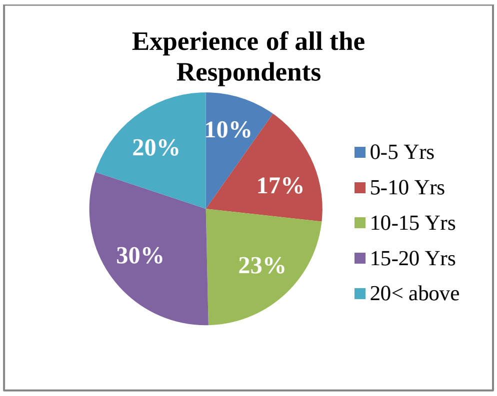



**Figure 5.6: Sample Distribution of Overall Respondents (Vegetables Supply Chain) on the Basis of Experience**

**5.1.2. Sample Profile- Research Objective 2:** *To identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

Total 912 respondents in fruits (mango) supply chain and 600 respondents in the vegetables (tomato) supply chain have been taken for the study as shown in Table 5.15 and Table 5.16. The description of the profile on the basis of age, educational qualifications, and experience are discussed in this section.

**Table 5.15: Sample Distribution of Respondents-Stage Wise (Fruits supply chain)**

| Stage | Respondent | Total | Percentage |
|---|---|---|---|
| Farm Stage | Farmer | 260 | 28.51% |
| Local Trader/Middlemen Stage | Local Trader/LCA | 140 | 15.35% |
| Wholesale/Mandi Stage | Commission Agents | 160 | 17.54% |
| Local Trader Stage at Azadpur | Local Trader (Mashakhor) | 180 | 19.74% |
| Transportation Stage | Transporter | 172 | 18.86% |
| **Grand Total** | | **912** | 100.00% |

**Table 5.16: Sample Distribution of Respondents-Stage Wise (Vegetables supply chain)**

| Stage | Respondent | Total | Percentage |
|---|---|---|---|
| Farm Stage | Farmer | 200 | 33.33% |
| Local Mandi Stage | Local Trader/LCA | 140 | 23.33% |
| Wholesale/Mandi Stage | Commission Agents | 120 | 20.00% |
| Transportation Stage | Transporter | 140 | 23.33% |
| **Grand Total** | | **600** | **100%** |

### 5.1.2.1. Sample Distribution of Respondents on the Basis of Age

The sample distributions of respondents (across the stages of F&V supply chain) on the basis of age are shown in Table 5.17 to Table 5.20.

**Table 5.17: Sample Distribution of Respondents (across the stages of fruits supply chain) on the Basis of Age**

| Stage | Respondent | Age (Yrs) | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 20-35 | 58 | 22% |
| | | 36-50 | 110 | 42% |
| | | 51-above | 92 | 35% |
| | **Grand Total** | | **260** | **100%** |
| Local Trader/Middlemen Stage | Local Trader/LCA | 20-35 | 43 | 31% |
| | | 36-50 | 66 | 47% |
| | | 51-above | 31 | 22% |
| | **Grand Total** | | **140** | **100%** |
| Wholesale/Mandi Stage | Wholesaler/ Commission Agents | 20-35 | 32 | 20% |
| | | 36-50 | 56 | 35% |
| | | 51-above | 72 | 45% |
| | **Grand Total** | | **160** | **100%** |
| Local Trader/Mashakhor | Local Trader (Mashakhor) | 20-35 | 54 | 30% |
| | | 36-50 | 86 | 48% |

| | | | | |
|---|---|---|---|---|
| Stage at Azadpur | | 51-above | 40 | 22% |
| | **Grand Total** | | **180** | **100%** |
| Transportation/ In Transit Stage | Transporter | 20-35 | 57 | 33% |
| | | 36-50 | 102 | 59% |
| | | 51-above | 13 | 8% |
| | **Grand Total** | | **172** | **100%** |

**Table 5.18: Composite Age Distribution of Respondents (across the stages of fruits supply chain)**

| Age (Yrs) | Total | Percentage |
|---|---|---|
| 20-35 Yrs | 291 | 32% |
| 36-50 Yrs | 374 | 41% |
| 51 Yrs-above | 247 | 27% |
| **Grand Total** | **912** | **100%** |

**Table 5.19: Sample Distribution of Respondents (across the stages of vegetables supply chain) on the Basis of Age**

| Stage | Respondent | Age (Yrs) | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 20-35 | 72 | 36% |
| | | 36-50 | 100 | 50% |
| | | 51-above | 28 | 14% |
| | **Grand Total** | | **200** | **100%** |
| Local Mandi Stage | Local Trader/LCA | 20-35 | 51 | 36% |
| | | 36-50 | 73 | 52% |
| | | 51-above | 16 | 11% |
| | **Grand Total** | | **140** | **100%** |
| Wholesale/Mandi Stage | Wholesaler/ Commission Agents | 20-35 | 22 | 18% |
| | | 36-50 | 56 | 47% |
| | | 51-above | 42 | 35% |
| | **Grand Total** | | **120** | **100%** |
| Transportation/ In Transit Stage | Transporter | 20-35 | 62 | 44% |
| | | 36-50 | 74 | 53% |
| | | 51-above | 4 | 3% |
| | **Grand Total** | | **140** | **100%** |

**Table 5.20: Composite Age Distribution of Respondents (across the stages of vegetables supply chain)**

| Age (Yrs) | Total | Percentage |
|---|---|---|
| 20-35 Yrs | 207 | 34% |
| 36-50 Yrs | 303 | 51% |
| 51 Yrs-above | 90 | 15% |
| **Grand Total** | **600** | **100%** |

The chart below (Figure 5.7 and Figure 5.8) shows the composite frequency distribution of the ages of all the respondents in F&V supply chain. Most of the respondents in case of both F&V were between the ages of 36 and 50 years (41% in case of fruits and 51% in case of the vegetables supply chain).

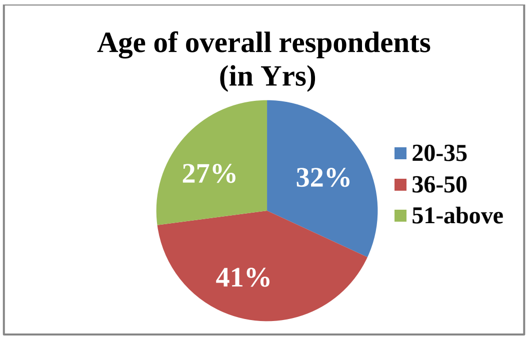



**Figure 5.7: Sample Distribution of Overall Respondents (Fruits Supply Chain) on the Basis of Age**

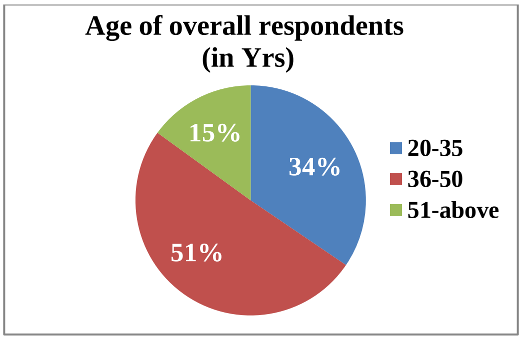



**Figure 5.8: Sample Distribution of Overall Respondents (Vegetables Supply Chain) on the Basis of Age**

### 5.1.2.2. Sample Distribution of Respondents on the Basis of Educational Qualifications

The sample distributions of respondents (across the stages of F&V supply chain) on the basis of Educational Qualifications are shown in Table 5.21 to Table 5.24.

**Table 5.21: Sample Distribution of Respondents (across the stages of fruits supply chain) on the Basis of Educational Qualifications**

| Stage | Respondent | Level of Qualifications | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | No Education | 38 | 15% |
| | | Primary | 105 | 40% |
| | | Secondary | 70 | 27% |
| | | Tertiary education | 47 | 18% |
| | **Grand Total** | | **260** | **100%** |
| Local Trader/Middlemen Stage | Local Trader/LCA | No Education | 12 | 9% |
| | | Primary | 38 | 27% |
| | | Secondary | 50 | 36% |
| | | Tertiary education | 40 | 29% |
| | **Grand Total** | | **140** | **100%** |
| Wholesale/Mandi Stage | Commission Agents | No Education | 5 | 3% |
| | | Primary | 16 | 10% |
| | | Secondary | 77 | 48% |
| | | Tertiary education | 62 | 39% |
| | **Grand Total** | | **160** | **100%** |
| Local Trader/Mashakhor Stage at Azadpur | Local Trader (Mashakhor) | No Education | 9 | 5% |
| | | Primary | 77 | 43% |
| | | Secondary | 63 | 35% |
| | | Tertiary education | 31 | 17% |
| | **Grand Total** | | **180** | **100%** |
| Transportation/ In Transit Stage | Transporter | No Education | 26 | 15% |
| | | Primary | 122 | 71% |
| | | Secondary | 16 | 9% |
| | | Tertiary education | 8 | 5% |
| | **Grand Total** | | **172** | **100%** |

**Table 5.22: Composite Educational Qualifications of Respondents (across the stages of fruits supply chain)**

| Level of Qualifications | Total | Percentage |
|---|---|---|
| No Education | 90 | 10% |
| Primary *(I-VIII)* | 358 | 39% |
| Secondary *(VIII-XII)* | 276 | 30% |
| Tertiary education *(college/university)* | 188 | 21% |
| **Grand Total** | **912** | **100%** |

**Table 5.23: Sample Distribution of Respondents (across the stages of vegetables supply chain) on the Basis of Educational Qualifications**

| Stage | Respondent | Level of Qualifications | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | No Education | 48 | 24% |
| | | Primary | 126 | 63% |
| | | Secondary | 20 | 10% |
| | | Tertiary education | 6 | 3% |
| | **Grand Total** | | **200** | **100%** |
| Local Mandi Stage | Local Trader/LCA | No Education | 8 | 6% |
| | | Primary | 26 | 19% |
| | | Secondary | 68 | 49% |
| | | Tertiary education | 38 | 27% |
| | **Grand Total** | | **140** | **100%** |
| Wholesale/Mandi Stage | Wholesaler/ Commission Agents | No Education | 0 | 0% |
| | | Primary | 16 | 13% |
| | | Secondary | 56 | 47% |
| | | Tertiary education | 48 | 40% |
| | **Grand Total** | | **120** | **100%** |
| Transportation/ In Transit Stage | Transporter | No Education | 16 | 11% |
| | | Primary | 82 | 59% |
| | | Secondary | 34 | 24% |
| | | Tertiary education | 8 | 6% |
| | **Grand Total** | | **140** | **100%** |

**Table 5.24: Composite Educational Qualifications of Respondents (across the stages of vegetables supply chain)**

| Level of Qualifications | Total | Percentage |
|---|---|---|
| No Education | 72 | 12% |
| Primary *(I-VIII)* | 250 | 42% |
| Secondary *(VIII-XII)* | 178 | 30% |
| Tertiary education *(college/university)* | 100 | 17% |
| **Grand Total** | **600** | **100%** |

The chart below (Figure 5.9 and Figure 5.10) shows the composite frequency distribution of the educational qualifications of all the respondents in F&V supply chain. Most of the respondents had primary education, 39% in fruits and 42% in vegetable.

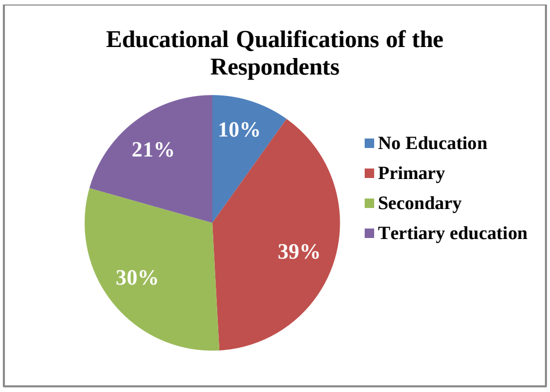



Figure 5.9: Sample Distribution of Overall Respondents (Fruits Supply Chain) on the Basis of Educational Qualifications

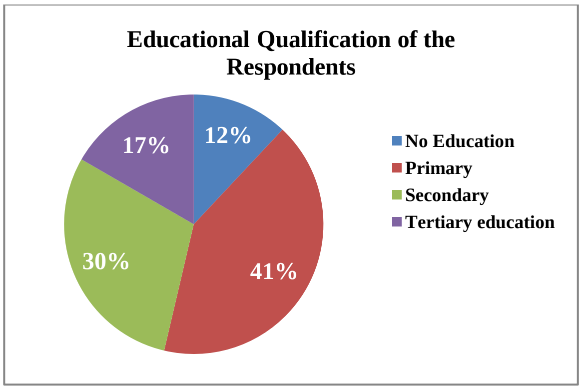



Figure 5.10: Sample Distribution of Overall Respondents (Vegetables Supply Chain) on the Basis of Educational Qualifications

### 5.1.2.3. Sample Distribution of Respondents on the Basis of Experience

The sample distributions of respondents (across the stages of F&V supply chain) on the basis of the level of experience are shown in Table 5.25 to Table 5.28.

**Table 5.25: Sample Distribution of Respondents (across the stages of fruits supply chain) on the Basis of Experience**

| Stage | Respondent | Experience | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 0-5 Yrs | 8 | 3% |
| | | 5-10 Yrs | 24 | 9% |
| | | 10-15 Yrs | 56 | 22% |
| | | 15-20 Yrs | 90 | 35% |
| | | 20< above | 82 | 32% |
| | **Grand Total** | | **260** | **100%** |
| Local Trader/Middlemen Stage | Local Trader/LCA | 0-5 Yrs | 18 | 13% |
| | | 5-10 Yrs | 25 | 18% |
| | | 10-15 Yrs | 41 | 29% |
| | | 15-20 Yrs | 38 | 27% |
| | | 20< above | 18 | 13% |
| | **Grand Total** | | **140** | **100%** |
| Wholesale/Mandi Stage | Commission Agents | 0-5 Yrs | 5 | 3% |
| | | 5-10 Yrs | 16 | 10% |
| | | 10-15 Yrs | 27 | 17% |
| | | 15-20 Yrs | 45 | 28% |
| | | 20< above | 67 | 42% |
| | **Grand Total** | | **160** | **100%** |
| Local Trader/Mashakhor Stage at Azadpur | Local Trader (Mashakhor) | 0-5 Yrs | 14 | 8% |
| | | 5-10 Yrs | 34 | 19% |
| | | 10-15 Yrs | 38 | 21% |
| | | 15-20 Yrs | 35 | 19% |
| | | 20< above | 59 | 33% |
| | **Grand Total** | | **180** | **100%** |
| Transportation/ In Transit Stage | Transporter | 0-5 Yrs | 18 | 10% |
| | | 5-10 Yrs | 36 | 21% |
| | | 10-15 Yrs | 61 | 35% |
| | | 15-20 Yrs | 41 | 24% |
| | | 20< above | 16 | 9% |
| | **Grand Total** | | **172** | **100%** |

**Table 5.26: Composite-Level of Experience of All Respondents (across the stages of fruits supply chain)**

| Level of Experience | Total | Percentage |
|---|---|---|
| 0-5 Yrs | 63 | 7% |
| 5-10 Yrs | 135 | 15% |
| 10-15 Yrs | 223 | 24% |
| 15-20 Yrs | 249 | 27% |
| 20< above | 242 | 27% |
| **Grand Total** | **912** | **100%** |

**Table 5.27: Sample Distribution of Respondents (across the stages of vegetables supply chain) on the Basis of Experience**

| Stage | Respondent | Level of Qualifications | Total | Percentage |
|---|---|---|---|---|
| Farm Stage | Farmer | 0-5 Yrs | 12 | 6% |
| | | 5-10 Yrs | 28 | 14% |
| | | 10-15 Yrs | 43 | 22% |
| | | 15-20 Yrs | 71 | 36% |
| | | 20< above | 46 | 23% |
| | **Grand Total** | | **200** | **100%** |
| Local Mandi Stage | Local Trader/LCA | 0-5 Yrs | 4 | 3% |
| | | 5-10 Yrs | 18 | 13% |
| | | 10-15 Yrs | 38 | 27% |
| | | 15-20 Yrs | 46 | 33% |
| | | 20< above | 34 | 24% |
| | **Grand Total** | | **140** | **100%** |
| Wholesale/Mandi Stage | Wholesaler/ Commission Agents | 0-5 Yrs | 5 | 4% |
| | | 5-10 Yrs | 20 | 17% |
| | | 10-15 Yrs | 33 | 28% |
| | | 15-20 Yrs | 46 | 38% |
| | | 20< above | 16 | 13% |
| | **Grand Total** | | **120** | **100%** |
| Transportation/ In Transit Stage | Transporter | 0-5 Yrs | 11 | 8% |
| | | 5-10 Yrs | 32 | 23% |
| | | 10-15 Yrs | 54 | 39% |
| | | 15-20 Yrs | 37 | 26% |
| | | 20< above | 6 | 4% |
| | **Grand Total** | | **140** | **100%** |

**Table 5.28: Composite Experience of Respondents (across the stages of vegetables supply chain)**

| Level of Experience | Total | Percentage |
|---|---|---|
| 0-5 Yrs | 32 | 5% |
| 5-10 Yrs | 98 | 16% |
| 10-15 Yrs | 168 | 28% |
| 15-20 Yrs | 200 | 34% |
| 20< above | 102 | 17% |
| **Grand Total** | **600** | **100.00%** |

The chart below (Figure 5.11 and Figure 5.12) shows the composite frequency distribution of the experience of all the respondents in F&V supply chain. More than one-half of the respondents (54%) have an experience of more than 15 years in fruits agribusiness. In case of vegetables business, most of the respondents (34%) have 15-

20 years of experience. 17% of the respondents have experience of more than 20 years.

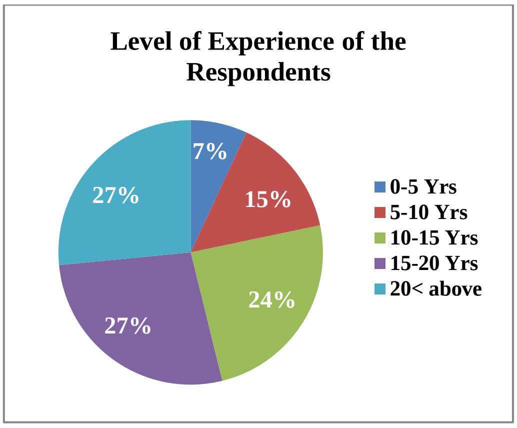



**Figure 5.11: Sample Distribution of Overall Respondents (Fruits Supply Chain) on the Basis of Experience**

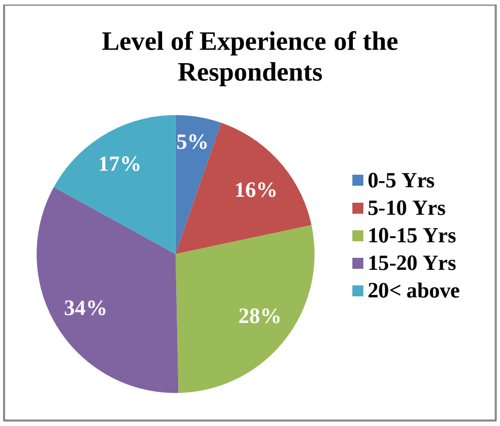



**Figure 5.12: Sample Distribution of Overall Respondents (Vegetables Supply Chain) on the Basis of Experience**

**5.1.3. Sample Profile- Research Objective 3:** *To develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato*

The sample profile consists of the experts based on judgment sample consisting of:

a) F&V supply chain expert
b) Cold chain expert
c) Logistics expert
d) Horticulture Supply Chain expert
e) Agribusiness experts
f) Experts from Academia (Agricultural/Supply Chain)

## 5.2. Reliability Analysis

Reliability test needs to be conducted and it is essential before going for any discussion on analysis. Reliability is the basic criterion by which a particular measurement can be accepted in research. It indicates stability and the internal consistency of a test, whether the same characteristic has been measured by different questions. The different items of the instrument were administered to validate the consistency of the results. There are various ways to test the internal consistency and one way that is used in this study is Cronbach alpha. In reliability analysis, the Cronbach's alpha is an "index of reliability" related with the "variation accounted for" by the true score of the "underlying construct". A reliability coefficient reflects how well the items in a set are positively correlated to one another. The construct is the hypothetical variable, which is measured (Hatcher, 1994). The closer the value of Cronbach alpha is to 1, the higher the internal consistency reliability (Kerlinger, 1986). Peter (1979); and Churchill and Peter (1984) outlined the criterion, that those reliability levels that are greater than 0.5 are acceptable in social sciences. Moreover, George and Mallery (2003) provide the following thumb rules: "$\alpha$ <.5-Unacceptable, $\alpha$ >.5-Poor, $\alpha$ >.6-Questionnable, $\alpha$ >.7-Acceptable, $\alpha$ >.8-Good, and $\alpha$ >.9-Excellent".

### 5.2.1. Reliability Analysis for Research Objective 1: *To identify the most significant activities contributing to supply chain inefficiency (with respect to cost, time and quality) in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

The reliability has been tested for the questionnaire used across the stages. For the entire questionnaires across the stages of the F&V supply chain, the value of Cronbach alpha is more than 0.8 in maximum cases, which is a good measure for that assess the consistency of entire scale (Hair et al., 2007). Hence, the data is reliable to proceed for further analysis.

The score-representing alpha is presented in Table 5.29 and Table 5.30 for each stakeholder across the stages of the F&V supply chain.

**Table 5.29: Reliability Statistics (Fruits Supply Chain)**

| Stage | Cronbach's Alpha | Cronbach's Alpha Based on Standardised Items | N of Items |
|---|---|---|---|
| Stage I-Farm Stage | .798 | .799 | 24 |
| Stage II-Local Trader/Middlemen Stage | .900 | .898 | 24 |
| Stage III-Wholesale/Mandi Stage | .886 | .886 | 18 |
| Stage IV-Local Trader/Mashakhor Stage | .901 | .899 | 21 |
| Stage V-Transportation Stage | .817 | .823 | 9 |

**Table 5.30: Reliability Statistics (Vegetables Supply Chain)**

| Stage | Cronbach's Alpha | Cronbach's Alpha Based on Standardised Items | N of Items |
|---|---|---|---|
| Stage I-Farm Stage | .847 | .844 | 30 |
| Stage II-Local Mandi Stage | .789 | .786 | 24 |
| Stage III-Wholesale/Mandi Stage | .749 | .737 | 27 |
| Stage IV-Transportation Stage | .900 | .899 | 6 |

**5.2.2. Reliability Analysis for Research Objective 2:** *To identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

The reliability has been tested for each section of the questionnaire with respect to cost, time, and quality. For the entire questionnaires across the stages of the F&V supply chain with respect to cost, time, and quality the value of Cronbach alpha is more than 0.8 in maximum cases, which is a good measure for that assess the consistency of entire scale (Hair et al., 2007). Hence, the data is reliable to proceed with Factor Analysis.

The score representing alpha is presented in Table 5.31 and Table 5.32 for each stakeholder across the stages of the F&V supply chain with respect to cost, time, and quality.

**Table 5.31: Reliability Statistics (Fruits Supply Chain)**

| Stage | Supply Chain Inefficiency: with respect to | Cronbach's Alpha | Cronbach's Alpha Based on Standardised Items | N of Items |
|---|---|---|---|---|
| Stage I-Farm Stage | Cost | .869 | .872 | 18 |
| | Time | .836 | .837 | 22 |
| | Quality | .851 | .852 | 40 |
| Stage II-Local Trader/Middlemen Stage | Cost | .883 | .882 | 20 |
| | Time | .890 | .892 | 18 |
| | Quality | .858 | .859 | 25 |
| Stage III-Wholesale/Mandi | Cost | .900 | .901 | 15 |
| | Time | .827 | .828 | 17 |

| | | | | |
|---|---|---|---|---|
| Stage | Quality | .889 | .891 | 26 |
| Stage IV-Local Trader/Mashakhor Stage | Cost | .871 | .873 | 20 |
| | Time | .888 | .885 | 18 |
| | Quality | .898 | .900 | 30 |
| Stage V-Transportation Stage | Cost | .704 | .700 | 10 |
| | Time | .809 | .814 | 11 |
| | Quality | .826 | .830 | 10 |

**Table 5.32: Reliability Statistics (Vegetables Supply Chain)**

| **Stage** | **Supply Chain Inefficiency: with respect to** | **Cronbach's Alpha** | **Cronbach's Alpha Based on Standardised Items** | **N of Items** |
|---|---|---|---|---|
| Stage I-Farm Stage | Cost | .876 | .902 | 19 |
| | Time | .886 | .893 | 23 |
| | Quality | .874 | .876 | 25 |
| Stage II-Local Mandi Stage | Cost | .898 | .900 | 16 |
| | Time | .866 | .870 | 18 |
| | Quality | .846 | .853 | 22 |
| Stage III-Wholesale/Mandi Stage | Cost | .900 | .905 | 15 |
| | Time | .875 | .883 | 18 |
| | Quality | .872 | .875 | 22 |
| Stage IV-Transportation Stage | Cost | .737 | .740 | 10 |
| | Time | .794 | .798 | 12 |
| | Quality | .785 | .798 | 10 |

**5.2.3. Reliability Analysis for Research Objective 3:** *To develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato*

Triangulation is an approach to increase the reliability and validity of qualitative data (Denzin and Lincoln, 2005). When the evidence is collected from manifold sources, data triangulation is employed for addressing the potential problems of construct validity (Yin, 2003). In order to assess the validity of construct, triangulation method is used, which offers a combination of various sources of data in a research study. The present research employs various sources for extracting requisite information like, observations, documents, artifacts and interviews. Interviews were conducted with experts in different fields such as supply chain expert, horticulture specialist, cold chain experts, and logistics experts. For data analysis, the interviews were transcribed and used. This approach helps in the enhancement of construct validity by providing a different perspective of the phenomenon. Also, the review of the process reports has been done by the key informants as advocated by Yin (2003). With the help of data triangulation, the research findings get its validity.

### 5.3. Analysis of Survey Data

The data analysis for research objective 1, 2 and 3 has been shown separately in this section, as different strategy has been adopted to achieve each objective.

**5.3.1. Analysis- Research Objective 1:** *To identify the most significant activities contributing to supply chain inefficiency (with respect to cost, time and quality) in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

Before preparing the questionnaire and going ahead to collect any data for Research objective 1, the activities, which takes place in different stages of fruits (mango) and vegetables (tomato) supply chain have been mapped and listed out in order to prepare the questionnaire and collect the data to identify the most significant activities contributing to supply chain inefficiency with respect to cost, time, and quality in each stage of F&V supply chain.

#### 5.3.1.1. Activities in the Supply Chain of F&V

The sequence of activities has been mapped out on the basis of a field visit by the researcher from Farm to Mashakhor level at Wholesale mandi in case of mango supply chain (Uttar Pradesh to Asia's largest wholesale mandi, Azadpur, Delhi), and Farm to Wholesale level in case of tomato supply chain (Uttarakhand and Himachal Pradesh to Asia's largest wholesale mandi, Azadpur, Delhi). The set of activities from the farm (Uttar Pradesh) to mashakhor stage (Azadpur, Delhi) in mango supply chain are shown below in Figure 5.13 to 5.17:

***STAGE I-Farm Stage of Mango Supply Chain***


**Figure 5.13: Activities in Farm Stage of Mango Supply Chain**

## *STAGE II-Local Trader/Middlemen Stage of Mango Supply Chain*


**Figure 5.14: Activities in Local Trader/Middlemen Stage of Mango Supply Chain**

## *STAGE III-Wholesale/Mandi Stage of Mango Supply Chain*


**Figure 5.15: Activities in Wholesale/Mandi Stage of Mango Supply Chain**

## *STAGE IV-Local Trader/Mashakhor Stage of Mango Supply Chain*


**Figure 5.16: Activities in Local Trader/Mashakhor Stage of Mango Supply Chain**

### *STAGE V-Transportation Stage of Mango Supply Chain*

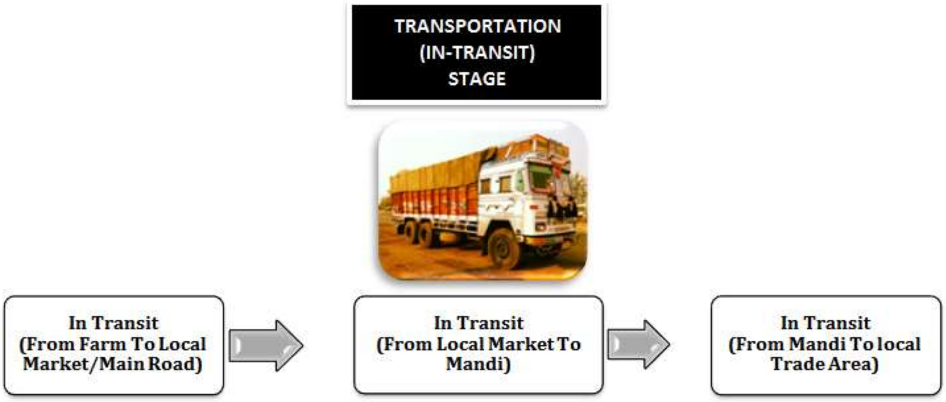



**Figure 5.17: Activities in Transportation Stage of Mango Supply Chain**

The set of activities from the farm (Uttarakhand and Himachal Pradesh) to Wholesale Mandi (Azadpur, Delhi) in Tomato supply chain are shown below in Figure 5.18-5.21:

### *STAGE I-Farm Stage of Tomato Supply Chain*


**Figure 5.18: Activities in Farm Stage of Tomato Supply Chain**

### *STAGE II-Local Mandi Stage of Tomato Supply Chain*


**Figure 5.19: Activities in Local Mandi Stage of Tomato Supply Chain**

*STAGE III-Wholesale Mandi Stage of Tomato Supply Chain*


**Figure 5.20: Activities in Wholesale Mandi Stage of Tomato Supply Chain**

*STAGE III-Transportation Stage of Tomato Supply Chain*

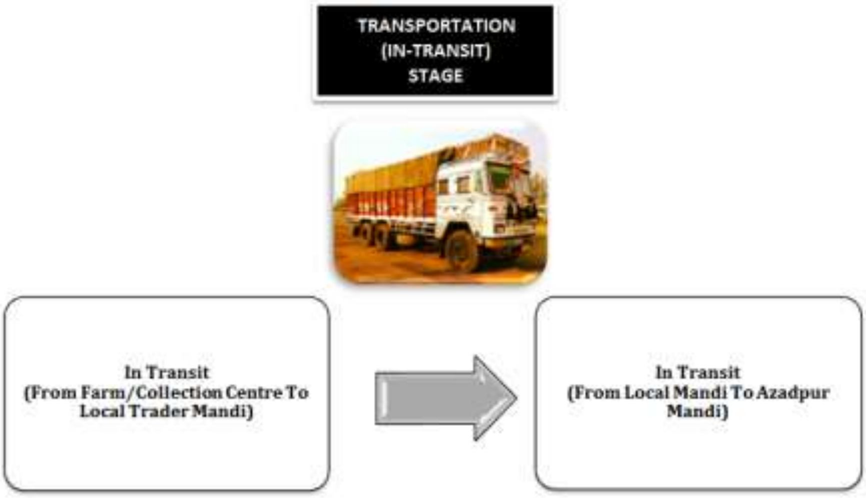



**Figure 5.21: Activities in Transportation Stage of Tomato Supply Chain**

To analyse and identify the activities contributing to supply chain inefficiency with respect to cost, time, and quality across the stages of fruits and vegetables supply chain i.e. farm stage, local trader stage, local mandi stage, wholesaler stage, and transportation stage, ranking method is adopted on the basis of weighted scores (Guritno, Fujianti and Kusumasari, 2015; Ramanathan and Parthasarathy, 2014; Ajagbe et al., 2014; Singh, 2012; Sarode, 2010; Aramyan et al., 2007; Shehrawat, 2006). The significant activity was measured on a five-point Likert based scale ranging from not significant, less significant, neutral, significant, and highly significant and a weightage of 1,2,3,4, and 5 (as shown in Table 5.33) were assigned, respectively as per experts' opinion. Based on the responses obtained from stakeholders on their degree of significance, a total choice score (TCS)/Weightage score for each activity and its percentage (%) contribution in overall weighted score was worked out and then the total choice scores/weighted score so obtained for each activity was converted into weighted mean score. At last, rank orders were given for each activity based on their weighted mean scores (Shehrawat, 2006; Singh, 2012).

**Table 5.33: Weight Assigned**

| Rating Scale | Degree of Significance | Weight Assigned |
|---|---|---|
| 1 | Not significant | 1 |
| 2 | Less significant | 2 |
| 3 | Neutral | 3 |
| 4 | Significant | 4 |
| 5 | Highly significant | 5 |

The activities contributing to supply chain inefficiency across the stages of F&V supply chain are discussed under.

#### 5.3.1.2. Activities contributing to supply chain inefficiency in Fruits supply chain with specific reference to Mango

***Activities contributing to supply chain inefficiency in Farm stage (Stage I) of fruits supply chain***

The activities, which are performed in farm stage of fruits (mango) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.34 highlights that major five activities, which are contributing to supply chain inefficiency with respect to cost in farm stage are Plucking & collection of mangoes in crates/baskets (4.26), Sorting, grading & packaging in carton box/wooden box/crates/gunny bags as per the grade & taping and tying (4.09), Carriage of packed crate/box/bags for loading in tractor/bullock cart/truck/mini trucks (4.06), Handling, loading & stacking of box/carton/crates in tractor/bullock cart/truck/mini trucks (3.99), and Cleaning/washing of mangoes (3.96).

Plucking & collection of mangoes in crates/baskets, Sorting grading & packaging in carton box/wooden box/crates/gunny bags as per the grade & taping and tying, and Carriage of packed crate/box/bags for loading in tractor/bullock cart/truck/mini trucks have been ranked as the top three activities contributing to supply chain inefficiency with respect to cost.

**Table 5.34: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage I**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Plucking & Collection of Mangoes in Crates/Baskets | 10 | 13 | 39 | 111 | 187 | 360 | 1532 | 14.63 | 4.26 | **1** |
| A2 | Carriage of Crates/Baskets to the Collection Area | 15 | 21 | 64 | 118 | 142 | 360 | 1431 | 13.66 | 3.98 | **6** |
| A3 | Unloading of fully loaded Crates/baskets at Collection/ Assembling area | 61 | 179 | 69 | 30 | 21 | 360 | 851 | 8.12 | 2.36 | **8** |
| A4 | Cleaning/Washing of Mangoes | 15 | 24 | 64 | 115 | 142 | 360 | 1425 | 13.60 | 3.96 | **5** |
| A5 | Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the grade & Taping and Tying | 24 | 17 | 37 | 108 | 174 | 360 | 1471 | 14.04 | 4.09 | **2** |
| A6 | Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/Mini Trucks | 12 | 18 | 58 | 120 | 152 | 360 | 1462 | 13.96 | 4.06 | **3** |
| A7 | Handling, Loading & Stacking of Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks | 19 | 26 | 55 | 101 | 159 | 360 | 1435 | 13.70 | 3.99 | **4** |
| A8 | Tying the Load in Tractor/Bullock cart/Truck/Mini Trucks | 58 | 152 | 111 | 22 | 17 | 360 | 868 | 8.29 | 2.41 | **7** |
| **Total** | | | | | | | | 10475 | 100 | | |

With respect to time inefficiency, sorting, grading & packaging in carton box/ wooden box/crates/gunny bags as per the grade & taping and tying (4.45), Plucking & collection of mangoes in crates/baskets (4.27), Carriage of crates/baskets to the collection area (4.14), Carriage of packed crate/box/bags for loading in tractor/bullock cart/truck/mini trucks (4.09), and Handling, loading & stacking of box/carton/crates in tractor/bullock cart/truck/mini trucks (4.00) are the five major activities contributing to supply chain inefficiency (shown in Table 5.35).

Sorting, grading & packaging in carton box/ wooden box/crates/gunny bags as per the grade & taping and tying, Plucking & collection of mangoes in crates/baskets, carriage of crates/baskets to the collection area have been ranked as the top three activities contributing to supply chain inefficiency with respect to time.

**Table 5.35: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage I**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Plucking & Collection of Mangoes in Crates/Baskets | 8 | 8 | 42 | 123 | 179 | 360 | 1537 | 13.77 | 4.27 | **2** |
| A2 | Carriage of Crates/Baskets to the Collection Area | 8 | 11 | 62 | 119 | 160 | 360 | 1492 | 13.36 | 4.14 | **3** |
| A3 | Unloading of fully loaded Crates/baskets at Collection/ Assembling area | 15 | 40 | 162 | 114 | 29 | 360 | 1182 | 10.59 | 3.28 | **7** |
| A4 | Cleaning/Washing of Mangoes | 17 | 36 | 39 | 133 | 135 | 360 | 1413 | 12.66 | 3.93 | **6** |
| A5 | Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the grade & Taping and Tying | 8 | 6 | 24 | 99 | 223 | 360 | 1603 | 14.36 | 4.45 | **1** |
| A6 | Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/Mini Trucks | 7 | 10 | 98 | 72 | 173 | 360 | 1474 | 13.20 | 4.09 | **4** |
| A7 | Handling, Loading & Stacking of Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks | 21 | 22 | 48 | 115 | 154 | 360 | 1439 | 12.89 | 4.00 | **5** |
| A8 | Tying the Load in Tractor/Bullock cart/Truck/Mini Trucks | 44 | 94 | 132 | 53 | 37 | 360 | 1025 | 9.18 | 2.85 | **8** |
| **Total** | | | | | | | | 11165 | 100 | | |

Sorting, grading & packaging in carton box/ wooden box/crates/gunny bags as per the grade & taping and tying (4.41), Plucking & collection of mangoes in crates/baskets (4.35), Handling, loading & stacking of box/carton/crates in tractor/bullock cart/truck/mini trucks (4.23), Unloading of fully loaded crates/baskets at collection/assembling area (4.09), and Cleaning/washing of mangoes (4.06) are the activities contributing to poor quality in the farm stage of fruits (mango) supply chain (as shown in Table 5.36).

Sorting, grading & packaging in carton box/ wooden box/crates/gunny bags as per the grade & taping and tying, Plucking & collection of mangoes in crates/baskets, and Handling, loading & stacking of box/carton/crates in tractor/bullock cart/truck/mini trucks have been ranked as the top three activities contributing to supply chain inefficiency with respect to quality.

**Table 5.36: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage I**

| Activity | | Scale 1 | 2 | 3 | 4 | 5 | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | Plucking & Collection of Mangoes in Crates/Baskets | 6 | 11 | 24 | 129 | 190 | 360 | 1566 | 13.70 | 4.35 | **2** |
| A2 | Carriage of Crates/Baskets to the Collection Area | 8 | 42 | 147 | 102 | 61 | 360 | 1246 | 10.90 | 3.46 | **7** |
| A3 | Unloading of fully loaded Crates/baskets at Collection/ Assembling area | 12 | 12 | 25 | 195 | 116 | 360 | 1471 | 12.87 | 4.09 | **4** |
| A4 | Cleaning/Washing of Mangoes | 11 | 14 | 75 | 101 | 159 | 360 | 1463 | 12.80 | 4.06 | **5** |
| A5 | Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the grade & Taping and Tying | 6 | 11 | 26 | 102 | 215 | 360 | 1589 | 13.91 | 4.41 | **1** |
| A6 | Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/Mini Trucks | 15 | 17 | 54 | 122 | 152 | 360 | 1459 | 12.77 | 4.05 | **6** |
| A7 | Handling, Loading & Stacking of Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks | 8 | 15 | 32 | 137 | 168 | 360 | 1522 | 13.32 | 4.23 | **3** |
| A8 | Tying the Load in Tractor/Bullock cart/Truck/Mini Trucks | 19 | 44 | 205 | 71 | 21 | 360 | 1111 | 9.72 | 3.09 | **8** |
| **Total** | | | | | | | | 11427 | 100 | | |

The Table 5.37 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in farm stage of fruits (mango) supply chain.

**Table 5.37: Activity Contributing to Supply Chain Inefficiency with respect to-**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| Plucking & Collection of Mangoes in Crates/Baskets | 4.26 | Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the grade & Taping and Tying | 4.45 | Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the grade & Taping and Tying | 4.41 |
| Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the grade & Taping and Tying | 4.09 | Plucking & Collection of Mangoes in Crates/Baskets | 4.27 | Plucking & Collection of Mangoes in Crates/Baskets | 4.35 |
| Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/Mini Trucks | 4.06 | Carriage of Crates/Baskets to the Collection Area | 4.14 | Handling, Loading & Stacking of Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks | 4.23 |

***Activities contributing to supply chain inefficiency in Local trader/Middlemen stage (Stage II) of fruits supply chain***

The activities, which are performed in local trader/Middlemen stage of fruits (mango) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables 5.38. An analysis of data presented in the Table 5.38 highlights that major five activities, which are leading to supply chain inefficiency with respect to cost in local trader/middlemen stage are Sorting, grading & repackaging of mango as per the grades in another crates by the buyer (local trader) for further selling (4.20), Handling, loading & stacking of box/carton/crates in trucks (4.07), Unloading of box/carton/crates/bags from tractor/bullock cart/truck/mini trucks to the area of local agents/local market (4.01), Unloading of mango from crates (at local market) by the buyer (local trader) (3.89), and Storing of fresh produce at local agents area/local market (3.15).

Sorting, grading & repackaging of mango as per the grades in another crates by the buyer (local trader) for further selling, Handling, loading & stacking of box/carton/crates in trucks, and Unloading of box/carton/crates/ bags from tractor/bullock cart/truck/mini trucks to the area of local agents/ local market have been ranked as the top three activities contributing to supply chain inefficiency with respect to cost in this stage.

**Table 5.38: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage II**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Box/Carton/Crates/ Bags from Tractor/Bullock cart/Truck/Mini Trucks to the area of Local Agents/ local market | 8 | 12 | 44 | 71 | 95 | 230 | 923 | 14.78 | 4.01 | **3** |
| A2 | Storing of Fresh Produce at Local Agents area/Local market | 16 | 38 | 95 | 58 | 23 | 230 | 724 | 11.59 | 3.15 | **5** |
| A3 | Auctioning/Selling of Fresh Produce | 28 | 105 | 58 | 16 | 23 | 230 | 591 | 9.46 | 2.57 | **8** |
| A4 | Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | 25 | 100 | 49 | 41 | 15 | 230 | 611 | 9.78 | 2.66 | **6** |
| A5 | Unloading of mango from Crates (at Local Market) by the buyer(Local trader) | 16 | 21 | 32 | 64 | 97 | 230 | 895 | 14.33 | 3.89 | **4** |
| A6 | Sorting, Grading & Repackaging of Mango as per the Grades in another Crates by the buyer (Local trader) for further selling | 12 | 14 | 18 | 58 | 128 | 230 | 966 | 15.47 | 4.20 | **1** |
| A7 | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 11 | 15 | 30 | 66 | 108 | 230 | 935 | 14.97 | 4.07 | **2** |
| A8 | Tying the Load in Trucks | 36 | 64 | 97 | 20 | 13 | 230 | 600 | 9.61 | 2.61 | **7** |
| **Total** | | | | | | | | 6245 | 100 | | |

Sorting, grading & repackaging of mango as per the grades in another crates by the buyer (local trader) for further selling (4.37), Unloading of mango from crates (at local market) by the buyer (local trader) (4.07), Handling, loading & stacking of box/carton/crates in trucks (4.00), Unloading of box/carton/crates/bags from tractor/bullock cart/truck/mini trucks to the area of local agents/local market (3.88), and Auctioning/selling of fresh produce (3.85) are the five major activities contributing to supply chain inefficiency with respect to time (as shown in Table 5.39).

Sorting, grading & repackaging of mango as per the grades in another crate by the buyer (local trader) for further selling, Unloading of mango from crates (at local market) by the buyer (local trader), and Handling, loading & stacking of box/carton/crates in trucks have been ranked as the top three activities contributing to supply chain inefficiency with respect to time at this stage.

**Table 5.39: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage II**

| **Activity** | | **Scale** | | | | | **N** | **TCS** | **%** | **WMS** | **Rank** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | | | | | |
| A1 | Unloading of Box/Carton/Crates/ Bags from Tractor/Bullock cart/Truck/Mini Trucks to the area of Local Agents/ local market | 16 | 21 | 31 | 68 | 94 | 230 | 893 | 13.17 | 3.88 | **4** |
| A2 | Storing of Fresh Produce at Local Agents area/Local market | 20 | 20 | 38 | 69 | 83 | 230 | 865 | 12.76 | 3.76 | **6** |
| A3 | Auctioning/Selling of Fresh Produce | 15 | 19 | 43 | 61 | 92 | 230 | 886 | 13.07 | 3.85 | **5** |
| A4 | Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | 25 | 74 | 105 | 16 | 10 | 230 | 602 | 8.88 | 2.62 | **8** |
| A5 | Unloading of mango from Crates (at Local Market) by the buyer(Local trader) | 12 | 8 | 41 | 59 | 110 | 230 | 937 | 13.82 | 4.07 | **2** |
| A6 | Sorting, Grading & Repackaging of Mango as per the Grades in another Crates by the buyer (Local trader) for further selling | 8 | 7 | 21 | 49 | 145 | 230 | 1006 | 14.84 | 4.37 | **1** |
| A7 | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 13 | 12 | 36 | 69 | 100 | 230 | 921 | 13.58 | 4.00 | **3** |
| A8 | Tying the Load in Trucks | 25 | 28 | 126 | 44 | 7 | 230 | 670 | 9.88 | 2.91 | **7** |
| **Total** | | | | | | | | 6780 | 100 | | |

With respect to quality, Storing of fresh produce at local agents area/local market (4.48), unloading of mango from crates (at local market) by the buyer (local trader) (4.20), Handling, loading & stacking of box/carton/crates in trucks (4.02), Sorting, grading & repackaging of mango as per the grades in another crates by the buyer (local trader) for further selling (3.92), and Inspection/quality check (random sampling) by the buyer (local trader) (3.76) are the five major activities contributing to supply chain inefficiency (as shown in Table 5.40).

In this stage, Storing of fresh produce at local agents area/local market, Unloading of mango from crates (at local market) by the buyer (local trader), Handling, loading & stacking of box/carton/crates in trucks have been ranked as the top three activities contributing to supply chain inefficiency with respect to quality.

**Table 5.40: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage II**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Box/Carton/Crates/ Bags from Tractor/Bullock cart/Truck/Mini Trucks to the area of Local Agents/ local market | 8 | 25 | 44 | 95 | 58 | 230 | 860 | 12.42 | 3.74 | **6** |
| A2 | Storing of Fresh Produce at Local Agents area/Local market | 5 | 8 | 10 | 56 | 151 | 230 | 1030 | 14.87 | 4.48 | **1** |
| A3 | Auctioning/Selling of Fresh Produce | 13 | 112 | 57 | 35 | 13 | 230 | 613 | 8.85 | 2.67 | **8** |
| A4 | Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | 8 | 21 | 43 | 105 | 53 | 230 | 864 | 12.48 | 3.76 | **5** |
| A5 | Unloading of mango from Crates (at Local Market) by the buyer(Local trader) | 5 | 10 | 28 | 79 | 108 | 230 | 965 | 13.94 | 4.20 | **2** |
| A6 | Sorting, Grading & Repackaging of Mango as per the Grades in another Crates by the buyer (Local trader) for further selling | 15 | 20 | 30 | 69 | 96 | 230 | 901 | 13.01 | 3.92 | **4** |
| A7 | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 8 | 13 | 38 | 79 | 92 | 230 | 924 | 13.34 | 4.02 | **3** |
| A8 | Tying the Load in Trucks | 8 | 28 | 102 | 62 | 30 | 230 | 768 | 11.09 | 3.34 | **7** |
| **Total** | | | | | | | | 6925 | 100 | | |

The table 5.41 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in local trader/middlemen stage of fruits (mango) supply chain.

**Table 5.41: Activity Contributing to Supply Chain Inefficiency with respect to-**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| Sorting, Grading & Repackaging of Mango as per the Grades in another Crates by the buyer (Local trader) for | 4.20 | Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the | 4.37 | Storing of Fresh Produce at Local Agents area/Local market | 4.48 |

| | | | | | |
|---|---|---|---|---|---|
| further selling | | grade & Taping and Tying | | | |
| Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 4.07 | Unloading of mango from Crates (at Local Market) by the buyer(Local trader) | 4.07 | Unloading of mango from Crates (at Local Market) by the buyer(Local trader) | 4.20 |
| Unloading of mango from Crates (at Local Market) by the buyer(Local trader) | 4.01 | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 4.00 | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 4.02 |

***Activities contributing to supply chain inefficiency in Wholesale/Mandi stage (Stage III) of fruits supply chain***

The activities, which are performed in wholesale/mandi stage of fruits (mango) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.42 highlights that major five activities, which are contributing to supply chain inefficiency with respect to cost in wholesale/mandi stage are Unloading of crates/cartons/wooden box from trucks at mandi level (4.25), Handling, loading & stacking of goods in mini vans/trucks/rickshaw/bullock carts (4.06), storing of crates/cartons/wooden box at mandi (3.91), Auctioning/selling of mangoes (2.71), and tying the load in trucks mini vans/rickshaw/bullock cart (2.63).

Unloading of crates/cartons/wooden box from trucks at mandi level, Handling, loading & stacking of goods in mini vans/trucks/rickshaw/bullock carts, and Storing of crates/cartons/wooden box at mandi have been ranked as the top three activities contributing to supply chain inefficiency with respect to cost in this stage.

**Table 5.42: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage III**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 7 | 11 | 20 | 34 | 108 | 180 | 765 | 21.34 | 4.25 | **1** |
| A2 | Storing of Crates/ Cartons /Wooden Box at Mandi | 10 | 15 | 31 | 50 | 74 | 180 | 703 | 19.61 | 3.91 | **3** |
| A3 | Auctioning/Selling of Mangoes | 27 | 43 | 76 | 23 | 11 | 180 | 488 | 13.62 | 2.71 | **4** |
| A4 | Quality Inspection by the buyers (Random Sampling) | 43 | 85 | 16 | 16 | 20 | 180 | 425 | 11.86 | 2.36 | **6** |
| A5 | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | 7 | 14 | 27 | 46 | 86 | 180 | 730 | 20.37 | 4.06 | **2** |
| A6 | Tying the Load in Trucks Mini Vans/ Rikshaw/Bullock Cart | 23 | 82 | 32 | 25 | 18 | 180 | 473 | 13.20 | 2.63 | **5** |
| **Total** | | | | | | | | 3584 | 100 | | |

With respect to time inefficiency, Unloading of crates/cartons/wooden box from trucks at mandi level (4.32), Storing of crates/cartons/wooden box at mandi (4.04), Handling, loading & stacking of goods in mini vans/trucks/rickshaw/bullock carts (3.94), Auctioning/Selling of mangoes (3.84), and Tying the load in trucks/mini vans/rickshaw/bullock cart (2.68) are the five major activities contributing to supply chain inefficiency (as shown in Table 5.43).

Unloading of crates/cartons/wooden box from trucks at mandi level, Storing of crates/cartons/wooden box at mandi, Handling, loading & stacking of goods in mini vans/trucks/rickshaw/bullock carts have been ranked as the top three activities contributing to supply chain inefficiency with respect to time in this stage.

**Table 5.43: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage III**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 7 | 9 | 13 | 41 | 110 | 180 | 778 | 20.27 | 4.32 | **1** |
| A2 | Storing of Crates/ Cartons /Wooden Box at Mandi | 9 | 11 | 27 | 50 | 83 | 180 | 727 | 18.94 | 4.04 | **2** |
| A3 | Auctioning/Selling of Mangoes | 11 | 16 | 36 | 45 | 72 | 180 | 691 | 18.00 | 3.84 | **4** |
| A4 | Quality Inspection by the buyers (Random Sampling) | 27 | 72 | 50 | 26 | 5 | 180 | 450 | 11.72 | 2.50 | **6** |
| A5 | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | 9 | 15 | 32 | 45 | 79 | 180 | 710 | 18.50 | 3.94 | **3** |
| A6 | Tying the Load in Trucks Mini Vans/ Rikshaw/Bullock Cart | 27 | 50 | 71 | 18 | 14 | 180 | 482 | 12.56 | 2.68 | **5** |
| **Total** | | | | | | | | 3838 | 100 | | |

Storing of crates/cartons/wooden box at mandi (4.48), unloading of crates/cartons/wooden box from trucks at mandi level (4.14), Handling, loading & stacking of goods in mini vans/trucks/rickshaw/bullock carts (3.91), Tying the load in trucks mini vans/rickshaw/bullock cart (2.65), and Auctioning/selling of mangoes (2.39) are the five major activities contributing to supply chain inefficiency with respect to quality (as shown in Table 5.44).

In this stage, Storing of crates/cartons/wooden box at mandi, Unloading of crates/cartons/wooden box from trucks at mandi level, and Handling, loading & stacking of goods in mini vans/trucks/rickshaw/bullock carts have been ranked as the top three activities contributing to supply chain inefficiency with respect to quality.

**Table 5.44: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage III**

| Activity | | Scale 1 | 2 | 3 | 4 | 5 | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 7 | 11 | 20 | 54 | 88 | 180 | 745 | 21.03 | 4.14 | **2** |
| A2 | Storing of Crates/ Cartons /Wooden Box at Mandi | 5 | 7 | 9 | 35 | 124 | 180 | 806 | 22.75 | 4.48 | **1** |
| A3 | Auctioning/Selling of Mangoes | 25 | 98 | 32 | 11 | 14 | 180 | 431 | 12.16 | 2.39 | **5** |
| A4 | Quality Inspection by the buyers (Random Sampling) | 63 | 72 | 20 | 11 | 14 | 180 | 381 | 10.75 | 2.12 | **6** |
| A5 | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | 7 | 18 | 34 | 47 | 74 | 180 | 703 | 19.84 | 3.91 | **3** |
| A6 | Tying the Load in Trucks Mini Vans/ Rikshaw/Bullock Cart | 25 | 47 | 81 | 20 | 7 | 180 | 477 | 13.46 | 2.65 | **4** |
| **Total** | | | | | | | | 3543 | 100 | | |

The table 5.45 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in wholesale/mandi stage of fruits (mango) supply chain.

**Table 5.45: Activity Contributing to Supply Chain Inefficiency with respect to:**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 4.25 | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 4.32 | Storing of Crates/ Cartons /Wooden Box at Mandi | 4.48 |
| Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 4.06 | Storing of Crates/ Cartons /Wooden Box at Mandi | 4.04 | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 4.14 |
| Storing of Crates/ Cartons /Wooden Box at Mandi | 3.91 | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | 3.94 | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | 3.91 |

***Activities contributing to supply chain inefficiency in Local Trader/Mashakhor stage (Stage IV) of fruits supply chain***

The activities, which are performed in Local Trader stage of fruits (mango) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.46 highlights that major five activities, which are contributing to supply chain inefficiency with respect to cost in local trader/mashakhor stage are Sorting, grading & repackaging of mangoes by the local traders/mashakhor at Azadpur mandi for further sale (4.46), Unloading of crates/cartons/box from mini vans/rickshaw/bullock cart to LT's/Mashakhor area at Azadpur mandi (4.04), Storing & Ripening (3.91), Cleaning of mangoes (3.76), and Storing of goods (2.85). Sorting, grading & repackaging of mangoes by the local traders/mashakhor at Azadpur mandi for further sale, Unloading of crates/cartons/box from mini vans/rickshaw/bullock cart to LT's/Mashakhor area at Azadpur mandi, and Storing & Ripening activity have been ranked as the top three activities contributing to supply chain inefficiency with respect to cost in this stage.

**Table 5.46: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage IV**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's/Mashakhor' s area at Azadpur mandi | 5 | 12 | 25 | 28 | 70 | 140 | 566 | 16.84 | 4.04 | **2** |
| A2 | Storing of Goods | 12 | 37 | 63 | 16 | 12 | 140 | 399 | 11.87 | 2.85 | **5** |
| A3 | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | 12 | 40 | 65 | 16 | 7 | 140 | 386 | 11.48 | 2.76 | **6** |
| A4 | Cleaning of Mangoes | 7 | 12 | 23 | 63 | 35 | 140 | 527 | 15.68 | 3.76 | **4** |
| A5 | Sorting, Grading & Repackaging of Mangoes by the Local traders/Mashakhor at Azadpur Mandi for further sale | 2 | 5 | 12 | 28 | 93 | 140 | 625 | 18.59 | 4.46 | **1** |
| A6 | Storing & Ripening | 9 | 12 | 19 | 42 | 58 | 140 | 548 | 16.30 | 3.91 | **3** |
| A7 | Selling of Mangoes to customers | 28 | 77 | 16 | 14 | 5 | 140 | 311 | 9.25 | 2.22 | **7** |
| **Total** | | | | | | | | 3362 | 100 | | |

With respect to time inefficiency, Storing & Ripening (4.38), Sorting, grading & repackaging of mangoes by the local traders/mashakhor at Azadpur mandi for further sale (4.21), Unloading of mango from crates/cartons/wooden box for the purpose of further sorting & grading (4.02), Storing of goods (3.85), and Cleaning of mangoes (3.81) are the five major activities contributing to supply chain inefficiency (as shown in Table 5.47).

Storing & Ripening, Sorting, grading & repackaging of mangoes by the local traders/mashakhor at Azadpur mandi for further sale, and Unloading of mango from crates/cartons/wooden box for the purpose of further sorting & grading have been ranked as the top three activities contributing to supply chain inefficiency with respect to time in this stage.

**Table 5.47: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage IV**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's/Mashakhor' s area at Azadpur mandi | 12 | 16 | 21 | 40 | 51 | 140 | 522 | 13.50 | 3.73 | **6** |
| A2 | Storing of Goods | 7 | 16 | 26 | 33 | 58 | 140 | 539 | 13.93 | 3.85 | **4** |
| A3 | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | 5 | 14 | 19 | 37 | 65 | 140 | 563 | 14.56 | 4.02 | **3** |
| A4 | Cleaning of Mangoes | 9 | 9 | 14 | 75 | 33 | 140 | 534 | 13.81 | 3.81 | **5** |
| A5 | Sorting, Grading & Repackaging of Mangoes by the Local traders/Mashakhor at Azadpur Mandi for further sale | 5 | 5 | 16 | 44 | 70 | 140 | 589 | 15.23 | 4.21 | **2** |
| A6 | Storing & Ripening | 5 | 7 | 9 | 28 | 91 | 140 | 613 | 15.85 | 4.38 | **1** |
| A7 | Selling of Mangoes to customers | 9 | 17 | 21 | 63 | 30 | 140 | 508 | 13.13 | 3.63 | **7** |
| **Total** | | | | | | | | 3868 | 100 | | |

Storing & Ripening (4.50), Storing of goods (4.06), Unloading of mango from crates/cartons/wooden box for the purpose of further sorting & grading (3.94), Unloading of crates/cartons/box from mini vans/rickshaw/bullock cart to LT's/Mashakhor' s area at Azadpur mandi (3.74), and Sorting, grading & repackaging of mangoes by the local traders/mashakhor at Azadpur mandi for further sale (3.21) are the five major activities contributing to supply chain inefficiency with respect to quality (as shown in Table 5.48).

In this stage, Storing & Ripening, Storing of goods, and Unloading of mango from crates/cartons/wooden box for the purpose of further sorting & grading have been ranked as the top three activities contributing to supply chain inefficiency with respect to quality.

**Table 5.48: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage IV**

| Activity | | Scale 1 | 2 | 3 | 4 | 5 | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's/Mashakhor' s area at Azadpur mandi | 5 | 14 | 28 | 58 | 35 | 140 | 524 | 15.30 | 3.74 | **4** |
| A2 | Storing of Goods | 7 | 9 | 21 | 35 | 68 | 140 | 568 | 16.59 | 4.06 | **2** |
| A3 | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | 7 | 14 | 21 | 37 | 61 | 140 | 551 | 16.09 | 3.94 | **3** |
| A4 | Cleaning of Mangoes | 16 | 63 | 40 | 12 | 9 | 140 | 355 | 10.37 | 2.54 | **6** |
| A5 | Sorting, Grading & Repackaging of Mangoes by the Local traders/Mashakhor at Azadpur Mandi for further sale | 9 | 17 | 63 | 37 | 14 | 140 | 450 | 13.14 | 3.21 | **5** |
| A6 | Storing & Ripening | 2 | 5 | 12 | 23 | 98 | 140 | 630 | 18.40 | 4.50 | **1** |
| A7 | Selling of Mangoes to customers | 23 | 56 | 40 | 14 | 7 | 140 | 346 | 10.11 | 2.47 | **7** |
| **Total** | | | | | | | | 3424 | 100 | | |

The table 5.49 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in local trader/mashakhor stage of fruits (mango) supply chain.

**Table 5.49: Activity Contributing to Supply Chain Inefficiency with respect to-**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| Sorting, Grading & Repackaging of Mangoes by the Local traders at Adarshnagar, Azadpur for further sale | 4.46 | Storing & Ripening | 4.38 | Storing & Ripening | 4.50 |
| Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's/Mashakhor' s area at Azadpur mandi | 4.04 | Sorting, Grading & Repackaging of Mangoes by the Local traders/Mashakhor at Azadpur Mandi for further sale | 4.21 | Storing of Goods | 4.06 |
| Storing & Ripening | 3.91 | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | 4.02 | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | 3.94 |

***Activities contributing to supply chain inefficiency in Transportation stage (Stage V) of fruits supply chain***

The Transportation stage of fruits (mango) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.50 highlights that transportation from the local market to mandi has maximum inefficiency with respect to cost (4.07), followed by transportation from farm to local market (3.90), and from mandi to local trade area (3.20).

Transportation from the local market to mandi has been ranked as the top transit phase contributing to supply chain inefficiency with respect to cost in transportation.

**Table 5.50: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage V**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | In Transit (From Farm To Local Market/Main Road) | 9 | 25 | 38 | 111 | 87 | 270 | 1052 | 34.90 | 3.90 | **2** |
| A2 | In Transit (From Local Market To Mandi) | 8 | 30 | 27 | 75 | 130 | 270 | 1099 | 36.46 | 4.07 | **1** |
| A3 | In Transit (From Mandi To local trade area) | 36 | 42 | 74 | 69 | 49 | 270 | 863 | 28.63 | 3.20 | **3** |
| **Total** | | | | | | | | 3014 | 100 | | |

With respect to time inefficiency, transportation of fresh produce from the local market to mandi has maximum inefficiency (4.31) which is contributing to high lead time, followed by transportation from farm to local market (4.12), and from mandi to local trade area (3.82) as shown in Table 5.51.

Transportation from the local market to mandi has been ranked as the top transit phase contributing to supply chain inefficiency with respect to time in transportation.

**Table 5.51: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage V**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | In Transit (From Farm To Local Market/Main Road) | 11 | 19 | 19 | 99 | 122 | 270 | 1112 | 33.62 | 4.12 | **2** |
| A2 | In Transit (From Local Market To Mandi) | 11 | 9 | 16 | 83 | 151 | 270 | 1164 | 35.19 | 4.31 | **1** |
| A3 | In Transit (From Mandi To local trade area) | 11 | 29 | 69 | 49 | 112 | 270 | 1032 | 31.20 | 3.82 | **3** |
| **Total** | | | | | | | | 3308 | 100 | | |

With respect to quality inefficiency, transportation of fresh produce from the local market to mandi has maximum inefficiency (4.32) which is contributing to poor quality, followed by transportation from farm to local market (4.19), and from mandi to local trade area (3.69) as shown in Table 5.52.

Transportation from the local market to mandi has been ranked as the top transit phase contributing to supply chain inefficiency with respect to quality in transportation.

**Table 5.52: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage V**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | In Transit (From Farm To Local Market/Main Road) | 13 | 16 | 13 | 93 | 135 | 270 | 1131 | 34.35 | 4.19 | **2** |
| A2 | In Transit (From Local Market To Mandi) | 9 | 11 | 22 | 71 | 157 | 270 | 1166 | 35.41 | 4.32 | **1** |
| A3 | In Transit (From Mandi To local trade area) | 24 | 20 | 38 | 122 | 66 | 270 | 996 | 30.25 | 3.69 | **3** |
| **Total** | | | | | | | | 3293 | 100 | | |

The table 5.53 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in transportation stage of fruits (mango) supply chain.

**Table 5.53: Activity Contributing to Supply Chain Inefficiency with respect to-**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| In Transit (From Local Market To Mandi) | 4.07 | In Transit (From Local Market To Mandi) | 4.31 | In Transit (From Local Market To Mandi) | 4.32 |
| In Transit (From Farm To Local Market/ Main Road) | 3.90 | In Transit (From Farm To Local Market/Main Road) | 4.12 | In Transit (From Farm To Local Market/Main Road) | 4.19 |
| In Transit (From Mandi To local trade area) | 3.20 | In Transit (From Mandi To local trade area) | 3.82 | In Transit (From Mandi To local trade area) | 3.69 |

5.3.1.3. **<u>Activities contributing to supply chain inefficiency in the Vegetables supply chain with specific reference to Tomato</u>**

***Activities contributing to supply chain inefficiency in Farm stage (Stage I) of the vegetables supply chain***

The activities, which are performed in farm stage of vegetables (tomato) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.54 highlights that major five activities, which are contributing to supply chain inefficiency with respect to cost in farm stage are Carriage of crates to the collection area/collection centre (4.46), Handling, loading and stacking of crates in mini vehicles or trucks (4.05), Sorting & grading of tomatoes and packing in crates as per the grade (4.00), Plucking & collecting tomato in bucket/basket (3.73), and Consolidation of goods (2.87).

Carriage of crates to the collection area/collection center, Handling, loading and stacking of crates in mini vehicles or trucks, and Sorting & grading of tomatoes and packing in crates as per the grade have been ranked as the top three activities contributing to supply chain inefficiency with respect to cost.

**Table 5.54: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage I**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Plucking & Collecting Tomato in Bucket/ Basket | 27 | 37 | 66 | 81 | 129 | 340 | 1268 | 12.30 | 3.73 | **4** |
| A2 | Picking from Bucket/ Basket and Putting in Crates | 99 | 144 | 56 | 22 | 19 | 340 | 738 | 7.16 | 2.17 | **9** |
| A3 | Carriage of Crates to the Collection Area/Collection Centre | 12 | 9 | 24 | 60 | 235 | 340 | 1517 | 14.71 | 4.46 | **1** |
| A4 | Storing of Goods | 82 | 151 | 61 | 32 | 14 | 340 | 765 | 7.42 | 2.25 | **7** |
| A5 | Unloading of fully loaded Crates at Collection Area/ Centre | 46 | 83 | 134 | 31 | 46 | 340 | 968 | 9.39 | 2.85 | **6** |
| A6 | Cleaning of Tomatoes | 70 | 192 | 37 | 26 | 15 | 340 | 744 | 7.22 | 2.19 | **8** |
| A7 | Sorting & Grading of Tomatoes and Packing in Crates as per the grade | 17 | 22 | 53 | 99 | 149 | 340 | 1361 | 13.20 | 4.00 | **3** |
| A8 | Consolidation of Goods | 32 | 79 | 158 | 44 | 27 | 340 | 975 | 9.46 | 2.87 | **5** |
| A9 | Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | 15 | 27 | 48 | 85 | 165 | 340 | 1378 | 13.36 | 4.05 | **2** |
| A10 | Tying the Load in Mini Vehicles or Trucks | 180 | 104 | 27 | 17 | 12 | 340 | 597 | 5.79 | 1.76 | **10** |
| **Total** | | | | | | | | 10311 | 100 | | |

With respect to time inefficiency, Carriage of crates to the collection area/collection centre (4.56), Sorting & grading of tomatoes and packing in crates as per the grade (4.33), Plucking & collecting tomato in bucket/basket (4.18), Storing of goods (3.98), and Picking from bucket/basket and putting in crates (3.88) are the five major activities contributing to supply chain inefficiency (shown in Table 5.55).

In this stage, Carriage of crates to the collection area/collection center, Sorting & grading of tomatoes and packing in crates as per the grade, and Plucking & collecting tomato in bucket/basket have been ranked as the top three activities contributing to supply chain inefficiency with respect to time.

**Table 5.55: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage I**

| **Activity** | | **Scale** | | | | | **N** | **TCS** | **%** | **WMS** | **Rank** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | | | | | |
| A1 | Plucking & Collecting Tomato in Bucket/ Basket | 12 | 20 | 34 | 102 | 172 | 340 | 1422 | 10.86 | 4.18 | **3** |
| A2 | Picking from Bucket/ Basket and Putting in Crates | 15 | 17 | 43 | 183 | 82 | 340 | 1320 | 10.09 | 3.88 | **5** |
| A3 | Carriage of Crates to the Collection Area/Collection Centre | 5 | 9 | 16 | 70 | 240 | 340 | 1551 | 11.85 | 4.56 | **1** |
| A4 | Storing of Goods | 15 | 25 | 54 | 105 | 141 | 340 | 1352 | 10.33 | 3.98 | **4** |
| A5 | Unloading of fully loaded Crates at Collection Area/ Centre | 22 | 32 | 53 | 99 | 134 | 340 | 1311 | 10.02 | 3.86 | **6** |
| A6 | Cleaning of Tomatoes | 31 | 83 | 172 | 32 | 22 | 340 | 951 | 7.27 | 2.80 | **10** |
| A7 | Sorting & Grading of Tomatoes and Packing in Crates as per the grade | 10 | 14 | 31 | 83 | 202 | 340 | 1473 | 11.25 | 4.33 | **2** |
| A8 | Consolidation of Goods | 10 | 24 | 61 | 162 | 83 | 340 | 1304 | 9.96 | 3.84 | **7** |
| A9 | Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | 20 | 37 | 59 | 90 | 134 | 340 | 1301 | 9.94 | 3.83 | **8** |
| A10 | Tying the Load in Mini Vehicles or Trucks | 17 | 34 | 181 | 65 | 43 | 340 | 1103 | 8.43 | 3.24 | **9** |
| **Total** | | | | | | | | 13088 | 100 | | |

Storing of Goods (4.45), Carriage of crates to the collection area/collection centre (4.22), Handling, loading and stacking of crates in mini vehicles or trucks (4.00), Sorting & grading of tomatoes and packing in crates as per the grade (3.91), and unloading of fully loaded crates at collection area/centre (3.79) are the activities contributing to poor quality in the farm stage of vegetables (tomato) supply chain (as shown in Table 5.56).

Storing of goods, Carriage of crates to the collection area/collection center, Handling, loading and stacking of crates in mini vehicles or trucks have been ranked as the top three activities contributing to supply chain inefficiency with respect to quality.

**Table 5.56: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage I**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Plucking & Collecting Tomato in Bucket/ Basket | 10 | 9 | 77 | 195 | 49 | 340 | 1284 | 10.75 | 3.78 | **7** |
| A2 | Picking from Bucket/ Basket and Putting in Crates | 68 | 196 | 42 | 22 | 12 | 340 | 734 | 6.15 | 2.16 | **10** |
| A3 | Carriage of Crates to the Collection Area/Collection Centre | 9 | 22 | 31 | 102 | 176 | 340 | 1434 | 12.01 | 4.22 | **2** |
| A4 | Storing of Goods | 10 | 17 | 22 | 51 | 240 | 340 | 1514 | 12.68 | 4.45 | **1** |
| A5 | Unloading of fully loaded Crates at Collection Area/ Centre | 24 | 31 | 65 | 92 | 128 | 340 | 1289 | 10.79 | 3.79 | **5** |
| A6 | Cleaning of Tomatoes | 48 | 174 | 75 | 31 | 12 | 340 | 805 | 6.74 | 2.37 | **9** |
| A7 | Sorting & Grading of Tomatoes and Packing in Crates as per the grade | 19 | 34 | 54 | 83 | 150 | 340 | 1331 | 11.15 | 3.91 | **4** |
| A8 | Consolidation of Goods | 22 | 34 | 70 | 80 | 134 | 340 | 1290 | 10.80 | 3.79 | **6** |
| A9 | Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | 18 | 30 | 53 | 72 | 167 | 340 | 1360 | 11.39 | 4.00 | **3** |
| A10 | Tying the Load in Mini Vehicles or Trucks | 46 | 82 | 173 | 24 | 15 | 340 | 900 | 7.54 | 2.65 | **8** |
| **Total** | | | | | | | | 11941 | 100 | | |

The table 5.57 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in farm stage of vegetables (tomato) supply chain.

**Table 5.57: Activity Contributing to Supply Chain Inefficiency with respect to-**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| Carriage of Crates to the Collection Area/Collection Centre | 4.46 | Carriage of Crates to the Collection Area/Collection Centre | 4.56 | Storing of Goods | 4.45 |
| Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | 4.05 | Sorting & Grading of Tomatoes and Packing in Crates as per the grade | 4.33 | Carriage of Crates to the Collection Area/Collection Centre | 4.22 |
| Sorting & Grading of Tomatoes and Packing in Crates as per the grade | 4.00 | Plucking & Collecting Tomato in Bucket/ Basket | 4.18 | Handling, Loading, and Stacking of Crates in Mini Vehicles or Trucks | 4.00 |

***Activities contributing to supply chain inefficiency in Local Mandi stage (Stage II) of the vegetables supply chain***

The activities, which are performed in local mandi stage of vegetables (tomato) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.58 highlights that major five activities, which are contributing to supply chain inefficiency with respect to cost in local mandi stage are Unloading of tomato and loading to the buyer's crate (4.16), Handling, loading & stacking of crates in trucks (4.04), Unloading of crates from mini-vehicles/truck to the local mandi (3.96), Storing of fresh produce at local mandi (2.70), and Sorting & grading of tomatoes (2.04).

Unloading of tomato and loading to the buyer's crate, Handling, loading & stacking of crates in trucks, and Unloading of crates from mini-vehicles/truck to the local mandi have been ranked as the top three activities leading to supply chain inefficiency with respect to cost in this stage.

**Table 5.58: Activities leading to Supply Chain Inefficiency with respect to Cost-Stage II**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | 7 | 16 | 26 | 49 | 72 | 170 | 673 | 17.42 | 3.96 | **3** |
| A2 | Storing of Fresh Produce at Local Mandi | 19 | 39 | 91 | 16 | 5 | 170 | 459 | 11.88 | 2.70 | **4** |
| A3 | Sorting & Grading of Tomatoes | 45 | 90 | 23 | 7 | 5 | 170 | 347 | 8.98 | 2.04 | **5** |
| A4 | Auctioning/Selling of Fresh Produce | 77 | 55 | 21 | 11 | 6 | 170 | 324 | 8.39 | 1.91 | **8** |
| A5 | Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | 57 | 82 | 21 | 6 | 4 | 170 | 328 | 8.49 | 1.93 | **7** |
| A6 | Unloading of Tomato and Loading to the buyer's Crate | 11 | 14 | 17 | 22 | 106 | 170 | 708 | 18.32 | 4.16 | **1** |
| A7 | Handling, Loading & Stacking of Crates in Trucks | 12 | 13 | 18 | 41 | 86 | 170 | 686 | 17.75 | 4.04 | **2** |
| A8 | Tying the load in Truck | 49 | 92 | 15 | 9 | 5 | 170 | 339 | 8.77 | 1.99 | **6** |
| **Total** | | | | | | | | 3864 | 100 | | |

With respect to time inefficiency, Unloading of tomato and loading to the buyer's crate (4.15), Unloading of crates from mini-vehicles/truck to the local mandi (4.04), Handling, loading & stacking of crates in trucks (3.99), Storing of fresh produce at local mandi (3.71), and Sorting & grading of tomatoes (3.50) are the five major activities contributing to supply chain inefficiency with respect to time (as shown in Table 5.59).

Unloading of tomato and loading to the buyer's crate, Unloading of crates from mini-vehicles/truck to the local mandi, and Handling, loading & stacking of crates in trucks have been ranked as the top three activities contributing to supply chain inefficiency with respect to time in this stage.

**Table 5.59: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage II**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | 9 | 12 | 22 | 47 | 80 | 170 | 687 | 15.29 | 4.04 | **2** |
| A2 | Storing of Fresh Produce at Local Mandi | 11 | 24 | 30 | 43 | 62 | 170 | 631 | 14.05 | 3.71 | **4** |
| A3 | Sorting & Grading of Tomatoes | 10 | 21 | 29 | 94 | 16 | 170 | 595 | 13.25 | 3.50 | **5** |
| A4 | Auctioning/Selling of Fresh Produce | 32 | 37 | 84 | 7 | 10 | 170 | 436 | 9.71 | 2.56 | **6** |
| A5 | Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | 38 | 92 | 17 | 13 | 10 | 170 | 375 | 8.35 | 2.21 | **8** |
| A6 | Unloading of Tomato and Loading to the buyer's Crate | 11 | 10 | 19 | 32 | 98 | 170 | 706 | 15.72 | 4.15 | **1** |
| A7 | Handling, Loading & Stacking of Crates in Trucks | 12 | 15 | 21 | 36 | 86 | 170 | 679 | 15.12 | 3.99 | **3** |
| A8 | Tying the load in Truck | 24 | 97 | 35 | 10 | 4 | 170 | 383 | 8.53 | 2.25 | **7** |
| **Total** | | | | | | | | 4492 | 100 | | |

Storing of fresh produce at local mandi (4.34), Unloading of tomato and loading to the buyer's crate (4.18), Unloading of crates from mini-vehicles/truck to the local mandi (4.02), Sorting & grading of tomatoes (3.85), and Handling, loading & stacking of crates in trucks (3.71) are the five major activities contributing to supply chain inefficiency with respect to quality (as shown in Table 5.60).

In this stage, Storing of fresh produce at local mandi, Unloading of tomato and loading to the buyer's crate, and Unloading of crates from mini-vehicles/truck to the local mandi have been ranked as the top three activities contributing to supply chain inefficiency with respect to quality.

**Table 5.60: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage II**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | 11 | 10 | 25 | 43 | 81 | 170 | 683 | 14.37 | 4.02 | **3** |
| A2 | Storing of Fresh Produce at Local Mandi | 5 | 6 | 24 | 27 | 108 | 170 | 737 | 15.50 | 4.34 | **1** |
| A3 | Sorting & Grading of Tomatoes | 9 | 21 | 26 | 45 | 69 | 170 | 654 | 13.76 | 3.85 | **4** |
| A4 | Auctioning/Selling of Fresh Produce | 10 | 29 | 107 | 17 | 7 | 170 | 492 | 10.35 | 2.89 | **6** |
| A5 | Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | 26 | 34 | 95 | 9 | 6 | 170 | 445 | 9.36 | 2.62 | **7** |
| A6 | Unloading of Tomato and Loading to the buyer's Crate | 7 | 15 | 15 | 36 | 97 | 170 | 711 | 14.96 | 4.18 | **2** |
| A7 | Handling, Loading & Stacking of Crates in Trucks | 15 | 19 | 30 | 42 | 64 | 170 | 631 | 13.27 | 3.71 | **5** |
| A8 | Tying the load in Truck | 23 | 83 | 49 | 10 | 5 | 170 | 401 | 8.44 | 2.36 | **8** |
| **Total** | | | | | | | | 4754 | 100 | | |

The table 5.61 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in local mandi stage of vegetables (tomato) supply chain.

**Table 5.61: Activity Contributing to Supply Chain Inefficiency with respect to-**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| Unloading of Tomato and Loading to the buyer's Crate | 4.16 | Unloading of Tomato and Loading to the buyer's Crate | 4.15 | Storing of Fresh Produce at Local Mandi | 4.34 |
| Handling, Loading & Stacking of Crates in Trucks | 4.04 | Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | 4.04 | Unloading of Tomato and Loading to the buyer's Crate | 4.18 |
| Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | 3.96 | Handling, Loading & Stacking of Crates in Trucks | 3.99 | Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | 4.02 |

***Activities contributing to supply chain inefficiency in Wholesale/Mandi stage (Stage III) of the vegetables supply chain***

The activities, which are performed in wholesale/mandi stage of vegetables (tomato) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.62 highlights that major five activities, which are contributing to supply chain inefficiency with respect to cost in wholesale/mandi stage are Unloading of tomato and loading to the buyer's crate (4.23), Unloading of crates from trucks at mandi level (4.04), Handling, loading & stacking of crates in mini vehicles/trucks/rickshaws/cart (3.91), Sorting & grading of tomatoes (2.51), and Tying the load (2.31).

Unloading of tomato and loading to the buyer's crate, Unloading of crates from trucks at mandi level, Handling, loading & stacking of crates in mini vehicles/trucks/rickshaws/cart have been ranked as the top three activities contributing to supply chain inefficiency with respect to cost in this stage.

**Table 5.62: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage III**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates from Trucks at Mandi Level | 7 | 9 | 19 | 32 | 63 | 130 | 525 | 16.36 | 4.04 | **2** |
| A2 | Storing & Handling of Crates at Mandi | 39 | 67 | 13 | 4 | 7 | 130 | 263 | 8.20 | 2.02 | **7** |
| A3 | Sorting & Grading of Tomatoes | 26 | 35 | 53 | 9 | 7 | 130 | 326 | 10.16 | 2.51 | **4** |
| A4 | Auctioning/Selling of Tomatoes | 54 | 30 | 24 | 13 | 9 | 130 | 283 | 8.82 | 2.18 | **6** |
| A5 | Quality Inspection by the buyers (Random Sampling) | 69 | 37 | 11 | 9 | 4 | 130 | 232 | 7.23 | 1.78 | **8** |
| A6 | Unloading of Tomato and Loading to the buyer's Crate | 7 | 6 | 15 | 24 | 78 | 130 | 550 | 17.14 | 4.23 | **1** |
| A7 | Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | 9 | 11 | 17 | 39 | 54 | 130 | 508 | 15.83 | 3.91 | **3** |
| A8 | Tying the load | 24 | 63 | 26 | 13 | 4 | 130 | 300 | 9.35 | 2.31 | **5** |
| A9 | Dispatch of Goods | 75 | 33 | 11 | 7 | 4 | 130 | 222 | 6.92 | 1.71 | **9** |
| **Total** | | | | | | | | 3209 | 100 | | |

With respect to time inefficiency, Unloading of tomato and loading to the buyer's crate (4.38), Unloading of crates from trucks at mandi level (4.05), Handling, loading & stacking of crates in mini vehicles/ trucks/ rickshaws/ cart (3.94), Storing & handling of crates at mandi (3.59), and Auctioning/selling of tomatoes (3.39) are the five major activities contributing to supply chain inefficiency (as shown in Table 5.63).

Unloading of tomato and loading to the buyer's crate, Unloading of crates from trucks at mandi level, and Handling, loading & stacking of crates in mini vehicles/ trucks/ rickshaws/ cart have been ranked as the top three activities contributing to supply chain inefficiency with respect to time in this stage.

**Table 5.63: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage III**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates from Trucks at Mandi Level | 8 | 11 | 13 | 33 | 65 | 130 | 526 | 13.65 | 4.05 | **2** |
| A2 | Storing & Handling of Crates at Mandi | 9 | 15 | 24 | 54 | 28 | 130 | 467 | 12.12 | 3.59 | **4** |
| A3 | Sorting & Grading of Tomatoes | 11 | 13 | 64 | 22 | 20 | 130 | 417 | 10.82 | 3.21 | **6** |
| A4 | Auctioning/Selling of Tomatoes | 13 | 17 | 30 | 46 | 24 | 130 | 441 | 11.44 | 3.39 | **5** |
| A5 | Quality Inspection by the buyers (Random Sampling) | 15 | 30 | 72 | 9 | 4 | 130 | 347 | 9.00 | 2.67 | **8** |
| A6 | Unloading of Tomato and Loading to the buyer's Crate | 4 | 9 | 11 | 15 | 91 | 130 | 570 | 14.79 | 4.38 | **1** |
| A7 | Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | 9 | 11 | 15 | 39 | 56 | 130 | 512 | 13.28 | 3.94 | **3** |
| A8 | Tying the load | 9 | 30 | 71 | 13 | 7 | 130 | 369 | 9.57 | 2.84 | **7** |
| A9 | Dispatch of Goods | 90 | 20 | 9 | 7 | 4 | 130 | 205 | 5.32 | 1.58 | **9** |
| **Total** | | | | | | | | 3854 | 100 | | |

Storing & handling of crates at mandi (4.45), Unloading of tomato and loading to the buyer's crate (4.20), Unloading of crates from trucks at mandi level (3.99), Handling, loading & stacking of crates in mini vehicles/trucks/rickshaws/cart (3.65), and Sorting & grading of tomatoes (3.61) are the five major activities in this stage, which are contributing to supply chain inefficiency with respect to quality (as shown in Table 5.64).

Storing & handling of crates at mandi, Unloading of tomato and loading to the buyer's crate, and Unloading of crates from trucks at mandi level have been ranked as the top three activities contributing to supply chain inefficiency with respect to quality.

**Table 5.64: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage III**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | Unloading of Crates from Trucks at Mandi Level | 7 | 13 | 17 | 30 | 63 | 130 | 519 | 13.35 | 3.99 | **3** |
| A2 | Storing & Handling of Crates at Mandi | 2 | 10 | 7 | 20 | 91 | 130 | 578 | 14.87 | 4.45 | **1** |
| A3 | Sorting & Grading of Tomatoes | 11 | 11 | 20 | 64 | 24 | 130 | 469 | 12.06 | 3.61 | **5** |
| A4 | Auctioning/Selling of Tomatoes | 13 | 24 | 75 | 7 | 11 | 130 | 369 | 9.49 | 2.84 | **6** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A5 | Quality Inspection by the buyers (Random Sampling) | 9 | 67 | 30 | 13 | 11 | 130 | 340 | 8.74 | 2.62 | **7** |
| A6 | Unloading of Tomato and Loading to the buyer's Crate | 7 | 8 | 15 | 22 | 78 | 130 | 546 | 14.04 | 4.20 | **2** |
| A7 | Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | 13 | 14 | 24 | 33 | 46 | 130 | 475 | 12.22 | 3.65 | **4** |
| A8 | Tying the load | 20 | 73 | 15 | 13 | 9 | 130 | 308 | 7.92 | 2.37 | **8** |
| A9 | Dispatch of Goods | 28 | 76 | 11 | 4 | 11 | 130 | 284 | 7.30 | 2.18 | **9** |
| **Total** | | | | | | | | 3888 | 100 | | |

The table 5.65 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in wholesale/mandi stage of vegetables (tomato) supply chain.

**Table 5.65: Activity Contributing to Supply Chain Inefficiency with respect to:**

| **Cost** | **Weighted Mean Score** | **Time** | **Weighted Mean Score** | **Quality** | **Weighted Mean Score** |
|---|---|---|---|---|---|
| Unloading of Tomato and Loading to the buyer's Crate | 4.23 | Unloading of Tomato and Loading to the buyer's Crate | 4.38 | Storing & Handling of Crates at Mandi | 4.45 |
| Unloading of Crates from Trucks at Mandi Level | 4.04 | Unloading of Crates from Trucks at Mandi Level | 4.05 | Unloading of Tomato and Loading to the buyer's Crate | 4.20 |
| Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | 3.91 | Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | 3.94 | Unloading of Crates from Trucks at Mandi Level | 3.99 |

***Activities contributing to supply chain inefficiency in Transportation stage (Stage IV) of the vegetables supply chain***

The Transportation stage of vegetables (tomato) supply chain along with their total composite score, weightage mean scores and the rank orders are illustrated in Tables below. An analysis of data presented in the Table 5.66 highlights that transportation from local mandi to Azadpur mandi has maximum inefficiency with respect to cost (4.25), followed by transportation from farm/collection center to local trader mandi (3.93).

Transportation from local mandi to Azadpur mandi has been ranked as the top transit phase contributing to supply chain inefficiency with respect to cost in the vegetables (tomato) supply chain.

**Table 5.66: Activities contributing to Supply Chain Inefficiency with respect to Cost-Stage IV**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | In Transit (From Farm/Collection Centre To Local Trader Mandi) | 13 | 27 | 19 | 64 | 97 | 220 | 865 | 48.03 | 3.93 | **2** |
| A2 | In Transit (From Local Mandi To Azadpur Mandi) | 6 | 13 | 19 | 63 | 119 | 220 | 936 | 51.97 | 4.25 | **1** |
| **Total** | | | | | | | | 1801 | 100 | | |

With respect to time inefficiency, transportation from local mandi to Azadpur mandi has maximum inefficiency (4.35) which is contributing to high lead time, followed by transportation from farm/collection center to local trader mandi (4.04) as shown in Table 5.67.

Transportation from local mandi to Azadpur mandi has been ranked as the top transit phase contributing to supply chain inefficiency with respect to time in the transportation of vegetable.

**Table 5.67: Activities contributing to Supply Chain Inefficiency with respect to Time-Stage IV**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | In Transit (From Farm/Collection Centre To Local Trader Mandi) | 5 | 17 | 36 | 69 | 93 | 220 | 888 | 48.16 | 4.04 | **2** |
| A2 | In Transit (From Local Mandi To Azadpur Mandi) | 8 | 13 | 17 | 39 | 143 | 220 | 956 | 51.84 | 4.35 | **1** |
| Total | | | | | | | | 1844 | 100 | | |

With respect to quality inefficiency, transportation of fresh produce from local mandi to Azadpur mandi (4.28) is contributing to poor quality, followed by transportation from farm/collection center to local trader mandi (4.01) as shown in Table 5.68.

Transportation from local mandi to Azadpur mandi has been ranked as the top transit phase contributing to supply chain inefficiency with respect to quality in the transportation of vegetable.

**Table 5.68: Activities contributing to Supply Chain Inefficiency with respect to Quality-Stage IV**

| Activity | | Scale | | | | | N | TCS | % | WMS | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | | | | |
| A1 | In Transit (From Farm/Collection Centre To Local Trader Mandi) | 17 | 19 | 22 | 49 | 113 | 220 | 882 | 48.38 | 4.01 | **2** |
| A2 | In Transit (From Local Mandi To Azadpur Mandi) | 14 | 11 | 16 | 38 | 141 | 220 | 941 | 51.62 | 4.28 | **1** |
| **Total** | | | | | | | | 1823 | 100 | | |

The table 5.69 below depicts the summary of three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in transportation stage of vegetables (tomato) supply chain.

**Table 5.69: Activity Contributing to Supply Chain Inefficiency with respect to-**

| Cost | Weighted Mean Score | Time | Weighted Mean Score | Quality | Weighted Mean Score |
|---|---|---|---|---|---|
| In Transit (From Local Mandi To Azadpur Mandi) | 4.25 | In Transit (From Local Mandi To Azadpur Mandi) | 4.35 | In Transit (From Local Mandi To Azadpur Mandi) | 4.28 |
| In Transit (From Farm/Collection Centre To Local Trader Mandi) | 3.93 | In Transit (From Farm/Collection Centre To Local Trader Mandi) | 4.04 | In Transit (From Farm/Collection Centre To Local Trader Mandi) | 4.01 |

**5.3.2. Analysis- Research Objective 2:** *To identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

The data collected through survey was analysed by the application of statistical techniques. The techniques used involve descriptive statistics, assumptions for data analysis (e.g., normality, linearity), and quantitative data analysis using Exploratory Factor Analysis (EFA).

**5.3.2.1. Factor analysis**

Factor analysis has been used to examine the interconnection and interrelationship among the explanatory variables and to determine the important factors that are leading to supply chain inefficiency. According to Kim and Mueller (1978), Factor analysis refers to "a variety of statistical techniques whose common objective is to represent a set of variables in terms of a smaller number of hypothetical factors". The basic assumption of factor analysis is a linear combination of the factors that are not actually observed (Ruslan et al., 2013; Arumugam et al., 2010; Negi and Anand, 2017). Underlying variables are identified by factor analysis, which explains the trend of correlation within a set of measured/observed variables.

EFA is applied in cases where the researcher is willing to find out the factors having an impact on variables and to investigate, which variables 'go together' (DeCoster, 1998). This method is often put into practice in case of data reduction to classify limited number of factors that describe majority of the variance seen in case of larger number of manifest variables (Hair et al., 2010). This method is also helpful for research studies, which includes limited or larger number of items, variables that can be classified into smaller set to gather essential concept to enable interpretations in an easy manner (Rummel, 1970). This method assists researcher to emphasis on key factors rather than pondering over multiple variables, which might be insignificant, and hence is helpful in categorising variables into relevant sets (Yong & Pearce, 2013).

Pallant (2005) highlights the fact that EFA primarily includes three broad stages; a) evaluating appropriateness of the data, b) extraction of the factor, c) rotation of the factor. Hence, before proceeding with the factor analysis, certain assumptions are to be inducted in the initial analysis done to test the appropriateness of the dataset for performing EFA. The following table (Table 5.70) exhibits the gist of the above assumptions.

**Table 5.70: Summary of EFA Requirements on Data Set**

| Condition | Requirement | Reference |
|---|---|---|
| Outliers | No Outliers accepted | (Hair et al., 2010) |
| Linearity | No Multicollinearity; VIF < 10 | (Hair et al., 2010) |
| Sample Size | Minimum: 5 Cases to each study item | (Tabachnick & Fidell, 2007; Pallant, 2005;) |
| Bartlett's Test of Sphericity | Be Significant (p < .05) | (Tabachnick & Fidell, 2007) |
| Kaiser-Meyer- Olkin (KMO) Index | ≥ 0.5 | (Hair et al., 2010; Malhotra & Birks, 2007) |

***Source:*** *Battour, 2011*

The factor analysis was conducted using the "principal component method" with the following steps (Ruslan et al., 2013; Arumugam et al., 2010; Negi and Anand, 2017).

i. The criterion for the number of factors: Eigen value of each factor had to be equal or higher than one (Hair et al., 2010).

ii. The numbers of extracted factors were then rotated by the varimax method.

iii. Each of the variables was assigned to the factor, which had the highest correlation.

### 5.3.2.2. Measure of sampling adequacy

The Kaiser-Meyer-Olkin (KMO) sampling adequacy and Bartlett's test of sphericity have been used to measure adequacy in sampling and existence of correlation between the variables. It was initially performed on the data and confirmed the appropriateness of conducting the PCA (Principal Component Analysis) (Tabachnick and Fidell, 2001). The KMO static value differs between 0 and 1. Zero specifies that the summation of fractional correlations is highly relative to the sum of correlations, which indicates a diffusion in the pattern of correlations (hence, chances are likely that factor analysis will be unsuitable). Closer the value to 1, the pattern of correlation are relatively compact. Therefore, factor analysis is responsible for yielding distinct and reliable factors. Small values for the KMO shows that the factor analysis of the variables may not be suitable since the associations (correlations) between the variables cannot be described by the other variables (Norusis 1993). The values, which are higher than 0.6 are considered as satisfactory to carry out factor analysis.

It has been recommended by Kaiser (1974) that researcher should accept the values, which happened to be more than 0.5 (values less than 0.5 propels the researcher to go for further collection of data or reconsider what other variables could be included). The mediocre values are the ones, which lies between 0.5 to 0.7, 0.7 and 0.8 values are considered to be good and above all, values more than 0.9 are considered to be of excellent in nature (Hutcheson & Sofroniou, 1999).

The KMO test in maximum cases were more than 0.8 (Table 5.71 and Table 5.72), which means the values are very good, so it was judged to be acceptable.

**Table 5.71: KMO and Bartlett's Test**

**(Supply chain inefficiency with respect to cost, time and quality in Fruits Supply Chain)**

| Stage I-Farm Stage | | Cost | Time | Quality |
|---|---|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .843 | .919 | .941 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2490.997 | 4841.686 | 6683.447 |
| | df | 153 | 231 | 780 |
| | Sig. | .000 | .000 | .000 |
| **Stage II-Middlemen/Local Trader Stage** | | **Cost** | **Time** | **Quality** |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .829 | .849 | .914 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2322.078 | 1479.030 | 2628.514 |
| | df | 190 | 153 | 300 |
| | Sig. | .000 | .000 | .000 |
| **Stage III-Wholesale/Mandi Stage** | | **Cost** | **Time** | **Quality** |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .866 | .873 | .914 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1470.581 | 1849.904 | 2890.041 |
| | df | 105 | 136 | 325 |
| | Sig. | .000 | .000 | .000 |
| **Stage IV-Local trader/Mashakhor Stage** | | **Cost** | **Time** | **Quality** |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .760 | .773 | .845 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2719.786 | 2925.564 | 6340.006 |
| | df | 190 | 153 | 435 |
| | Sig. | .000 | .000 | .000 |
| **Stage V-Transportation Stage** | | **Cost** | **Time** | **Quality** |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .809 | .722 | .805 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 745.469 | 876.834 | 1032.284 |
| | df | 45 | 55 | 45 |
| | Sig. | .000 | .000 | .000 |

**Table 5.72: KMO and Bartlett's Test**

**(Supply chain inefficiency with respect to cost, time and quality in Vegetables Supply Chain)**

| Stage I-Farm Stage | | Cost | Time | Quality |
|---|---|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .844 | .852 | .910 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 3240.404 | 3755.351 | 2956.288 |
| | df | 171 | 253 | 300 |
| | Sig. | .000 | .000 | .000 |
| **Stage II-Local Mandi Stage** | | **Cost** | **Time** | **Quality** |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .807 | .836 | .841 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1867.069 | 2290.911 | 2480.167 |
| | df | 120 | 153 | 231 |
| | Sig. | .000 | .000 | .000 |

| Stage III-Wholesale/Mandi Stage | | Cost | Time | Quality |
|---|---|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .779 | .774 | .752 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1442.226 | 1830.465 | 2021.969 |
| | df | 105 | 153 | 231 |
| | Sig. | .000 | .000 | .000 |
| **Stage V-Transportation Stage** | | **Cost** | **Time** | **Quality** |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .760 | .632 | .788 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 414.960 | 841.534 | 782.901 |
| | df | 45 | 66 | 45 |
| | Sig. | .000 | .000 | .000 |

After the confirmation of sampling adequacy, it is evident that the sample is adequate and factor analysis can be carried out as an appropriate analysis.

**5.3.2.3. Common Method Bias Test**

The primary objective of using Common Method Bias (CMB) test is to understand the degree of biasness. This method helps the researcher to evaluate the degree to which the collected data may be prejudiced due to errors committed during the data collection process through survey method. (Eichhorn, 2014). Harman single factor test is used more frequently to calculate the estimation for CMB. This particular method (Harman, 1960) uses EFA in cases where all the items/variables are considered into a single factor and constrained so that there is no rotation (Podsakoff et al., 2003). This new factor is typically not in the researcher's model; it is presented primarily for the present analysis and then subsequently is ignored. If there is persistent of 50% or higher degree of variance presented by the common latent factor then it can be said that there is presence of CMB. On the contrary, in case of an individual factor if the variance level is less than 50%, then it can be said that the CMB does not affect the data and results (Podsakoff et al., 2012). This contains all the factors from several constructs of the research study into a factor analysis to understand if at all the major part of the variance can be explained by one single factor (Podsakoff et al., 2003).

In this present study, Harman single factor test has been used to check the CMB and to determine whether datasets suffer from the common method bias issue or not. In the dataset, it has been observed that the maximum variance that is explained by a single factor in each case (with respect to cost, time and quality) across the stages in fruits as well as vegetables supply chain is less than 50%. Therefore, it can be concluded that this data set does not suffer from the CMB issue because the variance explained by a single factor is less than 50%.

#### 5.3.2.4. <u>Factors Leading to Supply Chain Inefficiency in Different Stages of Fruits Supply Chain with Specific Reference to Mango</u>

Factors leading to supply chain inefficiency across the stages of fruits (mango) supply chain are discussed in this section.

#### 5.3.2.4. *i*. Factors Leading to Supply Chain Inefficiency in Farm Stage (Stage I)

Factors leading to supply chain inefficiency with respect to cost, time and quality in farm stage of fruits (mango) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.73 lists the eigen value connected with each linear component and the factor before extraction and after rotation. According to Hair, Anderson & Ronald (1991) "The eigen value is the column sum of squares for a factor, which also presents the mount of variance accounted for by a factor".

Four factors have been identified (possessing eigen values >1), which mutually amounts to 64.33% of the variation across the sample. In isolation, first factor explained 25.89% of the total variance; second factor explained 14.421% of the total variance; third factor explained 12.984% of the total variance, and fourth factor explained about 11.035% of the total variance.

**Table 5.73: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.839 | 37.992 | 37.992 | 4.660 | 25.891 | 25.891 |
| 2 | 1.996 | 11.089 | 49.082 | 2.596 | 14.421 | 40.312 |
| 3 | 1.444 | 8.025 | 57.106 | 2.337 | 12.984 | 53.296 |
| 4 | 1.300 | 7.224 | 64.331 | 1.986 | 11.035 | 64.331 |
| 5 | .897 | 4.984 | 69.314 | | | |
| 6 | .820 | 4.557 | 73.871 | | | |
| 7 | .767 | 4.261 | 78.132 | | | |
| 8 | .584 | 3.245 | 81.377 | | | |
| 9 | .540 | 3.001 | 84.378 | | | |
| 10 | .514 | 2.858 | 87.237 | | | |
| 11 | .472 | 2.621 | 89.858 | | | |
| 12 | .417 | 2.319 | 92.176 | | | |
| 13 | .351 | 1.948 | 94.124 | | | |
| 14 | .303 | 1.682 | 95.806 | | | |
| 15 | .254 | 1.409 | 97.215 | | | |
| 16 | .207 | 1.149 | 98.364 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | .189 | 1.052 | 99.416 | | | |
| 18 | .105 | .584 | 100.000 | | | |

The factor analysis revealed four broad issues (factors), which are leading to supply chain inefficiency in Farm stage with respect to cost (Table 5.74). Resource factor is one of the most important factors leading to supply chain inefficiency with respect to high cost, followed by labour and material charges, infrastructure and labour's knowledge. These four latent factors are summarized as follows:

**Table 5.74: Summary-Factors leading to supply chain inefficiency in farm stage with respect to cost**

| Variables | Component | | | | **Variance (% of explained) eigen values** | **Factor Name** |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Large number of Labour required for plucking & Collection | 0.808 | | | | ***25.891*** | *Resources* |
| Large number of Labour required for carriage activity | 0.749 | | | | | |
| Non-usage of Sorting & Grading Technology | 0.691 | | | | | |
| Requirement of expertise for grading and packaging | 0.687 | | | | | |
| Timely Non-availability of packaging materials | 0.673 | | | | | |
| Price differential of packing material at different places | 0.669 | | | | | |
| Non-availability of advanced packaging materials | 0.666 | | | | | |
| Excess usage of Material for layering and tapping the cartons/boxes | 0.599 | | | | | |
| High manual Labour charges-Plucking | | 0.843 | | | ***14.421*** | *Labour & Material Charges* |
| High Labour charges for carriage | | 0.838 | | | | |
| High Labour cost due to long distance between packing and loading area | | 0.657 | | | | |
| High Packaging Material charges | | 0.606 | | | | |
| Lack of mechanical sorting, grading and packaging facility | | | 0.830 | | ***12.984*** | *Infrastructure* |
| Lack of Government packing houses/grading facilities | | | 0.787 | | | |
| Poor farm connectivity by road | | | 0.661 | | | |
| Poor connectivity between plucking area and assembly area | | | 0.488 | | | |
| Ignorance of Farmers to new methods of cultivation | | | | 0.899 | ***11.035*** | *Labour's Knowledge* |
| Lack of Labour's knowledge pertaining to sorting & grading techniques and processes | | | | 0.815 | | |

*Factor 1– Resources:* Lack of resources is recognized as a first factor that leads to high cost in the farm stage of mango supply chain. This factor includes eight sub-variables having total variance 25.891%. Large number of Labour required for plucking & collection activity carries the maximum factor loading (0.808). This is followed by a large number of Labours required for carriage activity (.749), non-usage of sorting & grading technology (.691), requirement of expertise for grading and packaging (.687), timely non-availability of packaging materials (.673), price differential of packing material at different places (.669), non-availability of advanced packaging materials (.666), and excess usage of material for layering and tapping the cartons/boxes (.599). The results indicate that lack of resources pertaining to labour requirement, packing material, and technology is leading to cost escalation in farm stage of mango supply chain.

*Factor 2 – Labour and Material Charges:* The second factor is labour and material charges, possessing total variance of 14.421% and consists of four sub-variables. High manual labour charges for plucking and collection activity carries the highest factor loading (.843), followed by high labour charges for carriage (0.838), high labour cost due to the long distance between packing and loading area (0.657), and high packaging material charges (0.606). The results indicate that labour charges for different activities at farm area and packaging material charges are quite high, which escalate the cost of labour and packaging, which leads to high cost in the supply chain.

*Factor 3 – Infrastructure:* Infrastructure is the third factor, having a variance of 12.984% and consists of of four sub-variables. Lack of mechanical sorting, grading and packaging facility at farm area carries the highest factor loading (0.830), followed by lack of government packing houses/grading facilities (0.787), poor farm connectivity by road (0.661), and poor connectivity between plucking area and assembly area (.488). This factor indicates that there is a requirement of mechanical primary processing facilities, government supported facilities where the operations related to sorting, grading, and packaging can be performed at a reasonable price. The result also shows that well connectivity between road, plucking area, and assembly area is need of the hour.

*Factor 4 – Labour's Knowledge:* Labour's Knowledge is the fourth factor, possessing total variance of 11.035% and contain only two sub-variables; ignorance of farmers to new methods of cultivation (.899), followed by lack of labour's knowledge pertaining to sorting & grading techniques and processes (0.815). The farmers indicated that due to lack of advanced knowledge and techniques regarding the new methods of cultivation, sorting and grading process the cost in the supply chain is escalating.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.75 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 75.44% of the variation across the sample. In isolation, first factor explained 25.12% of the total variance; second factor explained 20.56% of the total variance; third factor explained 13.64% of the total variance, fourth factor explained 10.61% of the total variance and fifth factor explained about 5.48% of the total variance.

**Table 5.75: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 9.487 | 43.125 | 43.125 | 5.527 | 25.124 | 25.124 |
| 2 | 3.404 | 15.473 | 58.598 | 4.525 | 20.566 | 45.690 |
| 3 | 1.537 | 6.987 | 65.585 | 3.003 | 13.649 | 59.339 |
| 4 | 1.162 | 5.280 | 70.865 | 2.335 | 10.616 | 69.955 |
| 5 | 1.007 | 4.578 | 75.442 | 1.207 | 5.487 | 75.442 |
| 6 | .844 | 3.838 | 79.281 | | | |
| 7 | .672 | 3.055 | 82.336 | | | |
| 8 | .578 | 2.625 | 84.961 | | | |
| 9 | .483 | 2.194 | 87.155 | | | |
| 10 | .367 | 1.667 | 88.822 | | | |
| 11 | .352 | 1.598 | 90.420 | | | |
| 12 | .299 | 1.360 | 91.780 | | | |
| 13 | .282 | 1.281 | 93.061 | | | |
| 14 | .274 | 1.244 | 94.306 | | | |
| 15 | .225 | 1.022 | 95.328 | | | |
| 16 | .216 | .984 | 96.312 | | | |
| 17 | .214 | .972 | 97.284 | | | |
| 18 | .199 | .903 | 98.186 | | | |
| 19 | .140 | .637 | 98.823 | | | |
| 20 | .121 | .548 | 99.371 | | | |
| 21 | .090 | .411 | 99.782 | | | |
| 22 | .048 | .218 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency in farm stage with respect to time (Table 5.76). Labour factor happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by operational, infrastructure, resources, and connectivity issue. These five latent factors are summarized as follows:

**Table 5.76: Summary- Factors leading to supply chain inefficiency in farm stage with respect to time**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Lack of Training and Knowledge about sorting, grading & packaging | 0.845 | | | | | ***25.124*** | *Labour* |
| Lack of Skilled labour for plucking and collection | 0.799 | | | | | | |
| Lack of knowledge pertaining to sorting & grading techniques and processes | 0.771 | | | | | | |
| Employment of incapable labour (women and children) for carriage | 0.748 | | | | | | |
| Non-availability of skilled labour for sorting, grading & packaging | 0.745 | | | | | | |
| Labour's Ignorance for time allocated to sorting, grading, and packaging | 0.744 | | | | | | |
| Labour's Ignorance for time allocated to plucking and collection | 0.67 | | | | | | |
| Lack of farmer's awareness and knowledge regarding technology | 0.583 | | | | | | |
| Lack of proper planning for harvesting | | 0.858 | | | | ***20.566*** | *Operational* |
| Manual sorting, grading & packaging | | 0.857 | | | | | |
| Harvesting by hand picking | | 0.85 | | | | | |
| Manual carriage by means of head-load | | 0.831 | | | | | |
| Excess harvesting due to lack of information regarding market demand | | 0.79 | | | | | |
| Handling excess load by labour at the time of carriage | | 0.641 | | | | | |
| Lack of mechanical sorting, grading, and packaging facility | | | 0.889 | | | ***13.649*** | *Infrastructure* |
| Poor road connectivity | | | 0.881 | | | | |
| Poor condition of path used for carriage | | | 0.857 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lack of sorting & grading technology | | | | 0.753 | | | |
| Timely Non-availability of packaging materials | | | | 0.725 | | ***10.616*** | *Resources* |
| Lack of appropriate harvesting tools and equipment | | | | 0.715 | | | |
| Long distance between plucking area and assembly area | | | | | 0.786 | ***5.487*** | *Connectivity* |
| Assembly points are not properly identified-Plucking | | | | | 0.675 | | |

*Factor 1– Labour:* The Labour-related issue is recognized as a first factor that leads to high lead time in activities carried at farm stage of mango supply chain. This factor includes eight sub-variables having total variance 25.12%. Lack of training and knowledge about sorting, grading & packaging ensure highest factor loading (0.845), followed by lack of skilled labour for plucking and collection (0.799), lack of knowledge pertaining to sorting & grading techniques and processes (0.771), employment of incapable labour (women and children) for carriage (0.748), non-availability of skilled labour for sorting, grading & packaging (0.745), labour's Ignorance for time allocated to sorting, grading and packaging (0.744), labour's Ignorance for time allocated to plucking and collection (0.67), and lack of farmer's awareness and knowledge regarding technology (0.583). The results indicate that the labour-related issues like non-availability of skilled labour, incapable labour, knowledge and awareness of labour are some reasons due to which the farm operations could not performed well, which resulted into high lead time.

*Factor 2 – Operational:* The second factor is an operational issue, possessing total variance of 20.56% and consists of six sub-variables. Lack of proper planning for harvesting carries the highest factor loading of 0.858, followed by manual sorting, grading & packaging (0.857), harvesting by hand picking (0.85), manual carriage by the means of head-load (0.831), excess harvesting due to lack of information regarding market demand (0.79), and handling excess load by labour at the time of carriage (0.641). The results indicate that operational issues like improper planning, manual and inadequate operations, and lack of market information are also one of the major reasons for high lead time in the farm operations.

*Factor 3 – Infrastructure:* The third factor can be named as Infrastructure, having a variance of 13.64% and consists of three sub-variables. Lack of mechanical sorting, grading and packaging facility ensure highest factor loading in this factor (0.889), which is followed by poor road connectivity (0.881), and poor condition of the path used for carriage (0.857). This factor indicates that mechanical facilities to perform primary operations, poor connectivity, and poor conditions of the path are some issues, which are directly related to the infrastructure at farm stage and hindering the operations.

*Factor 4 – Resources:* Resources is the fourth factor, which is leading to high lead time in the farm operations, possessing total variance of 10.61% and consists of three sub-variables. Lack of sorting & grading technology (0.753) carries highest factor loading in this factor, followed by timely non-availability of packaging materials (0.725), and lack of appropriate harvesting tools and equipment (0.715). The results indicate that lack of technical resources and materials needed for packaging are some of the reasons for high lead time in farm operations.

*Factor 5 – Connectivity:* Connectivity is the fifth factor, which is leading to high lead time in farm operations having total variance 5.48%. This factor comprises two sub-variables. The long distance between plucking area and assembly area (0.786) carries highest factor loading, followed by assembly points are not properly identified in plucking and collection operations (0.675). The results indicate that the distance between the plucking area and assembly area is long and the assembly areas are not properly identified, which resulted into high lead time in the operations.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.77 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Eight factors have been identified (possessing eigen values >1), which mutually amounts to 66.49% of the variation across the sample. In isolation, first factor explained 30.33% of the total variance; second factor explained 7.41% of the total variance; third factor explained 7.37% of the total variance, fourth factor explained about 6.03% of the total variance, fifth factor explained 4.63% of the total variance; factor six explained 3.78% of the total variance; factor seven explained 3.54% of the total variance and factor eight explained 3.37% of the total variance.

**Table 5.77: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 16.264 | 40.659 | 40.659 | 12.133 | 30.333 | 30.333 |
| 2 | 2.014 | 5.034 | 45.693 | 2.966 | 7.415 | 37.748 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 1.834 | 4.585 | 50.278 | 2.951 | 7.377 | 45.125 |
| 4 | 1.596 | 3.990 | 54.268 | 2.414 | 6.035 | 51.160 |
| 5 | 1.386 | 3.466 | 57.734 | 1.855 | 4.638 | 55.798 |
| 6 | 1.311 | 3.278 | 61.012 | 1.513 | 3.782 | 59.580 |
| 7 | 1.113 | 2.782 | 63.794 | 1.416 | 3.541 | 63.120 |
| 8 | 1.079 | 2.698 | 66.492 | 1.349 | 3.371 | 66.492 |
| 9 | .920 | 2.301 | 68.793 | | | |
| 10 | .839 | 2.097 | 70.890 | | | |
| 11 | .796 | 1.991 | 72.881 | | | |
| 12 | .697 | 1.743 | 74.624 | | | |
| 13 | .691 | 1.726 | 76.351 | | | |
| 14 | .672 | 1.680 | 78.031 | | | |
| 15 | .632 | 1.579 | 79.610 | | | |
| 16 | .612 | 1.530 | 81.140 | | | |
| 17 | .573 | 1.434 | 82.574 | | | |
| 18 | .550 | 1.374 | 83.948 | | | |
| 19 | .488 | 1.220 | 85.168 | | | |
| 20 | .479 | 1.197 | 86.364 | | | |
| 21 | .444 | 1.109 | 87.473 | | | |
| 22 | .437 | 1.093 | 88.566 | | | |
| 23 | .407 | 1.018 | 89.584 | | | |
| 24 | .375 | .939 | 90.523 | | | |
| 25 | .357 | .893 | 91.416 | | | |
| 26 | .345 | .863 | 92.279 | | | |
| 27 | .336 | .839 | 93.119 | | | |
| 28 | .303 | .757 | 93.876 | | | |
| 29 | .291 | .729 | 94.604 | | | |
| 30 | .283 | .706 | 95.311 | | | |
| 31 | .268 | .669 | 95.980 | | | |
| 32 | .253 | .633 | 96.613 | | | |
| 33 | .235 | .588 | 97.202 | | | |
| 34 | .196 | .491 | 97.692 | | | |
| 35 | .187 | .467 | 98.159 | | | |
| 36 | .177 | .443 | 98.602 | | | |
| 37 | .159 | .397 | 98.999 | | | |
| 38 | .149 | .373 | 99.372 | | | |
| 39 | .136 | .340 | 99.713 | | | |
| 40 | .115 | .287 | 100.000 | | | |

The factor analysis revealed eight broad factors, which are leading to supply chain inefficiency in farm stage with respect to quality (Table 5.78). Operational issue happens to be the most crucial factor leading to poor quality of fresh produce during the operations at farm stage, followed by infrastructure issue, lack of resources, imprudence, labour's knowledge, labour availability, standardisation, and lack of quality control system. These eight latent factors are summarized as follows:

**Table 5.78: Summary-Factors leading to supply chain inefficiency in farm stage with respect to quality**

| Variables | Component 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|---|---|---|
| Exposure to high temperature during collection | 0.861 | | | | | | | | ***30.333*** | *Operational* |
| Non differentiation of produce on the level of ripening during sorting, grading and packaging | 0.834 | | | | | | | | | |
| Harvesting before maturity for getting higher price early in the season | 0.817 | | | | | | | | | |
| Mechanical injury during operations | 0.795 | | | | | | | | | |
| Rough handling at the time of loading & stacking | 0.745 | | | | | | | | | |
| Improper handling of fruits during sorting, grading & packaging | 0.741 | | | | | | | | | |
| Excess Plucking due to Lack of information regarding market demand | 0.73 | | | | | | | | | |
| Bulk handling of fresh produce | 0.713 | | | | | | | | | |
| Delayed or late harvesting | 0.708 | | | | | | | | | |
| Dumping of Crates in the vehicle | 0.686 | | | | | | | | | |
| Brushing and Crushing of fruits because of accidental falling | 0.683 | | | | | | | | | |
| Loose packing of fruits inside packaging | 0.672 | | | | | | | | | |
| Improper and high stacking | 0.666 | | | | | | | | | |
| No proper arrangement of packages/crates for | 0.663 | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| air circulation while stacking in vehicle | | | | | | | | | | |
| Brushing due to sharp edges of the packaging material | 0.658 | | | | | | | | | |
| Overloading of fruits while packaging | 0.656 | | | | | | | | | |
| Single manual handling while loading & stacking | 0.654 | | | | | | | | | |
| Inappropriate or poorly sealed packaging | 0.621 | | | | | | | | | |
| Non treatment of produce before sorting, grading and packaging | 0.549 | | | | | | | | | |
| Non-usage of padding material for packaging | 0.522 | | | | | | | | | |
| Harvesting during warmest part of the day | 0.507 | | | | | | | | | |
| Usage of inappropriate cushioning material for packaging | 0.43 | | | | | | | | | |
| Open Air area for sorting, grading and packaging operations | | 0.683 | | | | | | | | |
| Non-availability of cooling shed in the collection area | | 0.629 | | | | | | | ***7.415*** | *Infrastructure* |
| Open dock area which expose to direct sunlight/heat | | 0.565 | | | | | | | | |
| Spreading the produce on the floor in the orchard's yard | | 0.451 | | | | | | | | |
| Timely non-availability of packaging material | | | 0.701 | | | | | | | |
| Poor quality of packaging material | | | 0.666 | | | | | | | |
| Non-availability of support equipments for handling & loading | | | 0.622 | | | | | | ***7.377*** | *Resources* |
| Lack of appropriate harvesting tools | | | 0.546 | | | | | | | |
| Mishandling and carelessness while plucking and collection | | | | 0.666 | | | | | ***6.035*** | *Imprudence* |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Carelessness in sorting, grading & packaging | | | | 0.567 | | | | | | |
| Ignorance of time to be allocated to sorting, grading and packaging | | | | 0.487 | | | | | | |
| Lack of Training and Knowledge about packaging | | | | | 0.683 | | | | ***4.638*** | *Labour's Knowledge* |
| Lack of trained manpower-Plucking | | | | | 0.59 | | | | | |
| Lack of farmer's awareness and knowledge regarding technology | | | | | 0.513 | | | | | |
| Non-availability of skilled labour for sorting, grading & packaging | | | | | | 0.745 | | | ***3.782*** | *Labour's Availability* |
| Non-availability of skilled labour-HLS | | | | | | 0.685 | | | | |
| No scientific standard for determination of maturity | | | | | | | 0.819 | | ***3.541*** | *Standardisation* |
| Lack of proper grading and quality control system | | | | | | | | 0.801 | ***3.371*** | *Quality Control System* |

*Factor 1– Operational:* The operational issue is recognized as the first factor that leads to poor quality of fresh produce in farm stage of mango supply chain. This factor includes twenty-two sub-variables having total variance 30.33%. Exposure to high temperature during collection (0.861) carries highest factor loading, followed by non-differentiation of produce on the level of ripening during sorting, grading and packaging (0.834), harvesting before maturity for getting higher price early in the season (0.817), mechanical injury during operations (0.795), rough handling at the time of loading & stacking (0.745), improper handling of fruits during sorting, grading & packaging (0.741), excess plucking due to lack of information regarding market demand (0.73), bulk handling of fresh produce (0.713), delayed or late harvesting (0.708), dumping of Crates in the vehicle (0.686), brushing and Crushing of fruits because of accidental falling (0.683), loose packing of fruits inside packaging (0.672), improper and high stacking (0.666), no proper arrangement of packages/crates for air circulation while stacking in vehicle (0.663), brushing due to sharp edges of the packaging material (0.658), overloading of fruits while packaging

(0.656), single manual handling while loading & stacking (0.654), inappropriate or poorly sealed packaging (0.621), non-treatment of produce before sorting, grading and packaging (0.549), non-usage of padding material for packaging (0.522), harvesting during warmest part of the day (0.507), and usage of inappropriate cushioning material for packaging (0.430). The result indicates that operational issues need much consideration to maintain the quality of fresh produce during farm operations. It shows that the operations are not performed effectively at the farm stage, which affects the quality. Exposure to high temperature, improper planning, improper harvesting, rough handling, and improper sorting, grading & packaging are some of the major reason for inefficiency with respect to quality.

*Factor 2 – Infrastructure:* The second factor is Infrastructure, possessing total variance of 7.41% and consists of four sub-variables. Open air area for sorting, grading and packaging operations (0.683) carries highest factor loading, followed by non-availability of cooling shed in the collection area (0.629), open dock area which expose to direct sunlight/heat (0.565), and spreading the produce on the floor in the orchard's yard (0.451). This result indicates that there is an urgent requirement of proper infrastructure related to primary processing, i.e., sorting, grading and packaging, and covered area for operations at farm stage to avoid quality loss.

*Factor 3 – Resources:* Lack of resources is the third factor, possessing total variance of 7.37% and consists of four sub-variables. Timely non-availability of packaging material (0.701) is the main reason leading to poor quality in the farm stage. This is followed by poor quality of packaging material (0.666), non-availability of support equipment for handling & loading (0.622), and lack of appropriate harvesting tools (0.546). This result indicates that lack of availability of resources like packaging material and other supporting equipment are also the reasons for inefficiency with respect to quality at farm stage of mango supply chain.

*Factor 4 – Imprudence:* The fourth factor is Imprudence, having a variance of 6.03% and consists of three sub-variables. Mishandling and carelessness while plucking and collection (0.666) carries highest factor loading in this category, followed by carelessness in sorting, grading & packaging (0.567), and ignorance of time to be allocated to sorting, grading, and packaging (0.487). The result indicates that imprudence and carelessness of labour while performing farm operations is also one of the factors leading to poor quality.

*Factor 5 – Labour Knowledge:* The fifth factor is labour knowledge, having a variance of 4.63% and consists of three sub-variables. Lack of training and knowledge about packaging (0.683) carries highest factor loading in this category, followed by lack of trained manpower for plucking (0.590), and lack of farmer's awareness and knowledge regarding technology (0.513). The result indicates that labour knowledge is an important factor in the supply chain as the functions are carried out by the labour, and lack of knowledge and training regarding different operations leads to poor quality of fresh produce.

*Factor 6 – Labour Availability:* The sixth factor is labour availability, having a variance of 3.78% and consists of two sub-variables. Non-availability of skilled labour for sorting, grading & packaging (0.745) carries highest factor loading, followed by non-availability of skilled labour for Handling, loading and stacking activity (0.685). The result indicates that non- availability of skilled labour also leads to poor quality of fresh produce in farm stage of mango supply chain.

*Factor 7 – Standardisation:* The seventh factor is standardisation, having a variance of 3.54% and consist only one sub-variable named "No scientific standard for determination of maturity", with a factor loading of 0.819. The result indicates that there is no scientific standard, which has been practiced by the farmers to determine the maturity level, hence leading to poor quality of mango during farm level operations in the supply chain.

**5.3.2.4. *ii*. Factors Leading to Supply Chain Inefficiency in Middlemen/Local trader Stage (Stage II)**

Factors leading to supply chain inefficiency with respect to cost, time and quality in Middlemen/local trader stage of fruits (mango) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.79 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 78.01% of the variation across the sample. In isolation, first factor explained 24.90% of the total variance; second factor explained 21.18% of the total variance; third factor explained 16.84% of the total variance, fourth factor explained 9.60% of the total variance and fifth factor explained about 5.48% of the total variance.

**Table 5.79: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.407 | 32.034 | 32.034 | 4.981 | 24.903 | 24.903 |
| 2 | 4.302 | 21.512 | 53.546 | 4.236 | 21.181 | 46.085 |
| 3 | 2.431 | 12.153 | 65.699 | 3.368 | 16.840 | 62.924 |
| 4 | 1.418 | 7.091 | 72.790 | 1.920 | 9.602 | 72.526 |
| 5 | 1.045 | 5.224 | 78.014 | 1.098 | 5.488 | 78.014 |
| 6 | .722 | 3.611 | 81.625 | | | |
| 7 | .693 | 3.466 | 85.091 | | | |
| 8 | .537 | 2.685 | 87.776 | | | |
| 9 | .398 | 1.988 | 89.764 | | | |
| 10 | .355 | 1.775 | 91.539 | | | |
| 11 | .308 | 1.539 | 93.078 | | | |
| 12 | .269 | 1.347 | 94.426 | | | |
| 13 | .243 | 1.214 | 95.640 | | | |
| 14 | .195 | .977 | 96.617 | | | |
| 15 | .168 | .841 | 97.458 | | | |
| 16 | .154 | .769 | 98.227 | | | |
| 17 | .119 | .597 | 98.824 | | | |
| 18 | .091 | .456 | 99.281 | | | |
| 19 | .079 | .395 | 99.676 | | | |
| 20 | .065 | .324 | 100.000 | | | |

The factor analysis revealed five broad issues (factors), which are leading to supply chain inefficiency with respect to cost in middlemen/local trader stage of mango supply chain (Table 5.80). Resource factor is one of the most important factors leading to supply chain inefficiency with respect to high cost, followed by labour and material charges, operational issues, infrastructure, and knowledge. These five latent factors are summarized as follows:

**Table 5.80 Summary-Factors leading to supply chain inefficiency in middlemen/local trader stage with respect to cost**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Non-usage of Sorting & Grading Technology | 0.883 | | | | | ***24.903*** | *Resources* |
| Large number of Labour required for Handling and Loading | 0.872 | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Requirement of expertise for grading and packaging | 0.822 | | | | | | | |
| Non-availability of advanced packaging material | 0.819 | | | | | | | |
| Non-availability of tools and equipments for handling & loading | 0.765 | | | | | | | |
| Excess usage of Material for layering and tapping the cartons/boxes | 0.749 | | | | | | | |
| Large number of Labour required for Unloading | 0.74 | | | | | | | |
| Non-availability of tools and equipments for unloading the load | 0.544 | | | | | | | |
| High Manual Labour Charges-Unloading | | 0.933 | | | | | ***21.181*** | *Labour & Material Charges* |
| Expensive Packaging material | | 0.913 | | | | | | |
| High Manual Labour Charges-HLS | | 0.888 | | | | | | |
| Pre loading labour charges | | 0.852 | | | | | | |
| Pre unloading labour charges | | 0.851 | | | | | | |
| Repeated handling and grading & repackaging at every stage | | | 0.909 | | | | ***16.84*** | *Operational* |
| Manual operations in Unloading | | | 0.88 | | | | | |
| Damage to crates/boxes while unloading | | | 0.861 | | | | | |
| Manual operations in HLS | | | 0.797 | | | | | |
| Lack of mechanical sorting, grading and packaging facility | | | | 0.906 | | | ***9.602*** | *Infrastructure* |
| Lack of Government packing houses/grading facilities | | | | 0.902 | | | | |
| Lack of knowledge pertaining to sorting & grading techniques and processes | | | | | 0.919 | | ***5.488*** | *Knowledge* |

*Factor 1– Resources:* Lack of resources is recognized as a first factor that leads to high cost in the middlemen/local trader stage of mango supply chain. This factor includes eight sub-variables having total variance 24.90%. Non-usage of Sorting & Grading Technology (0.883) carries the maximum factor loading in Resources factor. This is followed large number of labour required for handling and loading (0.872), requirement of expertise for grading and packaging (0.822), non-availability of advanced packaging material (0.819), non-availability of tools and equipments for handling & loading (0.765), excess usage of Material for layering and tapping the cartons/boxes (0.749), large number of labour required for unloading (0.740), and

non-availability of tools and equipments for unloading the load (0.544). The results indicate that lack of resources pertaining to manpower, advance packing material, and tools & equipment are contributing to cost escalation in middlemen/local trader stage of mango supply chain.

*Factor 2 – Labour and Material Charges:* The second factor is labour and material charges, possessing total variance of 21.18% and consists of five sub-variables. High manual labour charges for unloading activity (0.933) carries highest factor loading. This is followed by expensive packaging material (0.913), high manual labour charges in handling, loading and stacking activity (0.888), pre-loading labour charges (0.852), and pre unloading labour charges (0.851). The results indicate that labour and packaging material charges are incurring high cost during the operations at middlemen stage resulting in high cost in the mango supply chain.

*Factor 3–Operational issue:* The operational issue is the third factor, having a variance of 16.84% and consists of four sub-variables. Repeated handling and grading & repackaging at every stage (0.909) ensure maximum factor loading in this category, followed by manual operations in Unloading (0.88), damage to crates/boxes while unloading (0.861), and manual operations in handling, loading, and stacking activity (0.797). This factor indicates that due to operational issues like manual operations, repetitive activities, and damages during operations are incurring high cost in the supply chain of mango.

*Factor 4–Infrastructure:* Infrastructure is the fourth factor, possessing total variance of 9.60% and contain only two sub-variables with the maximum loading of 0.906 in lack of mechanical sorting, grading, and packaging facility, followed by lack of government packing houses/grading facilities (0.902). The results indicate that infrastructure related to sorting, grading, and packaging activity is need of the hour, which may reduce the cost incurred in sorting and grading activity.

*Factor 5–Knowledge:* Lack of knowledge is the fifth factor, possessing total variance of 5.48% and contain only one sub-variable namely lack of knowledge pertaining to sorting & grading techniques and processes (0.919). The results indicate that due to lack of knowledge regarding the techniques, the labour takes a long time to perform the function and their number of working days also gets increase resulting to high cost in the supply chain.

### *Factors Leading to Supply Chain Inefficiency with respect to Time*

Table 5.81 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 68.79% of the variation across the sample. In isolation, first factor explained 24.80% of the total variance; second factor explained 17.99% of the total variance; third factor explained 15.51% of the total variance and fourth factor explained 10.47% of the total variance.

**Table 5.81 Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.678 | 37.102 | 37.102 | 4.465 | 24.803 | 24.803 |
| 2 | 2.948 | 16.375 | 53.477 | 3.240 | 17.998 | 42.801 |
| 3 | 1.585 | 8.807 | 62.284 | 2.793 | 15.515 | 58.316 |
| 4 | 1.171 | 6.507 | 68.791 | 1.886 | 10.475 | 68.791 |
| 5 | .834 | 4.636 | 73.427 | | | |
| 6 | .711 | 3.951 | 77.378 | | | |
| 7 | .613 | 3.405 | 80.783 | | | |
| 8 | .599 | 3.329 | 84.112 | | | |
| 9 | .481 | 2.670 | 86.781 | | | |
| 10 | .399 | 2.214 | 88.996 | | | |
| 11 | .389 | 2.162 | 91.158 | | | |
| 12 | .327 | 1.816 | 92.974 | | | |
| 13 | .292 | 1.621 | 94.595 | | | |
| 14 | .269 | 1.496 | 96.091 | | | |
| 15 | .215 | 1.197 | 97.288 | | | |
| 16 | .187 | 1.041 | 98.329 | | | |
| 17 | .165 | .915 | 99.243 | | | |
| 18 | .136 | .757 | 100.000 | | | |

The factor analysis revealed four broad factors, which are leading to supply chain inefficiency in middlemen/local trader stage with respect to time (Table 5.82). Labour factor happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by operational issues, resources, and infrastructure. These four latent factors are summarized as follows:

**Table 5.82: Summary- Factors leading to supply chain inefficiency in Middlemen/local trader stage with respect to time**

| Variables | Component | | | | Variance (% of explained) | Factor Name |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |

| | | | | | eigen values | |
|---|---|---|---|---|---|---|
| Non-availability of skilled labour for sorting, grading & packaging | 0.857 | | | | ***24.803*** | *Labour* |
| Non-availability of skilled labour-HLS | 0.856 | | | | | |
| Employment of inadequate labour for unloading operations | 0.812 | | | | | |
| Lack of knowledge pertaining to sorting & grading techniques and processes | 0.803 | | | | | |
| Non-availability of skilled labour for unloading the crates | 0.74 | | | | | |
| Lack of Training and Knowledge about sorting, grading & packaging | 0.726 | | | | | |
| Time Ignorance during sorting, grading, and packaging | | 0.793 | | | ***17.998*** | *Operational* |
| Manual sorting, grading & packaging | | 0.744 | | | | |
| Handling and Loading by the means of head load | | 0.7 | | | | |
| Single manual handling while loading | | 0.685 | | | | |
| Bulk handling at the time of loading operations | | 0.645 | | | | |
| Manual unloading | | 0.639 | | | | |
| Lack of sorting & grading technology | | | 0.828 | | ***15.515*** | *Resources* |
| Non-availability of tools and equipment for handling & loading | | | 0.783 | | | |
| Non-availability of equipment for unloading the crate | | | 0.704 | | | |
| Timely Non-availability of packaging materials | | | 0.694 | | | |
| Lack of mechanical sorting, grading and packaging facility | | | | 0.826 | ***10.475*** | *Infrastructure* |
| Inadequate space for unloading operations | | | | 0.815 | | |

*Factor 1– Labour:* The Labour-related issue is recognized as a first factor leading to high lead time in activities carried at middlemen/local trader stage of mango supply chain. This factor includes six sub-variables having total variance 24.80%. Non-availability of skilled labour for sorting, grading & packaging (0.857) carries highest loading in labour factor, followed by non-availability of skilled labour for handling, loading and stacking activities (0.856), employment of inadequate labour for unloading operations (0.812), lack of knowledge pertaining to sorting & grading techniques and processes (0.803), non-availability of skilled labour for unloading the crates (0.74), and lack of training and knowledge about sorting, grading & packaging activities (0.726). The results indicate that the labour-related issues like non-availability of skilled labour, inadequate labour, training, knowledge, and awareness of labour are some reasons due to which the operations at this stage could not performed well, which resulted into high lead time.

*Factor 2 – Operational:* The second factor is an operational issue, possessing total variance of 17.99% and consists of six sub-variables. Time ignorance during sorting, grading and packaging (0.793) variable has highest factor loading, followed by manual sorting, grading & packaging (0.744), handling and loading by the means of head load (0.700), single manual handling while loading (0.685), bulk handling at the time of loading operations (0.645), and manual unloading (0.639). The results indicate that operational issues like manual and inadequate operations, and ignorance are also the reasons for high lead time in mango supply chain.

*Factor 3 – Resources:* Lack of resources is the third factor, which is leading to high lead time in the operations performed at middlemen/local trader stage. This factor has a total variance of 15.51% and consists of four sub-variables. Lack of sorting & grading technology (0.828) carries highest factor loading in this category, followed by non-availability of tools and equipment for handling & loading (0.783), non-availability of equipment for unloading the supplier's crate (0.704), and timely non-availability of packaging materials (0.694). The results indicate that lack of resources pertaining to technology, tools and equipment and packaging materials are the main reasons under this category, which is leading to high lead time.

*Factor 4 – Infrastructure:* The fourth and last factor leading to supply chain inefficiency with respect to high lead time can be named as Infrastructure, having a variance of 10.47% and contain two sub-variables. Lack of mechanical sorting, grading, and packaging facility has the highest loading in this factor with the factor loading of 0.826, followed by inadequate space for unloading operations (0.815). The results indicate that lack of mechanical facilities for primary processing and inadequate space is the issue of concern, which needs to be improved to reduce lead time in the operations performed at middlemen/local trader stage.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.83 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 67.65% of the variation across the sample. In isolation, first factor explained 39.93% of the total variance; second factor explained 8.09% of the total variance; third factor explained 7.27% of the total variance, fourth factor explained about 6.93% of the total variance, and fifth factor explained 5.42% of the total variance.

**Table 5.83: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 11.355 | 45.421 | 45.421 | 9.983 | 39.930 | 39.930 |
| 2 | 1.643 | 6.573 | 51.993 | 2.023 | 8.090 | 48.021 |
| 3 | 1.539 | 6.157 | 58.151 | 1.819 | 7.275 | 55.296 |
| 4 | 1.272 | 5.089 | 63.240 | 1.735 | 6.939 | 62.235 |
| 5 | 1.104 | 4.417 | 67.657 | 1.356 | 5.423 | 67.657 |
| 6 | .982 | 3.929 | 71.586 | | | |
| 7 | .853 | 3.413 | 74.999 | | | |
| 8 | .821 | 3.285 | 78.285 | | | |
| 9 | .740 | 2.960 | 81.244 | | | |
| 10 | .636 | 2.543 | 83.788 | | | |
| 11 | .582 | 2.327 | 86.115 | | | |
| 12 | .552 | 2.208 | 88.323 | | | |
| 13 | .484 | 1.936 | 90.258 | | | |
| 14 | .410 | 1.639 | 91.897 | | | |
| 15 | .338 | 1.351 | 93.249 | | | |
| 16 | .312 | 1.249 | 94.498 | | | |
| 17 | .254 | 1.016 | 95.514 | | | |
| 18 | .225 | .902 | 96.416 | | | |
| 19 | .196 | .785 | 97.201 | | | |
| 20 | .171 | .683 | 97.884 | | | |
| 21 | .170 | .681 | 98.565 | | | |
| 22 | .122 | .487 | 99.052 | | | |
| 23 | .098 | .393 | 99.445 | | | |
| 24 | .080 | .320 | 99.765 | | | |
| 25 | .059 | .235 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency with respect to quality in middlemen/local trader stage (Table 5.84). Operational issue happens to be the most crucial factor leading to poor quality of fresh produce at this stage, followed by infrastructure issue, labour, ambience, and poor preservation. These five latent factors are summarized as follows:

**Table 5.84: Summary-Factors leading to supply chain inefficiency in middlemen/local trader stage with respect to quality**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Unloading the crates in an open area which expose to direct sunlight/heat | 0.884 | | | | | ***39.93*** | *Operational* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| No proper arrangement of packages/crates for air circulation while stacking in vehicle | 0.867 | | | | | | |
| Holding of goods in anticipation of high prices | 0.86 | | | | | | |
| Rough handling while unloading | 0.843 | | | | | | |
| Delays in moving the produce to the wholesale market | 0.831 | | | | | | |
| Rough handling at the time of loading & stacking | 0.821 | | | | | | |
| Improper and high stacking while storing | 0.816 | | | | | | |
| Rough handling while storing | 0.791 | | | | | | |
| Overstock due to Inadequate and non-availability of timely demand information | 0.779 | | | | | | |
| Unloading the crates in an inappropriate manner | 0.762 | | | | | | |
| Dumping of Crates into the vehicle | 0.734 | | | | | | |
| Improper and high stacking | 0.712 | | | | | | |
| Bulk handling of fresh produce | 0.706 | | | | | | |
| Non-usage of supporting equipments for handling & loading | 0.689 | | | | | | |
| Single manual handling while loading & stacking | 0.669 | | | | | | |
| Inappropriate storing practices leading to compression | 0.605 | | | | | | |
| Insufficient storage and temperature controlled facilities | | 0.731 | | | | ***8.09*** | *Infrastructure* |
| Non-availability of cooling shed at the place of storage | | 0.568 | | | | | |
| Open dock area which expose to direct sunlight/heat | | 0.55 | | | | | |
| Inadequate space for unloading operations | | 0.498 | | | | | |
| Non-usage of skilled labour for unloading the crates | | | 0.718 | | | ***7.275*** | *Labour* |
| Non-usage of skilled labour for Handling Loading & Stacking | | | 0.703 | | | | |
| Inadequate ventilation at the place of storage | | | | 0.778 | | ***6.939*** | *Ambience* |
| High temperature at storage area | | | | 0.618 | | | |
| Damage to the Mangoes caused by pest and fungal infection during storage | | | | | 0.774 | ***5.423*** | *Preservation* |

*Factor 1–Operational:* The operational issue is recognized as the first factor that leads to poor quality of fresh produce in middlemen/local trader stage of mango supply chain. This factor includes sixteen sub-variables having total variance 39.93%. The variable named unloading the crates in an open area, which expose to

direct sunlight/heat (0.884) carries highest factor loading in this category, followed by no proper arrangement of packages/crates for air circulation while stacking in vehicle (0.867), holding of goods in anticipation of high prices (0.860), rough handling while unloading (0.843), delays in moving the produce to the wholesale market (0.831), rough handling at the time of loading & stacking (0.821), improper and high stacking while storing (0.816), rough handling while storing (0.791), overstock due to Inadequate and non-availability of timely demand information (0.779), unloading the crates in an inappropriate manner (0.762), dumping of Crates into the vehicle (0.734), improper and high stacking (0.712), bulk handling of fresh produce (0.706), non-usage of supporting equipment for handling & loading (0.689), single manual handling while loading & stacking (0.669), and inappropriate storing practices leading to compression (0.605). The result indicates that the variables, which are underlying in this category are operational level issues, which are leading to poor quality of fresh produce.

Factor 2–Infrastructure: The second factor is Infrastructure, possessing total variance of 8.09% and consists of four sub-variables. Insufficient storage and temperature controlled facilities (0.731) carries the highest factor loading in this factor, followed by non-availability of cooling shed at the place of storage (0.568), open dock area which exposes to direct sunlight/heat (0.550), and inadequate space for unloading operations (0.498). The result indicates that lack of cold chain infrastructure, open area for operations and inadequate space are the main reasons leading to poor quality of the fresh produce at this stage.

*Factor 3 –Labour:* Labour is the third factor, possessing total variance of 7.27% and contain two sub-variables, i.e., non-usage of skilled labour for unloading the crates, and non-usage of skilled labour for handling loading & stacking. Non-usage of skilled labour for unloading the crates has the highest factor loading of 0.718, followed by non-usage of skilled labour for handling loading & stacking (0.703). This result indicates that there is an urgent requirement of skilled labour to perform the logistics operations in order to prevent the quality of fresh produce at this stage.

*Factor 4–Ambience:* The fourth factor is ambience, having a variance of 6.93% and consists of two sub-variables. Inadequate ventilation at the place of storage (.778) carries highest factor loading in this category, followed by high temperature at storage area with the factor loading of .618. The result indicates that improper ambience in the middlemen/local trader stage of mango supply chain is also one of the factors leading to poor quality of fresh produce.

*Factor 5–Preservation:* The fifth factor, which is leading to poor quality of fresh produce in the supply chain of mango at middlemen/local trader stage is poor preservation, having a variance of 5.42% and consist only one variable namely damage to the mangoes caused by pest and fungal infection during storage with the factor loading of 0.774. The result indicates that fresh produce gets damage due to pest and fungal infection, which results in losses, hence requires proper preservation to maintain the quality of fresh produce in the supply chain.

**5.3.2.4. *iii*. Factors Leading to Supply Chain Inefficiency in Wholesale/Mandi Stage (Stage III)**

Factors leading to supply chain inefficiency with respect to cost, time and quality in wholesale/mandi stage of fruits (mango) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.85 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Three factors have been identified (possessing eigen values >1), which mutually amounts to 63.343% of the variation across the sample. In isolation, first factor explained 32.902% of the total variance; second factor explained 21.055% of the total variance, and third factor explained 9.386% of the total variance.

**Table 5.85 Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.718 | 44.787 | 44.787 | 4.935 | 32.902 | 32.902 |
| 2 | 1.443 | 9.621 | 54.408 | 3.158 | 21.055 | 53.957 |
| 3 | 1.340 | 8.935 | 63.343 | 1.408 | 9.386 | 63.343 |
| 4 | 1.150 | 7.668 | 71.011 | | | |
| 5 | .857 | 5.713 | 76.724 | | | |
| 6 | .698 | 4.654 | 81.378 | | | |
| 7 | .598 | 3.986 | 85.364 | | | |
| 8 | .541 | 3.608 | 88.972 | | | |
| 9 | .362 | 2.416 | 91.388 | | | |
| 10 | .321 | 2.138 | 93.526 | | | |
| 11 | .275 | 1.836 | 95.361 | | | |
| 12 | .259 | 1.728 | 97.089 | | | |
| 13 | .182 | 1.211 | 98.300 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14 | .154 | 1.030 | 99.330 | | | |
| 15 | .100 | .670 | 100.000 | | | |

The factor analysis revealed three broad issues (factors), which are leading to supply chain inefficiency with respect to cost in Wholesale/Mandi stage of mango supply chain (Table 5.86). An operational charge happens to be the most crucial factor leading to supply chain inefficiency with respect to high cost, followed by labour, and resources. These three latent factors are summarized as follows:

**Table 5.86 Summary-Factors leading to supply chain inefficiency with respect to cost in Wholesale/Mandi stage**

| Variables | Component | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| High charges of cold storage | 0.857 | | | ***32.902*** | *Operational Charges* |
| High electricity charges | 0.835 | | | | |
| Expensive packaging materials | 0.833 | | | | |
| Damage to boxes/crates due to rough manual handling while storage | 0.795 | | | | |
| Manual operations for HLS | 0.766 | | | | |
| Damage to crates/boxes while unloading | 0.758 | | | | |
| Manual operations for Unloading | 0.581 | | | | |
| High Labour Charges in HLS | | 0.775 | | ***21.055*** | *Labour* |
| Large number of Labour required for Unloading | | 0.760 | | | |
| Labour charges for maintenance and security | | 0.643 | | | |
| High Labour Charges-Unloading | | 0.606 | | | |
| Pre unloading labour charges | | 0.541 | | | |
| Pre loading labour charges | | 0.528 | | | |
| Non-availability of tools and equipments for handling & loading | | | 0.857 | ***9.386*** | *Resources* |
| Non-availability of tools and equipments for unloading the load | | | 0.643 | | |

*Factor 1– Operational Charges:* Operational charge is recognized as a first factor that leads to high cost in the Wholesale/Mandi stage of mango supply chain. This factor includes seven sub-variables having total variance 32.902%. High charges of cold storage (0.857) carries highest factor loading in the operational charges factor, followed by high electricity charges (0.835), expensive packaging materials (0.833), damage to boxes/crates due to rough manual handling while storage (0.795), manual

operations for handling, loading and stacking (0.766), damage to crates/boxes while unloading (0.758), and manual operations for unloading (0.581). The results indicate that high charges involved in the day to day operations like rental charges for cold storage, high electricity charges, high packaging material charges, and unnecessary cost due to damage contributes to cost escalation in the Wholesale/Mandi stage of mango supply chain.

*Factor 2 – Labour:* The second factor leading to supply chain inefficiency with respect to cost in the Wholesale/Mandi stage of mango supply chain is labour, possessing total variance of 21.055% and contain six sub-variables. High Labour Charges in handling, loading and stacking activities (0.775) carries highest factor loading in this factor, followed by large number of Labour required for unloading (0.760), labour charges for maintenance and security (0.643), high labour charges in unloading of vehicle (0.606), pre unloading labour charges (0.541), and pre-loading labour charges (0.528). The results indicate that high charges by labour for handling, loading, unloading, maintenance and security activities incurring a high cost at this stage.

*Factor 3–Resources:* Lack of resource availability is the third and final factor leading to high cost in this stage, having a variance of 9.386% and consists of two sub-variables namely, Non-availability of tools and equipment for handling & loading, and Non-availability of tools and equipment for unloading the load from the vehicle. Non-availability of tools and equipment for handling & loading the vehicle (.857) carries highest factor loading, followed by non-availability of tools and equipment for unloading the load (.643). This factor indicates that due to non-availability of tools and equipment for loading and unloading operations, large number of manpower is required to perform the operations, which increases the unnecessary manpower cost.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.87 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 71.956% of the variation across the sample. In isolation, first factor explained 33.217% of the total variance; second factor explained 15.009% of the total variance; third factor explained 14.545% of the total variance and fourth factor explained 9.185% of the total variance.

**Table 5.87: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.583 | 44.603 | 44.603 | 5.647 | 33.217 | 33.217 |
| 2 | 2.209 | 12.993 | 57.596 | 2.552 | 15.009 | 48.226 |
| 3 | 1.409 | 8.290 | 65.886 | 2.473 | 14.545 | 62.771 |
| 4 | 1.032 | 6.070 | 71.956 | 1.561 | 9.185 | 71.956 |
| 5 | .822 | 4.832 | 76.788 | | | |
| 6 | .610 | 3.587 | 80.376 | | | |
| 7 | .562 | 3.307 | 83.683 | | | |
| 8 | .530 | 3.117 | 86.800 | | | |
| 9 | .454 | 2.670 | 89.470 | | | |
| 10 | .333 | 1.961 | 91.431 | | | |
| 11 | .323 | 1.899 | 93.330 | | | |
| 12 | .252 | 1.480 | 94.810 | | | |
| 13 | .238 | 1.397 | 96.207 | | | |
| 14 | .225 | 1.326 | 97.534 | | | |
| 15 | .179 | 1.051 | 98.584 | | | |
| 16 | .163 | .962 | 99.546 | | | |
| 17 | .077 | .454 | 100.000 | | | |

The factor analysis revealed four broad factors, which are leading to supply chain inefficiency with respect to time in the Wholesale/Mandi stage of mango supply chain (Table 5.88). Operational issue happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by labour, resources, and infrastructure. These four latent factors are summarized as follows:

**Table 5.88: Summary- Factors leading to supply chain inefficiency with respect to time in Wholesale/Mandi stage**

| Variables | Component | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Delay in auctioning of mangoes | 0.808 | | | | ***33.217*** | *Operational* |
| Holding of goods in anticipation of high prices | 0.793 | | | | | |
| Arrival of Larger Quantity of goods | 0.789 | | | | | |
| Improper planning for scheduling | 0.777 | | | | | |
| Manual unloading | 0.763 | | | | | |
| Inadequate and non-availability of timely demand information | 0.727 | | | | | |
| Improper and High stacking of crates | 0.672 | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Single manual handling while loading | 0.623 | | | | | |
| High Stock/Volume of unsold mangoes at Mandi | 0.590 | | | | | |
| Handling and Loading by the means of head load | 0.540 | | | | | |
| Bulk handling of the crates/packages | 0.512 | | | | | |
| Employment of inadequate labour for unloading operations | | 0.879 | | | | |
| Non-usage of skilled labour-HLS | | 0.842 | | | ***15.009*** | *Labour* |
| Non-usage of skilled labour for unloading the crates | | 0.658 | | | | |
| Non-availability of equipments for unloading | | | 0.922 | | ***14.545*** | *Resources* |
| Non-availability of tools and equipments for handling & loading | | | 0.920 | | | |
| Inadequate space for unloading operations | | | | 0.889 | ***9.185*** | *Infrastructure* |

Factor 1– Operational: The Operational issue is recognized as a first factor leading to high lead time in the Wholesale/Mandi stage of mango supply chain. This factor includes eleven sub-variables having total variance 33.217%. Delay in auctioning of mangoes (0.808) carries highest factor loading in this factor, followed by the variables namely, holding of goods in anticipation of high prices (0.793), arrival of Larger Quantity of goods (0.789),improper planning for scheduling (0.777), manual unloading (0.763), inadequate and non-availability of timely demand information (0.727), improper and high stacking of crates (0.672), single manual handling while loading (0.623), high stock/volume of unsold mangoes at Mandi (0.590), handling and loading by the means of head load (0.540), and bulk handling of the crates/packages (0.512). The results indicate that most of the variables underlying in this category are an operational related issue, which is leading to high lead time in Wholesale/Mandi stage.

*Factor 2 –Labour:* The second factor leading to high lead time in this stage is labour, possessing total variance of 15.009% and contain three sub-variables. The variable named, Employment of inadequate labour for unloading operations (0.879) has the highest factor loading in labour factor. This is followed by the variables namely, non-usage of skilled labour for handling, loading and stacking activities (0.842), and non-usage of skilled labour for unloading of the vehicle (0.658). The results indicate that non-availability of skilled labour and usage of inadequate labour are the issue of concern in this factor, which is leading to high lead time.

*Factor 3 – Resources:* Lack of resources is the third factor, which is leading to high lead time in the Wholesale/Mandi stage of mango supply chain. This factor has a total variance of 14.54% and consists of two sub-variables namely, Non-availability of equipment for unloading, and non-availability of tools and equipment for handling & loading. Non-availability of equipment for unloading (0.922) carries highest factor loading in this category, followed by non-availability of tools and equipment for handling & loading (0.920). The results indicate that lack of resources pertaining to tools and equipment for loading and unloading operations are leading to high lead time.

*Factor 4 – Infrastructure:* The fourth and last factor leading to supply chain inefficiency with respect to high lead time in this stage is infrastructure, having a variance of 9.185% and consist of only one sub-variable, namely, inadequate space for unloading operations with the factor loading of 0.889. The results indicate that at Wholesale/Mandi stage, there is an inadequate space for proper unloading operations, which leads to high turnaround time.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.89 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), mutually amounts to 64.441% of the variation across the sample. In isolation, first factor explained 31.52% of the total variance; second factor explained 15.57% of the total variance; third factor explained 10.47% of the total variance, and fourth factor explained about 6.86% of the total variance.

**Table 5.89: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 11.049 | 42.497 | 42.497 | 8.196 | 31.522 | 31.522 |
| 2 | 2.865 | 11.018 | 53.515 | 4.050 | 15.576 | 47.098 |
| 3 | 1.553 | 5.974 | 59.489 | 2.724 | 10.475 | 57.573 |
| 4 | 1.287 | 4.952 | 64.441 | 1.786 | 6.868 | 64.441 |
| 5 | 1.088 | 4.186 | 68.627 | | | |
| 6 | .919 | 3.536 | 72.163 | | | |
| 7 | .827 | 3.180 | 75.343 | | | |
| 8 | .666 | 2.562 | 77.906 | | | |
| 9 | .637 | 2.449 | 80.354 | | | |
| 10 | .559 | 2.150 | 82.504 | | | |
| 11 | .512 | 1.968 | 84.472 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | .459 | 1.767 | 86.239 | | | |
| 13 | .434 | 1.669 | 87.908 | | | |
| 14 | .404 | 1.556 | 89.463 | | | |
| 15 | .372 | 1.429 | 90.892 | | | |
| 16 | .324 | 1.247 | 92.140 | | | |
| 17 | .314 | 1.209 | 93.348 | | | |
| 18 | .289 | 1.113 | 94.461 | | | |
| 19 | .270 | 1.037 | 95.498 | | | |
| 20 | .240 | .923 | 96.421 | | | |
| 21 | .217 | .835 | 97.256 | | | |
| 22 | .196 | .754 | 98.010 | | | |
| 23 | .161 | .619 | 98.630 | | | |
| 24 | .142 | .546 | 99.175 | | | |
| 25 | .117 | .451 | 99.626 | | | |
| 26 | .097 | .374 | 100.000 | | | |

The factor analysis revealed four broad factors, which are leading to supply chain inefficiency with respect to quality in the Wholesale/Mandi stage of mango supply chain (Table 5.90). Operational issue happens to be the most crucial factor leading to poor quality of fresh produce at this stage, followed by infrastructure, resources, and ambience. These four latent factors are summarized as follows:

**Table 5.90 Summary-Factors leading to supply chain inefficiency with respect to quality in Wholesale/Mandi stage**

| **Variables** | **Component** | | | | **Variance (% of explained) Eigen values** | **Factor Name** |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Damage to the mangoes caused by pest and fungal infection during storage | 0.854 | | | | | |
| Compression of mangoes due to heavy load in storing | 0.841 | | | | | |
| Holding of goods in anticipation of high prices | 0.837 | | | | | |
| No proper arrangement of packages/crates for air circulation while stacking | 0.784 | | | | | |
| Rough handling while storing | 0.769 | | | | ***31.552*** | *Operational* |
| Expose to direct sunlight/heat while unloading | 0.746 | | | | | |
| Improper and high stacking | 0.721 | | | | | |
| Overstock due to Inadequate and non-availability of timely demand information | 0.720 | | | | | |
| Rough handling while unloading | 0.703 | | | | | |
| Dumping of Crates into the vehicle | 0.698 | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Unloading in an in appropriate manner | 0.697 | | | | | |
| Bulk Handling at the time of Loading and Stacking | 0.674 | | | | | |
| Rough handling at the time of loading & stacking | 0.628 | | | | | |
| Improper and high stacking while storing | 0.448 | | | | | |
| Single manual handling while loading & stacking | 0.442 | | | | | |
| Lack of cold storage facility | | 0.772 | | | | |
| Insufficient storage and temperature controlled facilities | | 0.762 | | | | |
| Open dock area which expose to direct sunlight/heat-UfT | | 0.739 | | | | |
| Non-availability of cooling shed at the place of storage | | 0.734 | | | ***15.576*** | *Infrastructure* |
| Inadequate space for unloading operations | | 0.666 | | | | |
| Open dock area which expose to direct sunlight/heat-HLS | | 0.537 | | | | |
| Non-availability of skilled labour for unloading the crates | | | 0.821 | | | |
| Non-availability of skilled labour-HLS | | | 0.809 | | ***10.475*** | *Resources* |
| Non-availability of equipments for handling & loading | | | 0.766 | | | |
| High temperature at storage area | | | | 0.852 | ***6.868*** | *Ambience* |
| Inadequate ventilation at the place of storage | | | | 0.828 | | |

*Factor 1–Operational:* The Operational issue is recognized as the first factor that leads to poor quality of fresh produce in the Wholesale/Mandi stage of mango supply chain. This factor includes fifteen sub-variables having total variance 31.52%. The variable named damage to the mangoes caused by pest and fungal infection during storage (0.854) carries highest factor loading in operational issue. This is followed by the following variables namely, compression of mangoes due to heavy load in storage (0.841), holding of goods in anticipation of high prices (0.837), no proper arrangement of packages/crates for air circulation while stacking (0.784), rough handling while storing (0.769), expose to direct sunlight/heat while unloading (0.746), improper and high stacking (0.721), overstock due to inadequate and non-availability of timely demand information (0.720), rough handling while unloading (0.703), dumping of crates into the vehicle (0.698), unloading in an inappropriate manner (0.697), bulk handling at the time of loading and stacking (0.674), rough handling at the time of loading & stacking (0.628), improper and high

stacking while storing (0.448), and single manual handling while loading & stacking (0.442). Most of the variables, which are underlying in this category are operational level issues. The result indicates that operations are not performed in an appropriate manner resulting in the poor quality of fresh produce.

Factor 2–Infrastructure: The second factor is Infrastructure, possessing total variance of 15.57% and consists of six sub-variables. Lack of cold storage facility (0.772) carries highest factor loading in this category, followed by insufficient storage and temperature controlled facilities (0.762), open dock area which expose to direct sunlight/heat while unloading the vehicle (0.739), non-availability of cooling shed at the place of storage (0.734), inadequate space for unloading operations (0.666), and open dock area which expose to direct sunlight/heat while handling, loading and stacking the load into the vehicle (0.537). The result indicates that lack of cold chain infrastructure, open dock area and inadequate space at Wholesale/Mandi stage are the main reasons for poor quality of the fresh produce at this stage.

Factor 3 –Resources: Resource is the third factor leading to poor quality in the Wholesale/Mandi stage of mango supply chain. It has a total variance of 10.47% and consists of three sub-variables. Non-availability of skilled labour for unloading the crates (0.821) carries highest factor loading in this category, followed by non-availability of skilled labour for handling, loading and stacking activities (0.809), and non-availability of equipment for handling & loading (0.766). The result indicates that due to non-availability of skilled manpower and equipment at the Wholesale/Mandi stage, the quality of fresh produce deteriorates, which leads to high losses.

*Factor 4–Ambience:* Ambience is the fourth and last factor leading to poor quality in the Wholesale/Mandi stage of mango supply chain. It displays a variance of 6.86% and consists of two sub-variables namely, the High temperature at storage area, and inadequate ventilation at the place of storage. The high temperature at storage area has the highest factor loading of 0.852, followed by inadequate ventilation at the place of storage (0.828). The result indicates that the problem of high temperature and inadequate ventilation is also an important issue of concern at Wholesale/Mandi stage, which impacts the quality of the fresh produce.

### 5.3.2.4. *iv*. Factors Leading to Supply Chain Inefficiency in Local Trader/Mashakhor stage at Azadpur Mandi (Stage IV)

Factors leading to supply chain inefficiency with respect to cost, time and quality in local trader/mashakhor stage at Azadpur mandi of fruits (mango) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.91 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 73.90% of the variation across the sample. In isolation, first factor explained 20.07% of the total variance; second factor explained 17.39% of the total variance; third factor explained 16.14% of the total variance, fourth factor explained 10.26% of the total variance, and fifth factor explained 10.04% of the total variance.

**Table 5.91: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.476 | 32.378 | 32.378 | 4.015 | 20.075 | 20.075 |
| 2 | 3.221 | 16.103 | 48.481 | 3.480 | 17.398 | 37.473 |
| 3 | 2.050 | 10.252 | 58.733 | 3.229 | 16.146 | 53.619 |
| 4 | 1.579 | 7.897 | 66.630 | 2.054 | 10.269 | 63.888 |
| 5 | 1.460 | 7.300 | 73.930 | 2.008 | 10.042 | 73.930 |
| 6 | .981 | 4.905 | 78.835 | | | |
| 7 | .711 | 3.554 | 82.389 | | | |
| 8 | .618 | 3.090 | 85.478 | | | |
| 9 | .500 | 2.499 | 87.977 | | | |
| 10 | .472 | 2.358 | 90.336 | | | |
| 11 | .379 | 1.895 | 92.231 | | | |
| 12 | .303 | 1.517 | 93.748 | | | |
| 13 | .284 | 1.422 | 95.170 | | | |
| 14 | .250 | 1.248 | 96.418 | | | |
| 15 | .211 | 1.056 | 97.474 | | | |
| 16 | .170 | .848 | 98.322 | | | |
| 17 | .118 | .589 | 98.911 | | | |
| 18 | .084 | .420 | 99.331 | | | |
| 19 | .069 | .346 | 99.677 | | | |
| 20 | .065 | .323 | 100.000 | | | |

The factor analysis revealed five broad issues (factors), which are leading to supply chain inefficiency with respect to cost in local trader/mashakhor stage (at Azadpur) of mango supply chain (Table 5.92). Resources happens to be the most crucial factor leading to supply chain inefficiency with respect to high cost at this stage, followed by operational issues, operational charges, labour, and infrastructure. These five latent factors are summarized as follows:

**Table 5.92: Summary-Factors leading to supply chain inefficiency with respect to cost in local trader/mashakhor stage (at Azadpur)**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Non-usage of Sorting & Grading Technology | 0.9 | | | | | ***20.075*** | *Resources* |
| Non-usage of Advanced Packaging Materials | 0.873 | | | | | | |
| Non-availability of tools and equipments for unloading the load | 0.822 | | | | | | |
| Timely Non-availability of packaging materials | 0.819 | | | | | | |
| Price differential of Packaging Materials at different places | 0.742 | | | | | | |
| Damage to crates/boxes while unloading | | 0.898 | | | | ***17.398*** | *Operational* |
| Excess usage of Material for layering and tapping the cartons/boxes | | 0.877 | | | | | |
| Damage to boxes/crates due to rough handling while storage | | 0.865 | | | | | |
| Manual operations in Unloading | | 0.798 | | | | | |
| High charges of cold storage facilities | | | 0.872 | | | ***16.146*** | *Operational Charges* |
| Expenditure on chemicals used for ripening | | | 0.855 | | | | |
| High electricity charges | | | 0.848 | | | | |
| High charges of ripening chamber | | | 0.588 | | | | |
| Expensive Packaging material | | | 0.519 | | | | |
| High Labour charges arising out of expertise required for grading and packaging | | | | 0.746 | | ***10.269*** | *Labour* |
| High Labour Charges for Unloading | | | | 0.647 | | | |
| Cost of labour for maintenance and security | | | | 0.622 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lack of knowledge pertaining to sorting & grading techniques and processes | | | | 0.46 | | | |
| Lack of mechanical sorting, grading and packaging facility | | | | | 0.906 | ***10.042*** | *Infrastructure* |
| Lack of Government packing houses/grading facilities | | | | | 0.883 | | |

*Factor 1– Resources:* Resource factor is recognized as a first category that leads to high cost in the local trader/mashakhor stage (at Azadpur) of mango supply chain. This factor includes five sub-variables having total variance 20.07%. Non-usage of sorting & grading technology (0.900) carries highest factor loading in this category, followed by the following variables namely, non-usage of advanced packaging materials (0.873), non-availability of tools and equipment for unloading the load (0.822), timely non-availability of packaging materials (0.819), and price differential of packaging materials at different places (0.742). The results indicate that non-availability of resources pertaining to technology, tools, equipment, and materials are the major issue underlying in this factor and leading to high cost in the supply chain.

*Factor 2 – Operational:* The second factor leading to supply chain inefficiency with respect to cost in the local trader/mashakhor stage (at Azadpur) of mango supply chain is an operational issue, possessing total variance of 17.39% and contain four sub-variables. Damage to crates/boxes while unloading (0.898) carries highest factor loading in this factor, followed by excess usage of material for layering and tapping the cartons/boxes (0.877), damage to boxes/crates due to rough handling while storage (0.865), and manual operations in unloading (0.798). The results indicate that inadequate and improper operations causes damage to the packaging crates/boxes, and also leads to excess usage of materials, which escalate cost in the supply chain of mango at local trader/mashakhor stage.

Factor 3–Operational Charges: The third factor, which leads to high cost in the supply chain of mango is operational charges, having a variance of 16.14% and consists of five sub-variables. High charges of cold storage facilities (0.872) ensure highest factor loading, followed by expenditure on chemicals used for ripening (0.855), high electricity charges (0.848), high charges of ripening chamber (0.588), and expensive packaging material (0.519). This factor indicates high charges related to the basic and day-to-day operations are escalating the cost, i.e., high rental charges for cold storage, high electricity charges, and high rental ripening chambers.

*Factor 4–Labour:* The fourth factor is directly related to the labour and leading to high cost at this stage. It displays a variance of 10.26% and consists of four sub-variables. The main reason for high cost in this factor is high labour charges arising out of expertise required for grading and packaging (0.746), followed by high Labour Charges for Unloading (0.647), cost of labour for maintenance and security (0.622), and lack of knowledge pertaining to sorting & grading techniques and processes (0.460). The results indicate that high labour charges and lack of knowledge are the main reason for a high cost under this factor.

*Factor 5–Infrastructure:* The fifth and last factor leading to high cost in the supply chain of mango at this stage is poor infrastructure. It displays a variance of 10.04% and consists of only two sub-variables, namely, lack of mechanical sorting, grading and packaging facility, and lack of government packing houses/grading facilities. Lack of mechanical sorting, grading and packaging facility (0.906) carries the highest factor loading, followed by the variable; lack of government packing houses/grading facilities (0.883). The results indicate that due to non-availability of sorting, grading and packaging facilities, the cost incurred in the sorting, grading, and packaging activities are high.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.93 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 80.96% of the variation across the sample. In isolation, first factor explained 19.98% of the total variance; second factor explained 19.44% of the total variance; third factor explained 18.69% of the total variance, fourth factor explained 12.88% of the total variance and fifth factor explained 9.95% of the total variance.

**Table 5.93: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.967 | 38.705 | 38.705 | 3.597 | 19.985 | 19.985 |
| 2 | 2.453 | 13.626 | 52.331 | 3.500 | 19.444 | 39.428 |
| 3 | 2.047 | 11.370 | 63.701 | 3.365 | 18.694 | 58.123 |
| 4 | 1.780 | 9.888 | 73.590 | 2.319 | 12.883 | 71.005 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 1.327 | 7.373 | 80.963 | 1.792 | 9.958 | 80.963 |
| 6 | .665 | 3.693 | 84.656 | | | |
| 7 | .502 | 2.787 | 87.444 | | | |
| 8 | .394 | 2.189 | 89.633 | | | |
| 9 | .352 | 1.958 | 91.591 | | | |
| 10 | .327 | 1.814 | 93.405 | | | |
| 11 | .288 | 1.598 | 95.003 | | | |
| 12 | .243 | 1.348 | 96.351 | | | |
| 13 | .201 | 1.118 | 97.469 | | | |
| 14 | .154 | .857 | 98.326 | | | |
| 15 | .132 | .734 | 99.060 | | | |
| 16 | .095 | .530 | 99.590 | | | |
| 17 | .049 | .271 | 99.861 | | | |
| 18 | .025 | .139 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency with respect to time in the local trader/mashakhor stage (at Azadpur) of mango supply chain (Table 5.94). Labour issue happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by operational issue, resources, market uncertainties, and infrastructure. These five latent factors are summarized as follows:

**Table 5.94 Summary- Factors leading to supply chain inefficiency with respect to time in Local trader/mashakhor stage (at Azadpur)**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Non-availability of skilled labour for sorting, grading & packaging | 0.964 | | | | | | |
| Non-availability of skilled labour for unloading the crates | 0.936 | | | | | | |
| Employment of inadequate labour for unloading operations | 0.706 | | | | | ***19.985*** | *Labour* |
| Lack of knowledge pertaining to sorting & grading techniques and processes | 0.658 | | | | | | |
| Lack of Training and Knowledge about sorting, grading & packaging | 0.643 | | | | | | |
| Manual sorting, grading & packaging | | 0.813 | | | | | |
| Lack of proper and uniform grading which hinder to achieve uniform ripening | | 0.81 | | | | ***19.444*** | *Operational* |
| Holding of goods in anticipation of high prices | | 0.793 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ignorance of time allocated to sorting, grading and packaging<br>Manual unloading | | 0.717<br>0.526 | | | | | |
| Lack of sorting & grading technology<br>Inadequate equipment for ripening<br>Timely Non-availability of packaging materials<br>Non-availability of equipments for unloading the crate | | | 0.957<br>0.939<br>0.846<br>0.479 | | | ***18.694*** | *Resources* |
| Poor information regarding market demand<br>Lack of demand in the market | | | | 0.933<br>0.912 | | ***12.883*** | *Market Uncertainty* |
| Lack of mechanical sorting, grading and packaging facility<br>Inadequate space for unloading operations | | | | | 0.946<br>0.936 | ***9.958*** | *Infrastructure* |

*Factor 1– Labour:* Labour issue is recognized as a first factor leading to high lead time in the local trader/mashakhor stage (at Azadpur) of mango supply chain. This factor includes five sub-variables having total variance 19.98%. Non-availability of skilled labour for sorting, grading & packaging (0.964) carries highest factor loading, followed by non-availability of skilled labour for unloading the crates (0.936), employment of inadequate labour for unloading operations (0.706), lack of knowledge pertaining to sorting & grading techniques and processes (0.658) and lack of training and knowledge about sorting, grading & packaging (0.643). The results indicate that non-availability of skilled labour, and knowledge and training of the labour is the major issue of concern under this factor resulting in high lead time in the supply chain.

*Factor 2 –Operational:* The second factor leading to high lead time in this stage is an operational issue, possessing total variance of 19.44% and contain five sub-variables. The variable named, manual sorting, grading & packaging (0.813) carries highest factor loading in operational factor. This is followed by the variables, namely, Lack of proper and uniform grading which hinder to achieve uniform ripening (0.810), holding of goods in anticipation of high prices (0.793), ignorance of time allocated to sorting, grading and packaging (0.717), and Manual unloading (0.526). The results indicate that manual operations, improper grading activities, and ignorance by the workers are some of the major issues of concern under operational factor.

*Factor 3 – Resources:* The third factor leading to high lead time in the local trader/mashakhor stage of mango supply chain is resource availability. This factor has a total variance of 18.69% and contain four sub-variables namely, Lack of sorting & grading technology, inadequate equipment for ripening, timely non-availability of packaging materials, and non-availability of equipment for unloading the crate. Lack of sorting & grading technology (0.957) carries highest factor loading, followed by inadequate equipment for ripening (0.939), timely non-availability of packaging materials (0.846), and non-availability of equipment for unloading the crate (0.479). The results indicate that lack of resource availability pertaining to technology, tools, equipment, and packaging materials are a major issue of concern in the supply chain of mango at local trader/mashakhor stage.

*Factor 4 –Market Uncertainties:* The fourth factor leading to high lead time in this stage is market uncertainties, having a variance of 12.88% and contain only two sub-variables, namely, Poor information regarding market demand, and lack of demand in the market. Poor information regarding market demand has the highest factor loading of 0.933, followed by lack of demand in the market (0.912). The results indicate that due to poor information regarding market demand, the fresh produce is stored at local trader/mashakhor stage for a long period of time.

*Factor 5–Infrastructure:* The fifth and final factor leading to high lead time in this stage is infrastructure. It displays a variance of 9.95% and consists of only two sub-variables, namely, Lack of mechanical sorting, grading and packaging facility, and inadequate space for unloading operations. Lack of mechanical sorting, grading and packaging facility (0.946) carries highest factor loading in this category, followed by inadequate space for unloading operations (0.936). The results indicate that infrastructure needs to be developed at local trader/mashakhor stage to reduce the lead time in the supply chain. At present, there is a lack of mechanical facility for primary processing and inadequate space to perform crate unloading and loading operations.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.95 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Six factors have been identified (possessing eigen values >1), which mutually amounts to 74.77% of the variation across the sample. In isolation, first factor explained 38.55% of the total variance; second factor explained 10.33% of the total variance; third factor explained 7.95% of the total variance, fourth factor explained 7.08% of the total variance, fifth factor explained about 6.18% of the total variance, and factor six explained about 4.67% of the total variance.

**Table 5.95: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 13.600 | 45.335 | 45.335 | 11.567 | 38.555 | 38.555 |
| 2 | 2.375 | 7.916 | 53.251 | 3.099 | 10.331 | 48.886 |
| 3 | 1.957 | 6.523 | 59.774 | 2.385 | 7.950 | 56.836 |
| 4 | 1.785 | 5.951 | 65.725 | 2.124 | 7.081 | 63.917 |
| 5 | 1.645 | 5.485 | 71.210 | 1.857 | 6.189 | 70.106 |
| 6 | 1.071 | 3.569 | 74.779 | 1.402 | 4.673 | 74.779 |
| 7 | .982 | 3.273 | 78.052 | | | |
| 8 | .962 | 3.208 | 81.260 | | | |
| 9 | .782 | 2.605 | 83.865 | | | |
| 10 | .721 | 2.405 | 86.270 | | | |
| 11 | .665 | 2.215 | 88.485 | | | |
| 12 | .546 | 1.818 | 90.304 | | | |
| 13 | .451 | 1.503 | 91.806 | | | |
| 14 | .438 | 1.459 | 93.265 | | | |
| 15 | .367 | 1.222 | 94.487 | | | |
| 16 | .321 | 1.069 | 95.556 | | | |
| 17 | .267 | .891 | 96.447 | | | |
| 18 | .175 | .582 | 97.029 | | | |
| 19 | .167 | .557 | 97.586 | | | |
| 20 | .132 | .441 | 98.027 | | | |
| 21 | .118 | .394 | 98.421 | | | |
| 22 | .112 | .373 | 98.794 | | | |
| 23 | .093 | .310 | 99.104 | | | |
| 24 | .081 | .271 | 99.375 | | | |
| 25 | .046 | .154 | 99.529 | | | |
| 26 | .042 | .140 | 99.669 | | | |
| 27 | .037 | .122 | 99.791 | | | |
| 28 | .035 | .116 | 99.907 | | | |
| 29 | .017 | .055 | 99.963 | | | |
| 30 | .011 | .037 | 100.000 | | | |

The factor analysis revealed four broad factors, which are leading to supply chain inefficiency with respect to quality in the local trader/mashakhor stage of mango supply chain (Table 5.96). Operational issue happens to be the most crucial factor leading to poor quality of fresh produce at this stage, followed by infrastructure, resources, and ambience. These four latent factors are summarized as follows:

**Table 5.96: Summary-Factors leading to supply chain inefficiency with respect to quality in local trader/mashakhor stage**

| Variables | Component | | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| Lack of proper and uniform grading which hinder to achieve uniform ripening | 0.966 | | | | | | | |
| Unloading the crates in an open area which expose to direct sunlight/heat | 0.956 | | | | | | | |
| Compression of mangoes due to heavy load in storing-S&R | 0.951 | | | | | | | |
| Damage to the mangoes caused by pest and fungal infection during storage-S | 0.947 | | | | | | | |
| Holding of goods in anticipation of high prices-S | 0.939 | | | | | | | |
| Improper and high stacking while storing-S&R | 0.916 | | | | | | | |
| Rough handling while unloading | 0.899 | | | | | | | |
| Holding of goods in anticipation of high prices-S&R | 0.823 | | | | | | ***38.555*** | *Operational* |
| Compression of mangoes due to heavy load in storing-S | 0.81 | | | | | | | |
| Rough handling while storing-S | 0.782 | | | | | | | |
| Improper placing of fruits during ripening | 0.761 | | | | | | | |
| Lack of Proper Monitoring in Ripening Process | 0.753 | | | | | | | |
| Unloading the crates in an inappropriate manner | 0.73 | | | | | | | |
| Rough handling while storing-S&R | 0.6 | | | | | | | |
| Damage to the mangoes caused by pest and fungal infection during storage-S&R | 0.585 | | | | | | | |
| Improper and high stacking while storing-S | 0.489 | | | | | | | |
| Non-availability of cooling shed at the place of storage-S | | 0.885 | | | | | ***10.331*** | *Infrastructure* |
| Insufficient storage and ripening chamber facilities | | 0.809 | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Inadequate space for unloading operations | | 0.56 | | | | | | |
| Lack of usage of cold storage facility | | 0.528 | | | | | | |
| Insufficient storage and temperature controlled facilities | | 0.404 | | | | | | |
| High temperature at storage area-S | | | 0.719 | | | | ***7.95*** | *Ambience* |
| Inadequate ventilation at the place of storage-S&R | | | 0.67 | | | | | |
| Inadequate ventilation at the place of storage-S | | | 0.663 | | | | | |
| High temperature at storage and ripening area-S&R | | | 0.483 | | | | | |
| Inadequate and non-availability of timely demand information-S&R | | | | 0.949 | | | ***7.081*** | *Information* |
| Lack of Information regarding market conditions-S | | | | 0.938 | | | | |
| Inadequate equipment and ripening method | | | | | 0.897 | | ***6.181*** | *Technique* |
| Usage of calcium carbide for ripening process | | | | | 0.825 | | | |
| Non-availability of skilled labour for unloading the crates | | | | | | 0.808 | ***4.673*** | *Labour Availability* |

*Factor 1–Operational:* The Operational issue is recognized as the first factor that leads to poor quality of fresh produce in the local trader/mashakhor stage (at Azadpur) of mango supply chain. This factor includes sixteen sub-variables having total variance 38.55%. The variable named "lack of proper and uniform grading which hinder to achieve uniform ripening" carries highest factor loading (0.966). This is followed by unloading the crates in an open area which expose to direct sunlight/heat (0.956), compression of mangoes due to heavy load in storing during ripening process (0.951), damage to the mangoes caused by pest and fungal infection during storage (0.947), holding of goods in anticipation of high prices (0.939), improper and high stacking while storing (during ripening process) (0.916), rough handling while unloading (0.899), holding of goods in anticipation of high prices during storing & ripening process (0.823), compression of mangoes due to heavy load in stacking (0.81), rough handling while storing (0.782), improper placing of fruits during ripening (0.761), lack of proper monitoring in ripening process (0.753), unloading the crates in an inappropriate manner (0.730), rough handling while storing during ripening process (0.600), damage to the mangoes caused by pest and fungal infection during storage in ripening process (0.585), and

improper and high stacking while storing (0.489). Most of the variables, which are underlying in this category are operational level issues. The result indicates that operations are not performed in an appropriate manner during storing and ripening, storing of fresh produce, and unloading of fresh produce from supplier's crate and loading to buyer's crate, which results to the poor quality of fresh produce.

*Factor 2–Infrastructure:* The second factor is Infrastructure, possessing total variance of 10.33% and consists of five sub-variables. Non-availability of cooling shed at the place of storage (0.885) carries highest factor loading in this category, followed by insufficient storage and ripening chamber facilities (0.809), inadequate space for unloading supplier's crate and loading to buyer's crate (0.560), lack of usage of cold storage facility (0.528), and insufficient storage and temperature controlled facilities (0.404). The result indicates that lack of infrastructure at local trader/mashakhor stage related to cold chain, facilities of ripening chamber, inadequate space for operations are some of the main reasons under this category for poor quality of mango in the supply chain.

*Factor 3 –Ambience:* Ambience is the third factor leading to poor quality of fresh produce in the local trader/mashakhor stage of mango supply chain. It has a total variance of 7.95% and consists of four sub-variables. The high temperature at storage area has the highest factor loading of (0.719), followed by inadequate ventilation at the place of storage during ripening process (0.670), inadequate ventilation at the place of storage (0.663), and high temperature at storage and ripening area (0.483). The result indicates that high temperature and poor ventilation are the main reason for poor quality of fresh produce in the local trader/mashakhor stage of mango supply chain. The issues underlying in this factor are directly related to the ambience.

*Factor 4–Information:* Information is the fourth factor leading to poor quality of fresh produce at this stage. It displays a variance of 7.08% and consists of two sub-variables namely, Inadequate and non-availability of timely demand information during storing and ripening process, and lack of information regarding market conditions. Inadequate and non-availability of timely demand information during storing and ripening process (0.949) carries highest factor loading, followed by lack of information regarding market conditions (0.938). The result indicates that due to lack of information regarding market demand, the fresh produce is stored in anticipation at this stage for a long time, which deteriorates the quality of the produce.

*Factor 5–Technique:* Technique is the fifth factor leading to poor quality of fresh produce at this stage. It displays a variance of 6.18% and consists of two sub-variables namely, Inadequate equipment and ripening method, and usage of calcium carbide for ripening process. Inadequate equipment and ripening method ensure highest factor loading (0.897), followed by usage of calcium carbide for ripening process (0.825). The result indicates that poor technique and a poor method of ripening process is the main area of concern under this factor, which is leading to poor quality of fresh produce.

*Factor 6–Labour:* Labour is the fifth and final factor leading to poor quality in the local trader/mashakhor stage of mango supply chain. It displays a variance of 4.67% and consist only one sub-variable namely, Non-availability of skilled labour for unloading the crates with the factor loading of 0.808. The result indicates that non-availability of skilled labour to perform operations at local trader/mashakhor stage (at Azadpur) of mango supply chain is also resulting to the poor quality of fresh produce.

**5.3.2.4. *v.* Factors Leading to Supply Chain Inefficiency in Transportation Stage (Stage V)**

Factors leading to supply chain inefficiency with respect to cost, time and quality in transportation stage of fruits (mango) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.97 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 78.12% of the variation across the sample. In isolation, first factor explained 37.29% of the total variance; second factor explained 17.13% of the total variance; third factor explained 13.23% of the total variance, and fourth factor explained 10.37% of the total variance.

**Table 5.97: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.937 | 39.371 | 39.371 | 3.730 | 37.295 | 37.295 |
| 2 | 1.628 | 16.280 | 55.651 | 1.713 | 17.131 | 54.426 |
| 3 | 1.212 | 12.117 | 67.768 | 1.332 | 13.323 | 67.749 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 1.035 | 10.351 | 78.120 | 1.037 | 10.370 | 78.120 |
| 5 | .677 | 6.767 | 84.887 | | | |
| 6 | .439 | 4.387 | 89.274 | | | |
| 7 | .350 | 3.500 | 92.774 | | | |
| 8 | .286 | 2.862 | 95.636 | | | |
| 9 | .249 | 2.486 | 98.122 | | | |
| 10 | .188 | 1.878 | 100.000 | | | |

The factor analysis revealed four broad issues (factors), which are leading to supply chain inefficiency with respect to cost in transportation stage of mango supply chain (Table 5.98). Rates and Charges happens to be the most crucial factor leading to supply chain inefficiency with respect to high cost at this stage, followed by infrastructure issues, connectivity, and resource/transportation facilities. These four latent factors are summarized as follows:

**Table 5.98: Summary-Factors leading to supply chain inefficiency with respect to cost in Transportation stage**

| **Variables** | **Component** | | | | **Variance (% of explained) eigen values** | **Factor Name** |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| High Freight Charges | 0.904 | | | | ***37.295*** | *Rates & Charges* |
| High charges of Taxes | 0.873 | | | | | |
| High Fuel Prices | 0.863 | | | | | |
| Convenience Charges by Policemen | 0.85 | | | | | |
| Crossing and Toll Booth Charges | 0.792 | | | | | |
| Poor road connectivity | | 0.911 | | | ***17.131*** | *Infrastructure* |
| High Traffic Jams | | 0.887 | | | | |
| Inappropriate Vehicle Routing | | | 0.818 | | ***13.323*** | *Connectivity* |
| Long distance between Farm and Wholesale Market | | | 0.789 | | | |
| Timely Non-availability of transport facilities | | | | 0.986 | ***10.37*** | *Resource/ Transportation Facilities* |

*Factor 1–Rates and Charges:* Rates and Charges are recognized as the first factor that leads to high cost in the transportation stage of mango supply chain. This factor includes five sub-variables having total variance 37.29%. High freight charges (0.904) carries highest factor loading in the factor of Rates and Charges, followed by high charges of taxes (0.873), high fuel prices (0.863), convenience charges by policemen (0.85), and crossing and toll booth charges (0.792). The results indicate

that operational charges in the transportation phase incurred high cost in the supply chain. The transporter has to forgo many charges like freight charges, taxes, fuel, convenience charges, and crossing & tollbooths.

*Factor 2 – Infrastructure:* The second factor leading to supply chain inefficiency with respect to cost in the transportation stage of mango supply chain is infrastructure issue, possessing total variance of 17.13% and contain two sub-variables. Poor road connectivity (0.911) carries highest factor loading followed by the variable named high traffic jams (0.887). The results indicate that due to poor road connectivity the distance between the farm and market increases, which results in high freight charges. High traffic jams are also one of the reasons for high cost as due to the traffic the vehicle is not able to reach the market at the right time, which results to penalty and also the fresh produce has to wait for the next day of auctioning, which may result to opportunity loss.

*Factor 3–Connectivity:* The third factor, which leads to high cost in the transportation stage, is a connectivity issue. This factor displays a variance of 13.32% and consists of two sub-variables namely, inappropriate vehicle routing, and long distance between farm and wholesale market. Inappropriate vehicle routing (0.818) has the highest factor loading in this factor, followed by the long distance between farms and wholesale market (0.789). The results indicate that due to inappropriate vehicle routing, the travel distance increases, which leads to high freight charges as well as high fuel charges. The result also indicates that the distance between the farms and market is long, which also impacts the transportation cost.

*Factor 4–Resources/Transportation facility:* The fourth factor is non-availability of resources, due to which the transportation cost increases. It displays a variance of 10.37% and consist of only one sub-variable, namely, timely non-availability of transport facilities (0.986). The results indicate that due to non-availability of transportation facilities the farmers and other stakeholders have to arrange the transportation services from other areas and these transportation providers' charges different rates, which results in high transportation cost.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.99 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 81.22% of the variation across the sample. In isolation, first factor explained 28.74% of the total variance; second factor explained 16.49% of the total variance; third factor explained 15.70% of the total variance, fourth factor explained 10.14% of the total variance, and fifth factor explained about 10.13% of the total variance.

**Table 5.99: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.795 | 34.498 | 34.498 | 3.162 | 28.743 | 28.743 |
| 2 | 1.710 | 15.548 | 50.046 | 1.815 | 16.496 | 45.239 |
| 3 | 1.342 | 12.203 | 62.249 | 1.728 | 15.706 | 60.946 |
| 4 | 1.084 | 9.854 | 72.103 | 1.116 | 10.143 | 71.089 |
| 5 | 1.003 | 9.117 | 81.220 | 1.114 | 10.131 | 81.220 |
| 6 | .780 | 7.088 | 88.307 | | | |
| 7 | .378 | 3.440 | 91.747 | | | |
| 8 | .340 | 3.087 | 94.834 | | | |
| 9 | .261 | 2.376 | 97.209 | | | |
| 10 | .206 | 1.870 | 99.080 | | | |
| 11 | .101 | .920 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency with respect to high lead time in the transportation stage of mango supply chain (Table 5.100). Infrastructure issue happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by imprudence, verification and frisking, connectivity, and, resource/transportation facilities. These five latent factors are summarized as follows:

**Table 5.100 Summary- Factors leading to supply chain inefficiency with respect to time in Transportation stage**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Poor road conditions | 0.935 | | | | | ***28.743*** | *Infrastructure* |
| Congestion and Traffic Jams | 0.899 | | | | | | |
| Traffic Jams in Azadpur Mandi | 0.847 | | | | | | |
| Poor road connectivity | 0.805 | | | | | | |
| Non adherence to time scheduled allocated for Transportation | | 0.87 | | | | ***16.496*** | *Imprudence* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Irresponsible and Careless driving | | 0.838 | | | | | |
| Police Verification and Frisking | | | 0.894 | | | ***15.706*** | *Verification & Frisking* |
| Frequent Crossings and Toll Booths | | | 0.875 | | | | |
| Long distance between Farm and Wholesale Market | | | | 0.78 | | ***10.143*** | *Connectivity* |
| Inappropriate Vehicle Routing | | | | 0.678 | | | |
| Timely Non-availability of transport vehicle | | | | | 0.92 | ***10.131*** | *Resource/ Transportation Facilities* |

*Factor 1– Infrastructure:* Factor one can be named as "Infrastructure issues” which affects the transportation lead time as the variables underlying in this factor/category are directly related to infrastructure. The variables, which are underlying in this factor/category and explained 28.74% of the variation, are "Poor road conditions”, “Congestion and Traffic Jams”, “Traffic Jams in Azadpur Mandi” and “Poor road connectivity”. Poor road conditions ensure the maximum factor loading (0.935) followed by Congestion and Traffic Jams (0.899), Traffic Jams in Azadpur Mandi (0.847) and Poor road connectivity (.805). The result indicates that poor road condition is one of the most important issues, which affect the transportation time. Due to poor road conditions, the vehicles take a significant amount of time to reach the market. Congestion and high traffic jam are also a major concern for the transporters during the peak season as large amount of goods happened to transport at this particular period of time. Azadpur Mandi is Asia's largest wholesale F&V market fully congested and packed with different types of vehicles including rickshaws, and carts. Sometimes vehicle takes a complete day to cover the distance within Azadpur Mandi due to high congestion and poor infrastructure.

*Factor 2 – Imprudence:* Factor two can be named as “Imprudence factor” which is affecting the transportation lead time as the issues/variables underlying in this factor/category are directly related to the carelessness and negligence of the drivers. The variables which are underlying in this factor/category and explained 16.49% of the variation are “Non-adherence to time scheduled allocated for transportation” and “irresponsible and careless driving.” Non-adherence to time scheduled allocated for transportation carries the maximum factor loading (0.870) in the said factor, which is followed by irresponsible and careless driving (0.838). The results indicate that due to the carelessness and irresponsibility of the drivers the transportation lead time increases. They do not adhere to the time allocated for transportation.

*Factor 3 – Verification & Frisking:* Factor three can be named as “Continuous Verification & Frisking” which is affecting the transportation lead time as the issues underlying in this factor/category are directly related to the problems associated with continuous checking of trucks at various places within a short distance. The variables, which are underlying in this factor/category and explained 15.70% of the variation, are “Police Verification and Frisking” and “Frequent Crossings and Toll Booths.” Police Verification and Frisking carries the maximum factor loading (.894) in this factor, followed by Frequent Crossings and Toll Booths (.875). The result indicates that during season’s time the vehicles are asked to stop at various places by different officials for convenience charges, which result to delay in the transportation process due to which, the fresh produce is not been able to reach the market at the expected time. Frequent crossings and small non-authorized tollbooths run by local villagers are also the matter of concern, which hampers the transport operations

*Factor 4 – Connectivity:* Factor four can be named as “Connectivity issue” which affects the transportation lead time as the issues covered under this factor/category are directly related to the issue of improper connectivity. The variables, which are underlying in this factor/category and explained 10.14% of the variation are “long distance between farm and wholesale market” and “inappropriate vehicle routing.” The long distance between farm and wholesale market carries the maximum factor loading (.780) in this factor, followed by improper vehicle routing. The result indicates that long distance is one of the major issues under this factor. The vehicle has to cover a long distance to deliver the produce to the market and traffic due to congestion at various routes during the peak seasons increase the time length.

*Factor5–Resource/Transportation facilities:* Factor five can be named as "Resource/Transportation facilities" which affects the transportation lead time as the issue covered under this factor/category is directly related to lack of resource availability. The only variable, which is underlying in this factor/category and explained 10.13% of the variation, is "Timely Non-availability of transport facilities" with the factor loading of .780. The result indicates that during peak season, non-availability of transportation facilities is a major issue of concern, which increases the lead time and also affects the quality of fresh produce. Sometimes the farmers have to wait for long days to get a vehicle for transporting their fresh produce to the market.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.101 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 82.46% of the variation across the sample. In isolation, first factor explained 33.83% of the total variance; second factor explained 26.69% of the total variance; third factor explained 11.44% of the total variance, and fourth factor explained about 10.48% of the total variance.

**Table 5.101 Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.458 | 44.582 | 44.582 | 3.383 | 33.831 | 33.831 |
| 2 | 1.687 | 16.869 | 61.451 | 2.670 | 26.699 | 60.530 |
| 3 | 1.082 | 10.820 | 72.271 | 1.144 | 11.444 | 71.974 |
| 4 | 1.019 | 10.189 | 82.460 | 1.049 | 10.487 | 82.460 |
| 5 | .570 | 5.703 | 88.164 | | | |
| 6 | .363 | 3.631 | 91.795 | | | |
| 7 | .313 | 3.130 | 94.925 | | | |
| 8 | .267 | 2.672 | 97.597 | | | |
| 9 | .131 | 1.313 | 98.911 | | | |
| 10 | .109 | 1.089 | 100.000 | | | |

The factor analysis revealed four broad factors, which are leading to supply chain inefficiency with respect to quality in transportation stage of mango supply chain (Table 5.102). Operational issue happens to be the most crucial factor leading to poor quality of fresh produce at this stage, followed by infrastructure, resources, and ambience. These four latent factors are summarized as follows:

**Table 5.102 Summary-Factors leading to supply chain inefficiency with respect to quality in Transportation stage**

| Variables | Component | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Non-usage of Temperature controlled Transportation system | 0.908 | | | | ***33.831*** | *Operational* |
| Overburden and Overloading | 0.889 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Compression of goods due to putting weight on the load | 0.849 | | | | | | |
| Packaging boxes of different weight, size, commodity in the same carrier | 0.733 | | | | | | |
| Improper stacking during transportation | 0.621 | | | | | | |
| Fungal infection during transit | | 0.946 | | | | ***26.699*** | *Preservation* |
| Hitchhiking pests during transit | | 0.89 | | | | | |
| No control on Temperature/ Humidity during transit | | 0.887 | | | | | |
| Jerks in Transit, by which pack structure get loose | | | 0.952 | | | ***11.444*** | *Transit Ease* |
| Poor road conditions | | | | | 0.977 | ***10.487*** | *Infrastructure* |

*Factor 1– Operational:* Factor one can be named as "Operational issues" which is leading to poor quality of fresh produce in the transportation stage as the variables underlying in this factor/category are directly related to operational issues. The variables, which are underlying in this factor/category and explained 33.83% of the variation are non-usage of temperature controlled transportation system, overburden and overloading, compression of goods due to putting weight on the load, packaging boxes of different weight, size, commodity in the same carrier, and improper stacking during transportation. Non-usage of temperature controlled transportation system carries the highest factor loading (0.908), followed by overburden and overloading (0.889), compression of goods due to putting weight on the load (0.849), packaging boxes of different weight, size, commodity in the same carrier (0.733), and improper stacking during transportation (0.621). The result indicates that non-usage of the refrigerated transportation system is one of the most important issues, which influence the quality of fresh produce. Overburden and overloading, putting unnecessary weight on the load, non-uniformity of packaging containers, and improper stacking are some of the issues, which lead to poor quality.

*Factor 2 – Preservation:* Factor two can be named as "Poor Preservation" as the issues/variables underlying in this factor/category are directly related to the preservation of fresh produce during transportation. The variables, which are underlying in this factor/category and explained 26.69% of the variation, are fungal infection during transit, hitchhiking pests during transit, and no control on temperature/humidity during transit. Fungal infection during transit carries highest factor loading (0.946), followed by hitchhiking pests during transit (0.890), and no control on temperature/humidity during transit (0.887). The results indicate that fungal infection, entry of pest, and no control on temperature during transit are main issues under this factor, which is leading to poor quality of fresh produce.

*Factor 3 – Transit Ease:* Factor three can be named as "Transit Ease" as the issue underlying in this factor/category is directly related to the problem of jerks during transportation, by which the pack structure gets loose, and the chances of bruising and mechanical injuries get high. The only variable, which is underlying in this factor and explained 11.44% of the variation, is "Jerks in transit, by which pack structure get loose" with the factor loading of 0.952. The result indicates that due to jerks during transit because of damaged roads, speed breakers, and bouncy and uneven road, the pack structure get loose that results to the bruising and mechanical injury of fresh produce.

*Factor 4 – Infrastructure:* Factor four can be named as "Infrastructure issue" which is leading to poor quality of fresh produce in the transportation stage and is directly related to the road infrastructure. The only variable, which is underlying in this factor and explained 10.48% of the variation is "poor road conditions" with the factor loading of 0.977. The result indicates that poor road condition is one of the most important areas of concern in the transportation of perishable food product.

**5.3.2.5. <u>Factors Leading to Supply Chain Inefficiency in Different Stages of Vegetables Supply Chain with Specific Reference to Tomato</u>**

Factors leading to supply chain inefficiency across the stages of vegetables (tomato) supply chain are discussed in this section.

**5.3.2.5. *i*. Factors Leading to Supply Chain Inefficiency in Farm Stage (Stage I)**

Factors leading to supply chain inefficiency with respect to cost, time and quality in farm stage of vegetables (tomato) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.103 lists the eigen value connected with each linear component and the factor before extraction and after rotation.

Six factors have been identified (possessing eigen values >1), which mutually amounts to 81.00% of the variation across the sample. In isolation, first factor explained 27.72% of the total variance; second factor explained 19.93% of the total variance; third factor explained 13.22% of the total variance, fourth factor explained about 8.78% of the total variance, fifth factor explained 5.80% of the total variance, and factor six explained 5.53% of the total variance.

**Table 5.103: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 8.274 | 43.550 | 43.550 | 5.268 | 27.727 | 27.727 |
| 2 | 2.146 | 11.296 | 54.846 | 3.788 | 19.936 | 47.663 |
| 3 | 1.665 | 8.765 | 63.611 | 2.512 | 13.223 | 60.886 |
| 4 | 1.241 | 6.532 | 70.143 | 1.668 | 8.780 | 69.667 |
| 5 | 1.057 | 5.561 | 75.704 | 1.102 | 5.801 | 75.467 |
| 6 | 1.006 | 5.296 | 81.000 | 1.051 | 5.532 | 81.000 |
| 7 | .659 | 3.466 | 84.466 | | | |
| 8 | .527 | 2.774 | 87.240 | | | |
| 9 | .465 | 2.447 | 89.687 | | | |
| 10 | .400 | 2.104 | 91.791 | | | |
| 11 | .381 | 2.006 | 93.797 | | | |
| 12 | .304 | 1.597 | 95.394 | | | |
| 13 | .223 | 1.175 | 96.569 | | | |
| 14 | .178 | .935 | 97.504 | | | |
| 15 | .162 | .851 | 98.355 | | | |
| 16 | .127 | .671 | 99.026 | | | |
| 17 | .078 | .412 | 99.438 | | | |
| 18 | .073 | .383 | 99.821 | | | |
| 19 | .034 | .179 | 100.000 | | | |

The factor analysis revealed six broad issues (factors), which are leading to supply chain inefficiency with respect to cost in Farm stage (Table 5.104). Resource factor is one of the most important factors leading to supply chain inefficiency with respect to high cost, followed by operational & labour charges, infrastructure, operational issues, geography, and labour's knowledge. These six latent factors are summarized as follows:

**Table 5.104: Summary-Factors leading to supply chain inefficiency in farm stage with respect to cost**

| **Variables** | **Component** | | | | | | **Variance (% of explained) eigen values** | **Factor Name** |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| Large number of Labour required for carriage activity | 0.876 | | | | | | ***27.727*** | *Resources* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Large number of Labour required for Handling and Loading | 0.874 | | | | | | | |
| Non-availability of advanced packaging materials | 0.87 | | | | | | | |
| Non-usage of Sorting & Grading Technology | 0.8 | | | | | | | |
| Timely Non-availability of packaging materials | 0.75 | | | | | | | |
| Price differential of Packaging materials at different places | 0.741 | | | | | | | |
| Non-availability of tools and equipments for handling & loading | 0.66 | | | | | | | |
| High Labour charges for carriage | | 0.831 | | | | | ***19.936*** | *Operational & Labour Charges* |
| High Labour charges arising out of expertise required for grading and packaging | | 0.811 | | | | | | |
| High Packaging material charges | | 0.801 | | | | | | |
| High Labour Charges-HLS | | 0.786 | | | | | | |
| Pre loading labour charges | | 0.717 | | | | | | |
| Poor farm connectivity by road | | | 0.909 | | | | ***13.223*** | *Infrastructure* |
| Lack of mechanical sorting, grading and packaging facility | | | 0.885 | | | | | |
| Lack of Government packing houses/grading facilities | | | 0.826 | | | | | |
| Manual operations for HLS | | | | 0.866 | | | ***8.78*** | *Operational* |
| Excess usage of packaging material for layering and tapping the cartons/boxes | | | | 0.804 | | | | |
| Hilly terrain | | | | | 0.932 | | ***5.801*** | *Geography* |
| Lack of knowledge pertaining to sorting & grading techniques and processes | | | | | | 0.976 | ***5.532*** | *Labour's Knowledge* |

*Factor 1– Resources:* Lack of resources is recognized as a first factor that leads to high cost in the farm stage of tomato supply chain. This factor includes seven sub-variables having total variance 27.72%. Large number of labour required for carriage activity (0.876) carries highest factor loading in this category, followed by

large number of labour required for handling and loading (0.874), non-availability of advanced packaging materials (0.870), non-usage of sorting & grading technology (0.800), timely non-availability of packaging materials (0.750), price differential of packaging materials at different places (0.741), and non-availability of tools and equipments for handling & loading (0.660). The results indicate that resources pertaining to large labour requirement, non-availability of advanced packing material, and sorting and grading technology are some of the main issues under this factor, which is leading to cost escalation in farm stage of tomato supply chain.

*Factor 2 – Operational & Labour Charges:* The second factor is operational & labour charges. This factor has a total variance of 19.93% and consists of five sub-variables. High Labour charges for carriage (0.831) carries highest factor loading in this category. This is followed by the following variables, namely, high labour charges arising out of expertise required for grading and packaging (0.811), high packaging material charges (0.801), high labour charges for handling, loading and stacking activities (0.786), and prep-loading labour charges (0.717). The results indicate that increasing labour charges to get the work done and high packaging material charges are the major issue of concern in this factor, which is leading to cost escalation in the supply chain.

*Factor 3 – Infrastructure:* The third factor can be named as Infrastructure, as the variables, which are underlying in this category are related to the farm infrastructure like road connectivity, and packing facilities. This factor displays a variance of 13.22% and consists of three sub-variables. Poor farm connectivity by road (0.909) carries highest factor loading, followed by lack of mechanical sorting, grading and packaging facility (0.885), and lack of Government packing houses/grading facilities (0.826). The results indicate that there is a lack of connectivity between farm and road, which escalates the cost of carriage. Also, due to non-availability of government supported and mechanical facilities for sorting, grading, and packaging operations, the manual labour cost escalate.

*Factor 4 – Operational:* The Operational issue is the fourth factor, possessing total variance of 8.78% and contain two sub-variables, i.e., Manual operations for handling, loading and stacking with a factor loading of .866, and excess usage of packaging material for layering and tapping the cartons/boxes (.804). The results indicate that due to manual operations and excess usage of materials, there is a cost escalation in the supply chain.

*Factor 5 –Geography:* The fifth factor can be named as geography, possessing total variance of 5.80%. This factor comprises only one sub-variable, named, hilly terrain with the factor loading of .932. The result indicates that due to hilly terrain, the worker charge high for carriage of tomato from farm to collection area. They have to carry the head load for about 2-3 kilometers.

*Factor 6 –Labour Knowledge:* The last factor is knowledge of the labor. It has a total variance of 5.53% and consists of one variable, i.e., Lack of knowledge pertaining to sorting & grading techniques and processes with the factor loading of .976. The results indicate that the workers are not aware of the different techniques to sort, grade and package the produce, due to which they take a long time in operations resulting in increasing in the number of working days and wages.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.105 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Six factors have been identified (possessing eigen values >1), which mutually amounts to 77.77% of the variation across the sample. In isolation, first factor explained 28.32% of the total variance; second factor explained 18.13% of the total variance; third factor explained 11.21% of the total variance, fourth factor explained 9.22% of the total variance, fifth factor explained 6.06% of the total variance and factor six explained about 4.80% of the total variance.

**Table 5.105: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.865 | 34.196 | 34.196 | 6.515 | 28.324 | 28.324 |
| 2 | 3.719 | 16.168 | 50.365 | 4.172 | 18.138 | 46.462 |
| 3 | 2.399 | 10.431 | 60.796 | 2.580 | 11.219 | 57.681 |
| 4 | 1.543 | 6.709 | 67.505 | 2.121 | 9.221 | 66.902 |
| 5 | 1.325 | 5.761 | 73.266 | 1.395 | 6.064 | 72.966 |
| 6 | 1.037 | 4.508 | 77.774 | 1.106 | 4.808 | 77.774 |
| 7 | .793 | 3.449 | 81.222 | | | |
| 8 | .774 | 3.363 | 84.586 | | | |
| 9 | .528 | 2.294 | 86.880 | | | |
| 10 | .450 | 1.955 | 88.835 | | | |
| 11 | .393 | 1.711 | 90.546 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | .324 | 1.407 | 91.953 | | | |
| 13 | .315 | 1.369 | 93.321 | | | |
| 14 | .263 | 1.144 | 94.466 | | | |
| 15 | .233 | 1.013 | 95.479 | | | |
| 16 | .191 | .831 | 96.310 | | | |
| 17 | .176 | .764 | 97.074 | | | |
| 18 | .156 | .679 | 97.753 | | | |
| 19 | .152 | .662 | 98.415 | | | |
| 20 | .117 | .510 | 98.924 | | | |
| 21 | .095 | .411 | 99.335 | | | |
| 22 | .080 | .347 | 99.682 | | | |
| 23 | .073 | .318 | 100.000 | | | |

The factor analysis revealed six broad factors, which are leading to supply chain inefficiency with respect to time in farm stage (Table 5.106). The operational factor happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by labour, infrastructure, technical resources, connectivity, and geography. These six latent factors are summarized as follows:

**Table 5.106 Summary- Factors leading to supply chain inefficiency in farm stage with respect to time**

| Variables | Component | | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| Manual sorting, grading & packaging | 0.909 | | | | | | ***28.324*** | *Operational* |
| Lack of proper planning for harvesting | 0.887 | | | | | | | |
| Handling excess load by labour at the time of carriage | 0.876 | | | | | | | |
| Ignorance of time allocated to plucking and collection | 0.874 | | | | | | | |
| Manual carriage by the means of head-load | 0.851 | | | | | | | |
| Ignorance of time allocated to sorting, grading and packaging | 0.847 | | | | | | | |
| Excess harvesting due to lack of information regarding market demand | 0.835 | | | | | | | |
| Harvesting by hand picking | 0.788 | | | | | | | |
| Non-availability of skilled labour for sorting, grading & packaging | | 0.867 | | | | | ***18.138*** | *Labour* |
| Lack of knowledge pertaining to sorting & | | 0.84 | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| grading techniques and processes | | | | | | | | |
| Lack of Skilled labour for plucking and collection | | 0.823 | | | | | | |
| Lack of farmer's awareness and knowledge regarding technology | | 0.807 | | | | | | |
| Lack of Training and Knowledge about sorting, grading & packaging | | 0.778 | | | | | | |
| Employment of incapable labour (women and children) for carriage | | 0.753 | | | | | | |
| Poor condition of path used for carriage | | | 0.934 | | | | | |
| Poor road connectivity | | | 0.893 | | | | ***11.219*** | *Infrastructure* |
| Lack of mechanical sorting, grading and packaging facility | | | 0.885 | | | | | |
| Lack of sorting & grading technology | | | | 0.892 | | | | |
| Lack of appropriate harvesting tools and equipments | | | | 0.876 | | | ***9.221*** | *Technical Resources* |
| Timely Non-availability of packaging materials | | | | 0.458 | | | | |
| Long distance between plucking area and assembly area | | | | | 0.77 | | ***6.064*** | *Connectivity* |
| Assembly points are not properly identified | | | | | 0.759 | | | |
| Hilly Terrain | | | | | | 0.913 | ***4.808*** | *Geography* |

*Factor 1– Operational:* Operations related issue is recognized as the first factor that leads to high lead time in farm stage of tomato supply chain. This factor includes eight sub-variables having total variance 28.32%. Manual sorting, grading & packaging (0.909) carries highest factor loading, followed by Lack of proper planning for harvesting (0.887), handling excess load by labour at the time of carriage (0.876), ignorance of time allocated to plucking and collection (0.874), manual carriage by the means of head-load (0.851), ignorance of time allocated to sorting, grading and packaging (0.847), excess harvesting due to lack of information regarding market demand (0.835), and harvesting by hand picking (0.788). The results indicate that operations related issues are the most important factor, which includes manual operations, improper planning of operations, improper handling, and ignorance of time. These are the reasons for a high lead time in the farm stage operations.

*Factor 2 – Labour:* The second factor is labour issue, possessing total variance of 18.13% and contain six sub-variables. Non-availability of skilled labour for sorting, grading & packaging carries the maximum loading of 0.867 in this factor. This is followed by lack of knowledge pertaining to sorting & grading techniques and processes (0.840), lack of skilled labour for plucking and collection (0.823), lack of farmer's awareness and knowledge regarding technology (0.807), lack of training and knowledge about sorting, grading & packaging (0.778), and employment of incapable labour (women and children) for carriage (0.753). The results indicate that lack of skilled labour, knowledge, and awareness of the workers, and usage of incapable labour are the major issue of concern, which is leading to high lead time in farm stage operations.

*Factor 3 – Infrastructure:* The third factor can be named as Infrastructure, having a variance of 11.21% and consists of three sub-variables. The poor condition of the path used for carriage (0.934) carries highest factor loading in this category, followed by poor road connectivity (0.893), and lack of mechanical sorting, grading, and packaging facility (0.885). This factor indicates that due to poor infrastructure related to path condition, connectivity, and lack of primary processing facilities at farm stage, the time taken for operations increases.

*Factor 4 – Technical Resources:* The fourth factor is technical resources, which is leading to high lead time in farm operations having total variance 9.22%. This factor comprises three sub-variables. Lack of sorting & grading technology (0.892) carries highest factor loading, followed by lack of appropriate harvesting tools and equipment (0.876), and timely non-availability of packaging materials (0.458). The results indicate that there is a lack of technical resource availability at farm stage like machinery, tools, and equipments to perform the operations effectively and in a timely manner.

*Factor 5 – Connectivity:* Connectivity is the fifth factor, which is leading to high lead time in farm operations having total variance 6.06%. This factor comprises two sub-variables. The first variable, which has the highest factor loading is a long distance between plucking area and assembly area (0.770), followed by the variable named, assembly points are not properly identified (0.759). The results indicate that during plucking and assembling, the workers have to walk long distances with the product due to which they get tired more quickly and take a long time to reach the produce at the assembly area. To get the produce from harvest point to a collection point by headload carriage may involve passing over one or around two kilometers of farm roads.

*Factor 5 – Geography:* Geography is the sixth factor, possessing total variance of 4.80%. This factor comprises only one variable, i.e., hilly terrain with the factor loading of 0.913. The results indicate that due to hilly terrain the carriage activity takes a long time as the workers have to carry the load by means of the head load for about one to two kilometers.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.107 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 65.04% of the variation across the sample. In isolation, first factor explained 32.79% of the total variance; second factor explained 11.72% of the total variance; third factor explained 9.68% of the total variance, fourth factor explained about 5.85% of the total variance, and fifth factor explained 4.98% of the total variance.

**Table 5.107 Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 9.684 | 38.734 | 38.734 | 8.199 | 32.794 | 32.794 |
| 2 | 2.427 | 9.706 | 48.441 | 2.930 | 11.720 | 44.515 |
| 3 | 1.850 | 7.399 | 55.839 | 2.421 | 9.684 | 54.198 |
| 4 | 1.213 | 4.852 | 60.692 | 1.465 | 5.858 | 60.057 |
| 5 | 1.087 | 4.349 | 65.040 | 1.246 | 4.984 | 65.040 |
| 6 | .894 | 3.577 | 68.617 | | | |
| 7 | .841 | 3.363 | 71.980 | | | |
| 8 | .731 | 2.923 | 74.904 | | | |
| 9 | .695 | 2.778 | 77.682 | | | |
| 10 | .654 | 2.617 | 80.299 | | | |
| 11 | .593 | 2.374 | 82.673 | | | |
| 12 | .528 | 2.110 | 84.783 | | | |
| 13 | .510 | 2.040 | 86.824 | | | |
| 14 | .443 | 1.770 | 88.594 | | | |
| 15 | .417 | 1.669 | 90.263 | | | |
| 16 | .364 | 1.455 | 91.718 | | | |
| 17 | .349 | 1.396 | 93.114 | | | |
| 18 | .319 | 1.276 | 94.390 | | | |
| 19 | .291 | 1.162 | 95.552 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | .242 | .969 | 96.521 | | | |
| 21 | .210 | .841 | 97.362 | | | |
| 22 | .201 | .805 | 98.167 | | | |
| 23 | .186 | .743 | 98.910 | | | |
| 24 | .154 | .617 | 99.527 | | | |
| 25 | .118 | .473 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency in farm stage with respect to quality (Table 5.108). Operational issue happens to be the most crucial factor in the farm stage leading to poor quality of fresh produce, followed by infrastructure, ambience, labour, and information. These five latent factors are summarized as follows:

**Table 5.108 Summary-Factors leading to supply chain inefficiency in farm stage with respect to quality**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Compression of Tomatoes due to heavy load in storing | 0.865 | | | | | 32.794 | Operational |
| No proper arrangement of packages/crates for air circulation while stacking | 0.851 | | | | | | |
| Rough handling while storing | 0.829 | | | | | | |
| Damage to the Tomatoes caused by pest and fungal infection during storage | 0.771 | | | | | | |
| Jerks during carriage which impact the quality | 0.737 | | | | | | |
| Improper stacking | 0.690 | | | | | | |
| Handling excess load by labour at the time of carriage | 0.689 | | | | | | |
| Rough handling at the time of loading & stacking | 0.680 | | | | | | |
| Bulk handling of fresh produce | 0.671 | | | | | | |
| Dumping of Crates | 0.657 | | | | | | |
| Holding of goods in anticipation of high prices | 0.647 | | | | | | |
| Falling of Tomatoes from crates/baskets during carriage | 0.644 | | | | | | |
| Single manual handling while loading & stacking | 0.622 | | | | | | |
| Mishandling and Carelessness during carriage | 0.607 | | | | | | |
| Open Air Loading operations which expose to direct sunlight/heat | 0.568 | | | | | | |
| High stacking while storing | 0.536 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lack of availability of temperature controlled storage area | | 0.789 | | | | 11.720 | Infrastructure |
| Insufficient storage and temperature controlled facilities | | 0.771 | | | | | |
| Non-availability of cooling shed at the place of storage | | 0.759 | | | | | |
| Non-availability of Mechanical handling & loading facility | | 0.622 | | | | | |
| High temperature during carriage | | | 0.897 | | | 9.684 | Ambience |
| High temperature at storage area | | | 0.863 | | | | |
| Inadequate ventilation at the place of storage | | | 0.841 | | | | |
| Non-usage of skilled labour-HLS | | | | 0.845 | | 5.858 | Labour Availability |
| Lack of information regarding market demand | | | | | 0.749 | 4.984 | Information |

*Factor 1– Operational:* The Operational issue is recognized as the first factor that leads to poor quality of fresh produce in farm stage of tomato supply chain. This factor includes sixteen sub-variables having total variance 32.79%. Compression of tomatoes due to heavy load in storing (0.865) has the highest factor loading, followed by no proper arrangement of packages/crates for air circulation while stacking (0.851), rough handling while storing (0.829), damage to the tomatoes caused by pest and fungal infection during storage (0.771), jerks during carriage which impact the quality (0.737), improper stacking (0.690), handling excess load by labour at the time of carriage (0.689), rough handling at the time of loading & stacking (0.680), bulk handling of fresh produce (0.671), dumping of Crates (0.657), holding of goods in anticipation of high prices (0.647), falling of tomatoes from crates/baskets during carriage (0.644), single manual handling while loading & stacking (0.622), mishandling and Carelessness during carriage (0.607), open air loading operations which expose to direct sunlight/heat (0.568), and high stacking while storing (0.536). The result indicates that all the issues, which are underlying in this category are directly associated with the operational issues, which are leading to poor quality of fresh produce at farm stage operations.

*Factor 2 – Infrastructure:* The second factor is Infrastructure, possessing total variance of 11.72% and consists of four sub-variables. Lack of availability of temperature controlled storage area (0.789) carries highest factor loading in this category, followed by insufficient storage and temperature controlled facilities (0.771), non-availability of cooling shed at the place of storage (0.759), and non-availability of mechanical handling & loading facility (0.622). The result indicates that there is a lack of infrastructure at farm stage related to the temperature controlled storage system and cold chain, which is leading to poor quality of fresh produce.

*Factor 3 – Ambience:* Ambience is the third factor, possessing total variance of 9.68% and consists of three sub-variables. The variable named "high temperature during carriage" has the highest factor loading of 0.897 in this factor, followed by high temperature at storage area (0.863), and inadequate ventilation at the place of storage (0.841). The result indicates that due to lack of control over high temperature and poor ventilation during storage, the quality of tomato gets deteriorate, which results in high losses.

*Factor 4 – Labour Availability:* The fourth factor is the availability of labour, having a variance of 5.85% and consist only one sub-variable, i.e., non- usage of skilled labour for handling, loading and stacking activities with the factor loading of (0.845). The result indicates that the packages are not handled properly by the labour and loaded into the vehicle by dumping forcefully. They tend to throw the packs rather than lift them gently which results in mechanical injury and crushing of tomato inside the packaging container/material.

*Factor 5 – Information:* The fifth factor is information, having a variance of 4.98% and consist only one sub-variable, namely, Lack of information regarding market demand with the factor loading of 0.749. The result indicates that due to lack of information regarding market demand the tomatoes are kept at the assembly area for a long time, which declines the market value of tomato as well as the quality.

**5.3.2.5. *ii*. Factors Leading to Supply Chain Inefficiency in Local Mandi stage**

Factors leading to supply chain inefficiency with respect to cost, time and quality in local mandi stage of vegetables (tomato) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.109 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 74.12% of the variation across the sample. In isolation, first factor explained 27.52% of the total variance; second factor explained 24.32% of the total variance; third factor explained 15.68% of the total variance, and fourth factor explained about 6.59% of the total variance.

**Table 5.109: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.819 | 42.618 | 42.618 | 4.403 | 27.521 | 27.521 |
| 2 | 2.387 | 14.922 | 57.540 | 3.892 | 24.325 | 51.847 |
| 3 | 1.640 | 10.250 | 67.790 | 2.510 | 15.686 | 67.533 |
| 4 | 1.014 | 6.336 | 74.125 | 1.055 | 6.593 | 74.125 |
| 5 | .833 | 5.204 | 79.330 | | | |
| 6 | .736 | 4.601 | 83.931 | | | |
| 7 | .594 | 3.711 | 87.642 | | | |
| 8 | .515 | 3.216 | 90.858 | | | |
| 9 | .418 | 2.615 | 93.473 | | | |
| 10 | .282 | 1.760 | 95.234 | | | |
| 11 | .215 | 1.341 | 96.574 | | | |
| 12 | .201 | 1.259 | 97.833 | | | |
| 13 | .158 | .985 | 98.818 | | | |
| 14 | .091 | .567 | 99.386 | | | |
| 15 | .066 | .413 | 99.798 | | | |
| 16 | .032 | .202 | 100.000 | | | |

The factor analysis revealed six broad issues (factors), which are leading to supply chain inefficiency with respect to cost in Farm stage (Table 5.110). Resource factor is one of the most important factors leading to supply chain inefficiency with respect to high cost, followed by operational & labour charges, infrastructure, operational issues, geography, and labour's knowledge. These six latent factors are summarized as follows:

**Table 5.110: Summary-Factors leading to supply chain inefficiency in Local Mandi stage with respect to cost**

| Variables | Component | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| High Labour Charges-HLS | 0.865 | | | | ***27.521*** | *Operational & Labour Charges* |
| High Labour charges for operations-SC | 0.845 | | | | | |
| Expensive packaging materials | 0.827 | | | | | |
| High Labour Charges-UFT | 0.819 | | | | | |
| Pre loading labour charges | 0.737 | | | | | |
| Pre unloading labour charges | 0.651 | | | | | |
| Large number of Labour required for Handling and Loading | | 0.891 | | | ***24.325*** | *Resources* |
| Large number of Labour required for Unloading the load from Truck-UFT | | 0.882 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Non-availability of tools and equipments for handling & loading | | 0.878 | | | | |
| Non-availability of tools and equipments for unloading the load-UFT | | 0.835 | | | | |
| Non-availability of equipments for unloading the crate-SC | | 0.756 | | | | |
| Damage to crates/boxes while unloading | | | 0.842 | | ***15.686*** | *Operational* |
| Manual operations for HLS | | | 0.816 | | | |
| Manual operations for Unloading-UFT | | | 0.629 | | | |
| Manually unloading operation-SC | | | 0.602 | | | |
| High cost due to non-availability of government facilities for operations | | | | 0.933 | ***6.593*** | *Infrastructure* |

*Factor 1 – Operational & Labour Charges:* The first factor can be named as operational & labour charges. This factor has a total variance of 27.52% and consists of six sub-variables. High labour charges for handling, loading and stacking (0.865) carries highest factor loading in this category, followed by high labour charges for operations related to unloading of supplier crate (0.845), expensive packaging materials (0.827), high labour charges for unloading of truck (0.819), pre-loading labour charges (0.737), and pre unloading labour charges (0.651). The results indicate that high labour charges to perform operations and expensive packaging materials are some of the main issues under this factor, which is leading to high in the local mandi stage of tomato supply chain.

*Factor 2– Resources:* Lack of resources is recognized as the second factor that leads to high cost in tomato supply chain. This factor includes five sub-variables having total variance 24.32%. Large number of labour required for handling and loading (0.891) carries highest factor loading in resource factor, followed by large number of labour required for unloading the load from truck (0.882), non-availability of tools and equipments for handling & loading (0.878), non-availability of tools and equipments for unloading the load from truck (0.835), and non-availability of equipments for unloading the suppliers crate (0.756). The results indicate that the issue of labour resource is the main reason for a high cost under this factor. There is a lack of availability of tools and equipment at the stage due to which most of the operations are performed by the manpower, which escalates the cost of labour.

*Factor 3 – Operational:* The Operational issue is the third factor, possessing total variance of 15.68% and consists of four sub-variables. Damage to crates/boxes while unloading (0.842) carries highest factor loading, followed by manual operations for handling, loading and stacking operations (0.816), manual operations for unloading of the truck (0.629), and manually unloading operation while unloading supplier crate (0.602). The results indicate that most of the variables under this factor are related to operational issues due to which the cost in the supply chain gets escalates.

*Factor 4 – Infrastructure:* The fourth and last factor, which is leading to high cost in Local mandi stage is infrastructure, having a variance of 6.59%. This factor includes only one sub-variable, i.e., High cost due to non-availability of government facilities for operations with a factor loading of 0.933. The results indicate that if there would be a government supported facility for primary processing the unnecessary cost incurred in operations could be saved.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.111 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 78.55% of the variation across the sample. In isolation, first factor explained 31.14% of the total variance; second factor explained 18.59% of the total variance; third factor explained 18.43% of the total variance, and fourth factor explained 10.38% of the total variance.

**Table 5.111: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.813 | 43.408 | 43.408 | 5.606 | 31.144 | 31.144 |
| 2 | 2.666 | 14.810 | 58.218 | 3.346 | 18.591 | 49.735 |
| 3 | 2.504 | 13.911 | 72.129 | 3.319 | 18.439 | 68.174 |
| 4 | 1.156 | 6.425 | 78.554 | 1.868 | 10.380 | 78.554 |
| 5 | .597 | 3.314 | 81.868 | | | |
| 6 | .480 | 2.666 | 84.535 | | | |
| 7 | .477 | 2.652 | 87.186 | | | |
| 8 | .413 | 2.296 | 89.482 | | | |
| 9 | .353 | 1.958 | 91.441 | | | |
| 10 | .301 | 1.675 | 93.116 | | | |
| 11 | .271 | 1.504 | 94.620 | | | |
| 12 | .246 | 1.364 | 95.984 | | | |
| 13 | .198 | 1.099 | 97.083 | | | |
| 14 | .184 | 1.020 | 98.103 | | | |
| 15 | .148 | .824 | 98.927 | | | |
| 16 | .095 | .528 | 99.455 | | | |
| 17 | .050 | .277 | 99.731 | | | |

| 18 | .048 | .269 | 100.000 | | | |
|---|---|---|---|---|---|---|

The factor analysis revealed four broad factors, which are leading to supply chain inefficiency with respect to time in local mandi stage of tomato supply chain (Table 5.112). The operational factor happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by technical resources, labour, and infrastructure. These four latent factors are summarized as follows:

**Table 5.112: Summary- Factors leading to supply chain inefficiency in local mandi stage with respect to time**

| Variables | Component | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Improper planning for scheduling of Incoming Goods | 0.917 | | | | ***31.144*** | *Operational* |
| Manual unloading-UfT | 0.861 | | | | | |
| Bulk handling of crates/packages | 0.858 | | | | | |
| Manual unloading-UfSC | 0.849 | | | | | |
| Single manual handling while loading | 0.813 | | | | | |
| Handling and Loading by the means of head load | 0.796 | | | | | |
| High stacking of crates | 0.76 | | | | | |
| Non-availability of tools and equipments for handling & loading | | 0.928 | | | ***18.591*** | *Technical Resources* |
| Non-availability of equipments for unloading-UfT | | 0.891 | | | | |
| Non-availability of equipments for unloading the crate-UfSC | | 0.871 | | | | |
| Inadequate Resources for dealing with unexpected bulk arrival | | 0.844 | | | | |
| Non-availability of skilled labour for unloading the crates-UfSC | | | 0.835 | | ***18.439*** | *Labour* |
| Employment of inadequate labour for unloading operations-UfT | | | 0.779 | | | |
| Non-availability of skilled labour for unloading the crates-UfT | | | 0.763 | | | |
| Employment of inadequate labour for unloading operations-UfSC | | | 0.754 | | | |
| Non-availability of skilled labour | | | 0.739 | | | |
| Inadequate space for unloading and loading operations-UfSC | | | | 0.851 | ***10.38*** | *Infrastructure* |
| Inadequate space for unloading operations-UfT | | | | 0.772 | | |

*Factor 1– Operational:* Operations related issue is recognized as the first factor that leads to high lead time in local mandi stage of tomato supply chain. This factor includes seven sub-variables having total variance 31.14%. Improper planning for scheduling of Incoming Goods (0.917) carries highest factor loading in operational factor. This is followed by manual unloading of the vehicle (0.861), bulk handling of crates/packages (0.858), manual unloading of supplier's crate and loading to buyers' crate (0.849), single manual handling while loading (0.813), handling and loading by the means of head load (0.796), and high stacking of crates (0.760). The results indicate that the variables underlying in this factor are operational issues, which are leading to high lead time in local mandi stage.

*Factor 2 – Technical Resources:* The second factor is technical resources, which is leading to high lead time in local mandi stage having total variance 18.59%. This factor comprises four sub-variables. Non-availability of tools and equipment for handling & loading (0.928) carries highest factor loading, followed by non-availability of equipment for unloading the vehicle (0.891), non-availability of equipment for unloading suppliers' crate and loading to buyers' crate (0.871), and inadequate resources for dealing with unexpected bulk arrival (0.844). The results indicate that non-availability of technical resources (like tools & equipment) for handling, loading, and unloading operations are one of the reasons for the high lead in local mandi stage of tomato supply chain. Due to non-availability of tools and equipment the handling, loading and unloading operations are carried out manually, which increases the length of time in operations.

*Factor 3 – Labour:* Labour issue is the third factor, possessing total variance of 18.43% and consists of five sub-variables. Non-availability of skilled labour for unloading the suppliers crate and loading to buyer's crate operations carries highest factor loading of 0.835, followed by employment of inadequate labour for unloading the vehicle (0.779), non-availability of skilled labour for unloading the crates from trucks/vehicle (0.763), employment of inadequate labour for unloading operations (unloading from suppliers' crate and loading to buyers' crate) (0.754), and non-availability of skilled labour (0.739). The results indicate that the issues, which are underlying in this factor are related to non-availability of skilled labour and employment of inadequate labour, due to which the lead time in local mandi stage is increasing.

*Factor 4 – Infrastructure:* The fourth factor can be named as Infrastructure, having a variance of 10.38% and contain two sub-variables namely, inadequate space for unloading the suppliers' crate and loading to buyers' crate operations, and inadequate space for unloading the truck. Inadequate space for unloading and loading operations from suppliers' crate carries highest factor loading with 0.851, followed by inadequate space for unloading the truck (0.772). The result indicates that due to improper space at local mandi stage, the operations are not performed in a timely manner.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.113 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 76.18% of the variation across the sample. In isolation, first factor explained 34.43% of the total variance; second factor explained 16.34% of the total variance; third factor explained 11.90% of the total variance, fourth factor explained 7.90% of the total variance, and fifth factor explained 5.59% of the total variance.

**Table 5.113: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.833 | 35.607 | 35.607 | 7.575 | 34.431 | 34.431 |
| 2 | 4.259 | 19.359 | 54.965 | 3.597 | 16.348 | 50.779 |
| 3 | 2.300 | 10.455 | 65.420 | 2.620 | 11.908 | 62.687 |
| 4 | 1.328 | 6.036 | 71.455 | 1.740 | 7.909 | 70.596 |
| 5 | 1.041 | 4.733 | 76.189 | 1.230 | 5.592 | 76.189 |
| 6 | .759 | 3.448 | 79.637 | | | |
| 7 | .642 | 2.918 | 82.555 | | | |
| 8 | .497 | 2.259 | 84.814 | | | |
| 9 | .463 | 2.103 | 86.918 | | | |
| 10 | .428 | 1.944 | 88.862 | | | |
| 11 | .373 | 1.697 | 90.559 | | | |
| 12 | .345 | 1.566 | 92.125 | | | |
| 13 | .288 | 1.308 | 93.433 | | | |
| 14 | .262 | 1.190 | 94.623 | | | |
| 15 | .247 | 1.122 | 95.745 | | | |
| 16 | .205 | .930 | 96.675 | | | |
| 17 | .182 | .827 | 97.502 | | | |
| 18 | .165 | .752 | 98.254 | | | |
| 19 | .125 | .566 | 98.820 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | .103 | .467 | 99.287 | | | |
| 21 | .085 | .387 | 99.674 | | | |
| 22 | .072 | .326 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency in farm stage with respect to quality (Table 5.114). Operational issue happens to be the most crucial factor in the farm stage leading to poor quality of fresh produce, followed by infrastructure, ambience, labour, and information. These five latent factors are summarized as follows:

**Table 5.114: Summary-Factors leading to supply chain inefficiency with respect to quality in local mandi stage**

| Variables | Component | | | | | Variance (% of explained) Eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Rough handling while storing | 0.933 | | | | | ***34.431*** | *Operational* |
| Inappropriate storing practices leading to compression of tomatoes | 0.881 | | | | | | |
| Delays in moving the produce to the wholesale market | 0.868 | | | | | | |
| Holding of goods in anticipation of high prices | 0.853 | | | | | | |
| Improper and high stacking while storing | 0.827 | | | | | | |
| Rough handling while unloading-UfSC | 0.786 | | | | | | |
| Unloading in an inappropriate manner-UfT | 0.769 | | | | | | |
| Unloading the crates in an open area which expose to direct sunlight/heat-UfSC | 0.752 | | | | | | |
| Unloading the crates in an inappropriate manner-UfSC | 0.749 | | | | | | |
| Rough handling while unloading-UfT | 0.748 | | | | | | |
| Expose to direct sunlight/heat while unloading | 0.731 | | | | | | |
| Insufficient storage and temperature controlled facilities | | 0.886 | | | | ***16.348*** | *Infrastructure* |
| Non-availability of cooling shed at the place of storage | | 0.836 | | | | | |
| Open Dock Area which expose to direct sunlight | | 0.811 | | | | | |
| Inadequate space for unloading operations-UfSC | | 0.786 | | | | | |
| Inadequate space for unloading operations-UfT | | 0.771 | | | | | |
| Damage to the Tomatoes caused by pest and fungal infection during | | | 0.931 | | | ***11.908*** | *Ambience* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| storage | | | | | | | |
| Inadequate ventilation at the place of storage | | | 0.92 | | | | |
| High temperature at storage area | | | 0.861 | | | | |
| Non-availability of skilled labour for unloading the crates-UfSC | | | | 0.926 | | ***7.909*** | *Labour Availability* |
| Non-availability of skilled labour for unloading the crates-UfT | | | | 0.861 | | | |
| Inadequate and non-availability of timely demand information | | | | | 0.896 | ***5.592*** | *Information* |

*Factor 1– Operational:* The Operational issue is recognized as the first factor that leads to poor quality of fresh produce in local mandi stage of tomato supply chain. This factor includes eleven sub-variables having total variance 34.43%. Rough handling while storing (0.933) carries highest factor loading, followed by the following variables, namely, inappropriate storing practices leading to compression of tomatoes (0.881), delays in moving the produce to the wholesale market (0.868), holding of goods in anticipation of high prices (0.853), improper and high stacking while storing (0.827), rough handling while unloading suppliers' crate and loading to buyer's crate (0.786), unloading of truck in an inappropriate manner (0.769), unloading the crates in an open area which expose to direct sunlight/heat while unloading suppliers' crate (0.752), unloading supplier's crate crates in an inappropriate manner (0.749), rough handling while unloading the truck (0.748), and expose to direct sunlight/heat while unloading the truck (0.731). The result indicates that all variables underling in this category are directly related to operational level issues and leading to poor quality of fresh produce at local mandi stage of tomato supply chain.

*Factor 2 – Infrastructure:* The second factor is Infrastructure, possessing total variance of 16.34% and consists of five sub-variables. Insufficient storage and temperature controlled facilities (0.886) carries highest factor loading in this category, followed by non-availability of cooling shed at the place of storage (0.836), open dock area which expose to direct sunlight (0.811), inadequate space for unloading suppliers' crate and loading to buyers' crate operations (0.786), and inadequate space for unloading the truck (0.771). The result indicates that there is a lack of cold chain infrastructure to store fresh produce and inadequate space to perform operations like, loading and unloading at local mandi stage, which is impacting the quality of tomato at local mandi stage.

*Factor 3 – Ambience:* Ambience is the third factor, possessing total variance of 11.90% and consists of three sub-variables. Damage to the tomatoes caused by pest and fungal infection during storage has the highest factor loading of 0.931, followed by inadequate ventilation at the place of storage (0.920), and high temperature at storage area (0.861). The result indicates that pest and fungal infection during storage, high temperature and inadequate ventilation at storage area are the main issue of concern under this factor and can be called as ambience factor, which is impacting the quality of fresh produce at local mandi stage.

*Factor 4 – Labour Availability:* The fourth factor is the availability of labour, having a variance of 7.90% and contain two sub-variables, i.e., Non-availability of skilled labour for unloading the suppliers' crate and loading to buyers' crates, and non-availability of skilled labour for unloading the crates from the truck. Non-availability of skilled labour for unloading the suppliers' crate and loading to buyers' crates (0.926) has the highest factor loading, followed by non-availability of skilled labour for unloading the crates from the truck (0.861). The result indicates that due to unskilled labour the operations are not performed so well, which leads to poor quality of tomato at local mandi stage of tomato supply chain. This indicates that skilled labour is a need of the hour in the agriculture sector.

*Factor 5 – Information:* The fifth and last factor, which is leading to poor quality in local mandi stage of tomato supply chain can be named as Information, having a variance of 5.59% and consist only one sub-variable, i.e., inadequate and non-availability of timely demand information with the factor loading of 0.896. The result indicates that due to lack of information regarding market demand the tomatoes are kept at local mandi stage in an open area for a long time, which declines the market value of tomato as well as the quality.

#### 5.3.2.5. *iii*. Factors Leading to Supply Chain Inefficiency in Wholesale/Mandi Stage (Stage III)

Factors leading to supply chain inefficiency with respect to cost, time and quality in wholesale/mandi stage of vegetables (tomato) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.115 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 74.58% of the variation across the sample. In isolation, first factor explained 28.43% of the total variance; second factor explained 21.87% of the total variance; third factor explained 15.36% of the total variance, and fourth factor explained about 8.91% of the total variance.

**Table 5.115: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.179 | 47.862 | 47.862 | 4.265 | 28.431 | 28.431 |
| 2 | 1.537 | 10.247 | 58.109 | 3.281 | 21.873 | 50.304 |
| 3 | 1.365 | 9.097 | 67.206 | 2.305 | 15.368 | 65.672 |
| 4 | 1.107 | 7.379 | 74.585 | 1.337 | 8.913 | 74.585 |
| 5 | .943 | 6.289 | 80.874 | | | |
| 6 | .690 | 4.598 | 85.472 | | | |
| 7 | .559 | 3.726 | 89.198 | | | |
| 8 | .431 | 2.875 | 92.073 | | | |
| 9 | .365 | 2.435 | 94.508 | | | |
| 10 | .212 | 1.416 | 95.925 | | | |
| 11 | .197 | 1.316 | 97.241 | | | |
| 12 | .157 | 1.046 | 98.287 | | | |
| 13 | .143 | .952 | 99.238 | | | |
| 14 | .060 | .400 | 99.638 | | | |
| 15 | .054 | .362 | 100.000 | | | |

The factor analysis revealed four broad issues (factors), which are leading to supply chain inefficiency with respect to cost (Table 5.116). Labour charges are one of the most important factors leading to supply chain inefficiency with respect to high cost, followed by operational issue, resources, and infrastructure. These four latent factors are summarized as follows:

**Table 5.116: Summary-Factors leading to supply chain inefficiency with respect to cost in Wholesale Mandi stage**

| Variables | Component | | | | Variance (% of explained) Eigen values | Factor Name |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| High Labour charges for operations- | 0.862 | | | | ***28.431*** | *Labour* |

| | | | | | | |
|---|---|---|---|---|---|---|
| UfSC | | | | | | *Charges* |
| Large number of Labour required for Unloading-UfT | 0.843 | | | | | |
| Pre loading labour charges | 0.796 | | | | | |
| High Labour Charges for Loading | 0.745 | | | | | |
| High Labour Charges-UfT | 0.661 | | | | | |
| Pre unloading labour charges | 0.559 | | | | | |
| Manual operations for HLS | | 0.873 | | | ***21.873*** | *Operational* |
| Damage to crates/boxes while unloading | | 0.836 | | | | |
| Manual operations for unloading the load-UfT | | 0.724 | | | | |
| Manual unloading -UfSC | | 0.599 | | | | |
| Large Requirement of Packaging Material | | | 0.753 | | ***15.368*** | *Resources* |
| Non-availability of tools and equipments for unloading the load-UfT | | | 0.655 | | | |
| Non-availability of tools and equipments for handling & loading | | | 0.597 | | | |
| Non-availability of equipments for unloading the crate-UfSC | | | 0.538 | | | |
| Non-availability of government facilities for operations | | | | 0.933 | ***8.913*** | *Infrastructure* |

*Factor 1– Labour Charges:* High Labour charges is recognized as a first factor that leads to high cost at wholesale stage of tomato supply chain. This factor includes six sub-variables having total variance 28.43%. High labour charges for operations in the activity of unloading tomatoes from supplier's crate ensure the maximum factor loading (0.862). This is followed by a large number of labour required for unloading the produce from the truck (.843), pre-loading labour charges (.796), high labour charges for loading (.745), high labour charges for unloading the produce from the truck (.661) and pre-unloading labour charges (.559). The results indicate that high labour charges pertaining to loading, unloading operations at the wholesale stage are leading to cost escalation.

*Factor 2 – Operational:* The second factor is operational, possessing total variance of 21.87% and consists of four sub-variables. Manual operations for Handling, Loading and Stacking activity carries the highest factor loading (.873), followed by Damage to crates/boxes while unloading (.836), Manual operations for unloading the load from the truck (.724) and Manual unloading while unloading supplier's crates (.599). The results indicate that all operations, which take place at the wholesale stage are done manually, which escalate the cost of manpower finally leads to high cost in the supply chain.

*Factor 3 – Resources:* Resources is the third factor, possessing total variance of 15.36% and consists of four sub-variables; Large requirement of packaging material has the highest factor loading (.753), followed by non-availability of tools and equipment for unloading the load from truck (.655), non-availability of tools and equipment for handling & loading (.597) and non-availability of equipment for unloading the supplier crate (.538). The results indicate that due to lack of resources pertaining to handling, loading and unloading operations the cost is escalating in the supply chain.

*Factor 4 – Infrastructure:* Infrastructure is the fourth factor, having a variance of 8.91% and consist of only one variable namely Non-availability of government facilities for operations with the factor loading of .933. This factor indicates that there is a requirement of government facilities where the operations related to unloading and loading of suppliers and buyers crate can be done at a reasonable price.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.117 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four identified factors having eigen values exceeding one, which mutually amounts to 71.76% of the variation across the sample. In isolation, first factor explained 26.23% of the total variance; second factor explained 21.33% of the total variance; third factor explained 14.86% of the total variance, and fourth factor explained about 9.33% of the total variance.

**Table 5.117: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.073 | 39.296 | 39.296 | 4.723 | 26.236 | 26.236 |
| 2 | 2.517 | 13.983 | 53.279 | 3.841 | 21.338 | 47.574 |
| 3 | 2.133 | 11.851 | 65.130 | 2.675 | 14.861 | 62.435 |
| 4 | 1.195 | 6.637 | 71.767 | 1.680 | 9.332 | 71.767 |
| 5 | .978 | 5.436 | 77.203 | | | |
| 6 | .827 | 4.596 | 81.798 | | | |
| 7 | .682 | 3.790 | 85.588 | | | |
| 8 | .633 | 3.514 | 89.103 | | | |
| 9 | .462 | 2.566 | 91.669 | | | |
| 10 | .401 | 2.227 | 93.895 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | .291 | 1.619 | 95.515 | | | |
| 12 | .228 | 1.267 | 96.782 | | | |
| 13 | .156 | .867 | 97.650 | | | |
| 14 | .144 | .798 | 98.448 | | | |
| 15 | .109 | .607 | 99.055 | | | |
| 16 | .070 | .389 | 99.445 | | | |
| 17 | .058 | .320 | 99.765 | | | |
| 18 | .042 | .235 | 100.000 | | | |

The factor analysis revealed four broad factors, which are leading to supply chain inefficiency with respect to time (Table 5.118). The operational factor is one of the most important factors leading to supply chain inefficiency with respect to high lead time, followed by labour issue, resources, and infrastructure. These four latent factors are summarized as follows:

**Table 5.118: Summary- Factors leading to supply chain inefficiency with respect to time in wholesale mandi stage**

| Variables | Component | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Improper planning for scheduling of Incoming Goods | 0.88 | | | | ***26.236*** | *Operational* |
| Manual unloading and loading operations-UfSC | 0.855 | | | | | |
| Handling and Loading by the means of head load | 0.849 | | | | | |
| Improper and High stacking of crates-UfT | 0.759 | | | | | |
| Bulk handling of crates/packages | 0.687 | | | | | |
| Manual unloading-UfT | 0.653 | | | | | |
| Manual handling while loading | 0.616 | | | | | |
| Non-availability of skilled labour for unloading the crates-UfT | | 0.906 | | | ***21.338*** | *Labour* |
| Employment of inadequate labour for unloading operations-UfT | | 0.881 | | | | |
| Non-availability of skilled labour for HLS | | 0.732 | | | | |
| Non-availability of skilled labour for unloading and loading the crates-UfSC | | 0.705 | | | | |
| Employment of inadequate labour for operations-UfSC | | 0.621 | | | | |
| Inadequate Resources for dealing with unexpected bulk arrival | | | 0.856 | | ***14.861*** | *Technical Resources* |
| Non-availability of tools and equipments for handling & loading | | | 0.846 | | | |
| Non-availability of equipments for loading and unloading the crate-UfSC | | | 0.778 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Non-availability of equipments for unloading-UfT | | | 0.515 | | | |
| Inadequate space for unloading and loading operations | | | | 0.837 | ***9.332*** | *Infrastructure* |
| Inadequate space for unloading operations-UfT | | | | 0.421 | | |

*Factor 1– Operational:* An operational issue is recognized as a first factor that leads to high lead time in tomato supply chain. This factor includes seven sub-variables having total variance 26.23%. Improper planning for scheduling of incoming goods ensure highest factor loading (.880), followed by manual unloading and loading of produce to supplier's crates (.855), handling and loading by the means of head load (.849), improper and high stacking of crates in trucks (.759), bulk handling of crates/packages (.687), manual unloading from truck (.653), and manual handling while loading the vehicle (.616). The results indicate that the operations at the wholesale stage are not performed so well and taking long time resulting in high lead time.

*Factor 2 – Labour:* The second factor is Labour, possessing total variance of 21.33% and consists of five sub-variables. Non-availability of skilled labour for unloading the crates from trucks carries the highest factor loading (.906). This is followed by employment of inadequate labour for unloading the produce from truck (.881), non-availability of skilled labour for handling, loading and stacking (.732), non-availability of skilled labour for unloading and loading the supplier's crates (.705), and employment of inadequate labour for operations of unloading supplier's crates (.621). The results indicate that non-availability of skilled labour and employing inadequate labour are the main reasons for lead time in the wholesale stage of tomato supply chain.

*Factor 3 – Resources:* Resources is the third factor, possessing total variance of 14.86% and consists of four sub-variables. Inadequate Resources for dealing with unexpected bulk arrival (.856) ensure the highest factor loading on this factor, followed by non-availability of tools and equipment for handling & loading (.846), non-availability of equipment for loading and unloading supplier's crates (.778), and non-availability of equipment for unloading the produce from truck (.515). The wholesalers indicated that lack of resources like proper tools and equipment to perform operations at the wholesale stage are affecting the lead time.

*Factor 4 – Infrastructure:* The fourth factor can be named as Infrastructure, having a variance of 9.33% and consists of two sub-variables. Inadequate space for unloading supplier's crate and loading buyer's crate ensure highest factor loading (.837), followed by inadequate space for unloading the truck (.421). This factor indicates that inadequate space is a constraint in the wholesale market to perform the operations effectively, which is increasing the lead time.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.119 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 71.51% of the variation across the sample. In isolation, first factor explained 27.816% of the total variance; second factor explained 17.76% of the total variance; third factor explained 11.96% of the total variance, fourth factor explained about 7.79% of the total variance and fifth factor explained 6.17% of the total variance.

**Table 5.119: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.095 | 32.252 | 32.252 | 6.119 | 27.816 | 27.816 |
| 2 | 3.514 | 15.971 | 48.222 | 3.909 | 17.766 | 45.582 |
| 3 | 2.214 | 10.062 | 58.284 | 2.632 | 11.965 | 57.547 |
| 4 | 1.711 | 7.778 | 66.062 | 1.715 | 7.794 | 65.341 |
| 5 | 1.199 | 5.449 | 71.511 | 1.358 | 6.171 | 71.511 |
| 6 | .995 | 4.524 | 76.035 | | | |
| 7 | .798 | 3.628 | 79.663 | | | |
| 8 | .736 | 3.346 | 83.009 | | | |
| 9 | .660 | 3.000 | 86.009 | | | |
| 10 | .560 | 2.545 | 88.554 | | | |
| 11 | .460 | 2.091 | 90.644 | | | |
| 12 | .382 | 1.735 | 92.379 | | | |
| 13 | .349 | 1.586 | 93.965 | | | |
| 14 | .307 | 1.395 | 95.360 | | | |
| 15 | .256 | 1.164 | 96.524 | | | |
| 16 | .170 | .772 | 97.296 | | | |
| 17 | .161 | .733 | 98.029 | | | |
| 18 | .122 | .554 | 98.583 | | | |
| 19 | .108 | .489 | 99.072 | | | |
| 20 | .086 | .391 | 99.463 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 21 | .073 | .334 | 99.797 | | | |
| 22 | .045 | .203 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency with respect to quality (Table 5.120). Operational issue happens to be the most crucial factor leading to supply chain inefficiency with respect to poor quality, followed by infrastructure, ambience, labour, and information. These five latent factors are summarized as follows:

**Table 5.120: Summary-Factors leading to supply chain inefficiency with respect to quality in wholesale mandi stage**

| Variables | Component | | | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Holding of goods in anticipation of high prices | 0.927 | | | | | ***27.816*** | *Operational* |
| Unloading and loading operations in an open area | 0.899 | | | | | | |
| Rough handling while unloading-UfT | 0.884 | | | | | | |
| Unloading in an inappropriate manner-UfT | 0.87 | | | | | | |
| Unloading the crates in an inappropriate manner-UfSC | 0.862 | | | | | | |
| Rough handling while unloading-UfSC | 0.806 | | | | | | |
| Inappropriate storing practices leading to compression of Tomatoes | 0.79 | | | | | | |
| Rough handling while storing | 0.564 | | | | | | |
| Improper and High stacking while storing | 0.548 | | | | | | |
| Open Area for Unloading which expose to direct sunlight/heat-UfT | | 0.85 | | | | ***17.766*** | *Infrastructure* |
| Open dock area which expose to direct sunlight/heat-UfT | | 0.846 | | | | | |
| Non-availability of cold storage facility | | 0.784 | | | | | |
| Non-availability of cooling shed at the place of storage | | 0.702 | | | | | |
| Insufficient storage and temperature controlled facilities | | 0.683 | | | | | |
| Inadequate space for unloading operations-UfSC | | 0.617 | | | | | |
| Inadequate space for unloading operations-UfT | | 0.598 | | | | | |
| Damage to the Tomatoes caused by pest and fungal infection during storage | | | 0.869 | | | ***11.965*** | *Ambience* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| High temperature at storage area | | | 0.837 | | | | |
| Inadequate ventilation at the place of storage | | | 0.774 | | | | |
| Non-availability of skilled labour for unloading the crates-UfSC | | | | 0.87 | | ***7.794*** | *Labour Availability* |
| Non-availability of skilled labour for unloading the crates-UfT | | | | 0.822 | | | |
| Inadequate and non-availability of timely demand information | | | | | 0.833 | ***6.171*** | *Information* |

*Factor 1– Operational:* An Operational issue is recognized as a first factor that leads to poor quality of tomato in the supply chain. This factor includes nine sub-variables having total variance 27.81%. Holding of goods in anticipation of high prices carries highest factor loading (.927), followed by unloading and loading operations in an open area (.899), rough handling while unloading the truck (.884), unloading the produce from truck in an inappropriate manner (.870), unloading the crates in an inappropriate manner while unloading supplier's crates (.862), rough handling while unloading supplier's crates (.806), inappropriate storing practices leading to compression of tomatoes (.790), rough handling while storing (.564), and improper and high stacking while storing (.548). The result indicates that operational issues need much consideration to maintain the quality of fresh produce. It shows that the operations are not performed effectively at the wholesale stage, which affects the quality. Loading and unloading are very important steps at each stage of the supply chain but are often neglected.

*Factor 2 – Infrastructure:* The second factor is Infrastructure, possessing total variance of 17.76% and consists of seven sub-variables. Open area for unloading the truck that exposes to direct sunlight/heat carries highest factor loading (.850). This is followed by open dock area for truck that exposes to direct sunlight/heat (.846), non-availability of cold storage facility (.784), non-availability of cooling shed at the place of storage (.702), insufficient storage and temperature-controlled facilities (.683), inadequate space for unloading supplier's crates (.617), and inadequate space for unloading the truck (.598). The results indicate that there is an urgent requirement of proper infrastructure related to cold storage, dock area, and space to perform the operations at the wholesale stage.

*Factor 3 – Ambience:* Ambience at the wholesale stage is the third factor, possessing total variance of 11.96% and consists of three sub-variables. Damage to the tomatoes caused by pest and fungal infection during storage (.869) carries the highest factor loading, followed by high temperature at storage area (.837), and inadequate ventilation at the place of storage (.774). The result indicates that the ambiance at the wholesale stage is inadequate causing damage to the product due to fungal infection and high temperature at the storage area.

*Factor 4 – Labour:* The fourth factor is Labour, having a variance of 7.79% and consists of two sub-variables. Non-availability of skilled labour for unloading the supplier's crates ensure highest factor loading (.870), followed by non-availability of skilled labour for unloading the crates from the truck (.822). The result indicates that due to non-availability of skilled labour, the produce is not handled properly, which affects the quality. Skilled labour is the need of the hour to perform effective operations and maintain quality in the supply chain.

*Factor 5 – Information:* The fourth factor is market information, having a variance of 6.17% and consist only one sub-variable named Inadequate and non-availability of timely demand information (.833). The result indicates that information regarding market demand is essential in the fresh supply chain. Due to non-availability of demand information, the wholesalers have to carry the fresh produce for a long time without storing them in the temperature-controlled atmosphere, which affects the quality of the produce.

### 5.3.2.5. *iv.* Factors Leading to Supply Chain Inefficiency in Transportation Stage (Stage IV)

Factors leading to supply chain inefficiency with respect to cost, time and quality in transportation stage of vegetables (tomato) supply chain are discussed as under.

***Factors Leading to Supply Chain Inefficiency with respect to Cost***

Table 5.121 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Four factors have been identified (possessing eigen values >1), which mutually amounts to 72.26% of the variation across the sample. In isolation, first factor explained 30.44% of the total variance; second factor explained 15.90% of the total variance; third factor explained 15.21% of the total variance, and fourth factor explained 10.69% of the total variance.

**Table 5.121: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.459 | 34.593 | 34.593 | 3.045 | 30.448 | 30.448 |
| 2 | 1.553 | 15.527 | 50.120 | 1.591 | 15.905 | 46.354 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 1.171 | 11.709 | 61.829 | 1.522 | 15.216 | 61.570 |
| 4 | 1.044 | 10.440 | 72.269 | 1.070 | 10.699 | 72.269 |
| 5 | .804 | 8.037 | 80.306 | | | |
| 6 | .520 | 5.202 | 85.507 | | | |
| 7 | .421 | 4.214 | 89.721 | | | |
| 8 | .367 | 3.669 | 93.390 | | | |
| 9 | .356 | 3.562 | 96.952 | | | |
| 10 | .305 | 3.048 | 100.000 | | | |

The factor analysis revealed four broad issues (factors), which are leading to supply chain inefficiency with respect to cost, in transportation stage of tomato supply chain (Table 5.122). Rates and Charges happens to be the most crucial factor leading to supply chain inefficiency with respect to high cost at this stage, followed by connectivity, infrastructure, and resource/transportation facilities. These four latent factors are summarized as follows:

**Table 5.122: Summary-Factors leading to supply chain inefficiency with respect to cost in Transportation stage**

| **Variables** | **Component** | | | | **Variance (% of explained) eigen values** | **Factor Name** |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Crossing and Toll Booth Charges | 0.849 | | | | | |
| High charges of Taxes | 0.829 | | | | | |
| High Freight Charges | 0.814 | | | | ***30.448*** | *Rates & Charges* |
| High Fuel prices | 0.761 | | | | | |
| Conveyance Charges by Policeman | 0.457 | | | | | |
| Long distance between Farm and Wholesale Market | | 0.877 | | | ***15.905*** | *Connectivity* |
| Inappropriate Vehicle Routing | | 0.861 | | | | |
| High Traffic Jams | | | 0.913 | | ***15.216*** | *Infrastructure* |
| Poor road connectivity | | | 0.745 | | | |
| Timely Non-availability of transport facilities | | | | 0.933 | ***10.699*** | *Resources/ Transportation Facilities* |

*Factor 1–Rates and Charges:* Rates and Charges are recognized as the first factor that leads to high cost in the transportation stage of tomato supply chain. This factor includes five sub-variables having total variance 30.44%. Crossing and toll booth charges (0.849) carries the highest factor loading, followed by high charges of taxes (0.829), high freight charges (0.814), high fuel prices (0.761), and conveyance charges by a policeman (0.457). The results indicate that high rates and charges

pertaining to tax, freight, and fuel are leading to high cost in the transportation stage of tomato supply chain. Increasing fuel prices is one of the main issues under this factor.

*Factor 2 – Connectivity:* The second factor, which leads to supply chain inefficiency with respect to cost in the transportation stage of tomato supply chain is a connectivity issue, possessing total variance of 15.90% and contain two sub-variables. The long distance between Farm and Wholesale Market (0.877) carries highest factor loading in this category, followed by inappropriate Vehicle Routing (0.861). The results indicate that due to long travel distance and inappropriate vehicle routing, the transportation cost in tomato supply chain gets an increase.

*Factor 3 – Infrastructure:* The third factor leading to supply chain inefficiency with respect to cost in transportation stage of tomato supply chain is infrastructure issue, possessing total variance of 15.21% and contain two sub-variables. High traffic jams (0.913) carries highest factor loading, followed by poor road connectivity (0.745). The results indicate that high traffic jam is also one of the reasons for high cost as due to the traffic the vehicle is not able to reach the market at the right time, which results to penalty and also the fresh produce has to wait for the next day of auctioning, which may results to opportunity loss. Due to poor road connectivity the distance between the farm and market increases, which results in high freight charges.

*Factor 4–Resources/Transportation facility:* The fourth factor is non-availability of transportation resources, due to which the transportation cost increases. This factor displays a variance of 10.69% and consist of only one sub-variable, namely, timely non-availability of transport facilities (0.933). The results indicate that due to non-availability of transportation facilities the farmers and other stakeholders have to arrange the transportation services from other areas and those transportation providers' charges high rates, which results in high transportation cost.

***Factors Leading to Supply Chain Inefficiency with respect to Time***

Table 5.123 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Five factors have been identified (possessing eigen values >1), which mutually amounts to 78.29% of the variation across the sample. In isolation, first factor explained 20.03% of the total variance; second factor explained 19.30% of the total variance; third factor explained 15.20%

of the total variance, fourth factor explained 14.22% of the total variance, and fifth factor explained 9.52% of the total variance.

**Table 5.123: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.974 | 33.120 | 33.120 | 2.404 | 20.034 | 20.034 |
| 2 | 2.042 | 17.017 | 50.137 | 2.317 | 19.306 | 39.340 |
| 3 | 1.322 | 11.015 | 61.152 | 1.824 | 15.202 | 54.542 |
| 4 | 1.031 | 8.594 | 69.747 | 1.707 | 14.228 | 68.770 |
| 5 | 1.026 | 8.553 | 78.299 | 1.144 | 9.529 | 78.299 |
| 6 | .837 | 6.975 | 85.275 | | | |
| 7 | .634 | 5.282 | 90.556 | | | |
| 8 | .337 | 2.810 | 93.366 | | | |
| 9 | .318 | 2.653 | 96.019 | | | |
| 10 | .265 | 2.207 | 98.225 | | | |
| 11 | .124 | 1.034 | 99.260 | | | |
| 12 | .089 | .740 | 100.000 | | | |

The factor analysis revealed five broad factors, which are leading to supply chain inefficiency with respect to high lead time in the transportation stage of tomato supply chain (Table 5.124). Connectivity issue happens to be the most crucial factor leading to supply chain inefficiency with respect to high lead time, followed by infrastructure, verification and frisking, imprudence, and resource/transportation facilities. These five latent factors are summarized as follows:

**Table 5.124: Summary- Factors leading to supply chain inefficiency with respect to time in Transportation stage**

| **Variables** | **Component** | | | | | **Variance (% of explained) eigen values** | **Factor Name** |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Hilly Terrain | 0.924 | | | | | ***20.034*** | *Connectivity* |
| Long distance between Farm and Wholesale Market | 0.911 | | | | | | |
| Inappropriate Vehicle Routing | 0.789 | | | | | | |
| Congestion and Traffic Jams | | 0.813 | | | | ***19.306*** | *Infrastructure* |
| Traffic Jams in Azadpur Mandi | | 0.73 | | | | | |
| Poor road conditions in hilly areas | | 0.721 | | | | | |
| Poor road connectivity | | 0.564 | | | | | |
| Police Verification and Frisking | | | 0.911 | | | ***15.202*** | *Verification & Frisking* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Frequent Crossings and Toll Booths | | | 0.853 | | | | |
| Irresponsible and Careless driving | | | | 0.795 | | ***14.228*** | *Imprudence* |
| Non Adherence to Time Schedule Allocated for Transportation | | | | 0.718 | | | |
| Timely Non-availability of transportation vehicle | | | | | 0.913 | ***9.529*** | *Resources/ Transportation Facilities* |

*Factor 1 – Connectivity:* Factor one can be named as “Connectivity issue”, which affects the transportation lead time in tomato supply chain as the issues covered under this factor/category are directly related to the issue of improper connectivity. The variables, which are underlying in this factor/category and explained 20.03% of the variation are "hilly terrain,” “Long distance between farm and wholesale market” and “inappropriate vehicle routing.” Hilly terrain carries the maximum loading (0.924) in this factor, followed by a long distance between farm and wholesale market (0.911), and inappropriate vehicle routing (0.789). The result indicates that due to hilly terrain, the vehicle takes a long time in transit. Long distance is also one of the issues under this factor. The vehicle has to cover a long distance to reach the market, which impacts the transportation lead time.

*Factor 2– Infrastructure:* Factor two can be named as “Infrastructure issues”, which affects the transportation lead time in tomato supply chain as the variables underlying in this factor/category are directly related to poor infrastructure. The variables, which are underlying in this factor/category and explained 19.30% of the variation are “congestion and traffic jams,” “traffic jams in Azadpur mandi,” “poor road conditions in hilly areas” and “poor road connectivity.” Congestion and traffic jam carries the maximum factor loading (0.813) followed by traffic jams in Azadpur mandi (0.730), poor road conditions in hilly areas (0.721), and poor road connectivity (.564). The result indicates that congestion and high traffic jam are the major concern for the transporters during the peak season as large amount of goods happened to transport at this particular period of time. Azadpur Mandi is Asia's largest wholesale F&V market fully congested and packed with different types of vehicles including rickshaws and carts. Sometimes vehicle takes a complete day to cover the distance within Azadpur Mandi due to high congestion and poor infrastructure. Poor road condition is also an important issue, which affects the transportation time. Due to poor road conditions, the vehicles take a significant amount of time to reach the market.

*Factor 3 – Verification & Frisking:* Factor three can be named as “Continuous Verification & Frisking”, which is affecting the transportation lead time in tomato supply chain as the issues underlying in this factor/category are directly related to the problems associated with continuous checking of vehicles at various places within a short distance. The variables, which are underlying in this factor/category and explained 15.20% of the variation are “police verification and frisking” and “frequent crossings and toll booths.” Police verification and frisking carries the maximum factor loading (.911) in this factor followed by Frequent Crossings and Toll Booths (.853). The result indicates that during season’s time the vehicles are asked to stop at various places by different officials for convenience charges, which result to delay in the transportation process due to which, the fresh produce is not been able to reach the market at the expected time. Frequent crossings and small non-authorized toll booths run by local villagers are also the matter of concern, which hampers the transport operations.

*Factor 4 – Imprudence:* Factor four can be named as “Imprudence factor”, which is affecting the transportation lead time in tomato supply chain as the issues/variables underlying in this factor/category are directly related to the carelessness and negligence of the drivers. The variables, which are underlying in this factor/category and explained 14.22% of the variation are “irresponsible and careless driving” and “non-adherence to time scheduled allocated for transportation.” Irresponsible and careless driving carries the maximum factor loading (0.795) in this factor, followed by non-adherence to time scheduled allocated for transportation (0.718). The results indicate that due to the carelessness and irresponsibility of the drivers the transportation lead time increases. They ignore the time estimated and allocated for transportation.

*Factor5–Resource/Transportation facilities:* Factor five can be named as “Resource/Transportation facilities”, which affects the transportation lead time in tomato supply chain as the issue covered under this factor/category is directly related to lack of resource availability. The only variable, which is underlying in this factor/category and explained 9.52% of the variation is "timely non-availability of transport facilities” with the factor loading of .913. The result indicates that during peak season, non-availability of transportation facilities is a major issue of concern, which increases the lead time and also affects the quality of fresh produce. Sometimes the farmers have to wait for long days to get a vehicle for transporting their fresh produce to the market.

***Factors Leading to Supply Chain Inefficiency with respect to Quality***

Table 5.125 lists the eigen value connected with each linear component and the factor before extraction and after rotation. Three factors have been identified (possessing eigen values >1), which mutually amounts to 75.15% of the variation across the sample. In isolation, first factor explained 37.39% of the total variance; second factor explained 23.07% of the total variance, and third factor explained 14.68% of the total variance.

**Table 5.125: Total Variance Explained**

| Component | Initial Eigen values | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.185 | 41.855 | 41.855 | 3.739 | 37.395 | 37.395 |
| 2 | 2.314 | 23.137 | 64.991 | 2.307 | 23.075 | 60.469 |
| 3 | 1.016 | 10.165 | 75.156 | 1.469 | 14.687 | 75.156 |
| 4 | .672 | 6.720 | 81.876 | | | |
| 5 | .475 | 4.753 | 86.629 | | | |
| 6 | .411 | 4.109 | 90.738 | | | |
| 7 | .327 | 3.269 | 94.007 | | | |
| 8 | .276 | 2.765 | 96.772 | | | |
| 9 | .178 | 1.782 | 98.555 | | | |
| 10 | .145 | 1.445 | 100.000 | | | |

The factor analysis revealed three broad factors, which are leading to supply chain inefficiency with respect to quality in the transportation stage of tomato supply chain (Table 5.126). Operational issue happens to be the most crucial factor leading to poor quality of fresh produce at this stage, followed by preservation, and infrastructure. These three latent factors are summarized as follows:

**Table 5.126: Summary-Factors leading to supply chain inefficiency with respect to quality in Transportation stage**

| Variables | Component | | | Variance (% of explained) eigen values | Factor Name |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| Non-usage of Temperature controlled Transportation system | 0.925 | | | ***37.395*** | *Operational* |
| Jerks in Transit, by which pack structure get loose | 0.838 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Packaging boxes of different weight, size, commodity in the same carrier | 0.829 | | | | |
| Compression of produce due to putting weight on the load | 0.741 | | | | |
| Overburden and Overloading | 0.676 | | | | |
| Improper stacking during transportation | 0.636 | | | | |
| Fungal infection during transit | | 0.927 | | | |
| No control on Temperature/ Humidity during transit | | 0.88 | | ***23.075*** | *Preservation* |
| Hitchhiking pests during transit | | 0.779 | | | |
| Poor road conditions | | | 0.913 | ***14.687*** | *Infrastructure* |

*Factor 1– Operational Factor:* Factor one can be named as an Operational factor, which impacts the quality of tomatoes as the issues/variables underling in this factor/category are directly related to operational issues. The variables, which are underlying in this factor/ category and explained 37.39% of the variation are “Non-usage of Temperature controlled Transportation system”, “Jerks in Transit by which pack structure get loose”, “Packaging boxes of different weight, size, commodity in the same carrier”, “Compression of produce due to putting weight on the load”, “Overburden and Overloading” and “Improper stacking during transportation”. Non-usage of Temperature controlled Transportation system carries the maximum factor loading (0.925) followed by Jerks in Transit by which pack structure get loose (0.838), Packaging boxes of different weight, size, commodity in the same carrier (0.829), Compression of produce due to putting weight on the load (0.741), Overburden and Overloading (0.676) and Improper stacking during transportation (0.636). The result indicates that most of the issues are arising from operational factors, which can be controlled and improvised by providing proper training to the workforce. Non-usage of the refrigerated transportation system is one of the most important issues, which impact the quality of fresh produce. Jerks in transit, overburden and overloading, putting unnecessary weight on the load, non-uniformity of packaging containers, and improper stacking are some of the issues, which lead to poor quality during the transportation stage.

*Factor 2 – Preservation:* Factor two can be named as Preservation issues, which are impacting the quality of tomatoes as the issues/variables underling in this factor/category are directly related to preservation and atmospheric controlled issues in transit. The variables, which are underlying in this factor/ category and explained

23.075% of the variation are “fungal infection during transit,” “no control on temperature/ humidity during transit” and “hitchhiking pests during transit.” Fungal infection during transit carries the maximum factor loading (0.927) in the said factor, which is followed by no control on temperature/ humidity during transit (0.880) and hitchhiking pests during transit (0.779). The results indicate that due to improper preservation during the transportation, quality of tomatoes is being deteriorated. Pest and infections due to poor preservation techniques and no control on temperature are the main reasons impacting the quality.

*Factor 3 – Infrastructure:* Factor three can be named as Infrastructure issue, which is impacting the quality of tomatoes as the variable underlying in this factor/category is directly related to the problem of infrastructure wherein the condition of roads is not good and hampering the quality. The variable, which is underlying in this factor/category and explained 14.687% of the variation, is “poor road conditions.” A poor road condition is the only one variable lying in this factor with the loadings 0.913. The results indicate that a poor road condition in hilly areas is one of the most important issues, which are leading to poor quality of tomatoes during in transit. Due to poor road conditions, it generally takes long hours to reach the goods to its destination, and mostly, these items are transported in open/ nonrefrigerated trucks, which hamper the transportation atmosphere required for perishable items. Due to poor road condition, the vehicle takes a lot of time to reach the market and deteriorate the quality of fresh items.

**5.3.3. Analysis- Research Objective 3:** *To develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato*

To develop a framework for improving supply chain efficiency, first of all, measures for the major reason under each factor leading to supply chain inefficiency across the stages were identified through in-depth semi-structured interview method of qualitative research.

After data collection through semi-structured interview, the responses were recorded, transcribed and codes were generated *(Refer to Appendix VI and VII)*. On the basis of transcribed conversation and codes, measures were taken out, as suggested by the experts. To make it more vivid and comprehensive, the measures to improve supply chain efficiency of F&V sector are represented in the diagrammatic form as shown below in Figure 5.22-Figure 5.48. Major reasons for inefficiency under each factor leading to supply chain inefficiency across the stages (Farm gate to the Wholesale stage) and corresponding measures have been highlighted in the figures (Figure 5.22 to Figure 5.48) for both the selected F&V, i.e., Mango and Tomato.

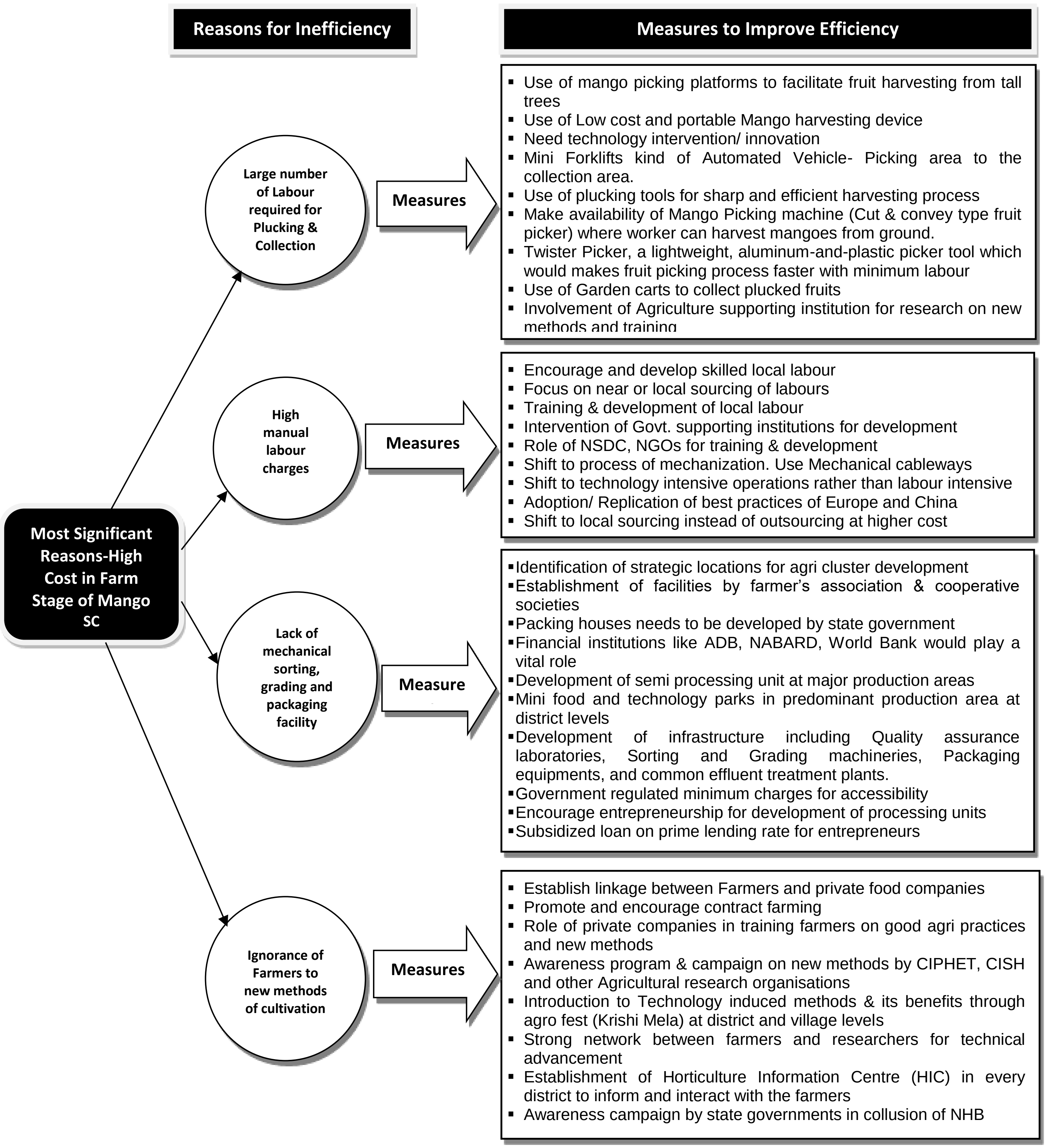



**Figure 5.22: Measures to improve SC Efficiency (with respect to Cost) in Farm Stage of Mango SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High lead time in Farm Stage of Mango SC**

**Lack of knowledge pertaining to sorting & grading** → **Measures**

- Supply Chain Collaboration between farmer and private companies
- Contract farming needs to be emphasised
- Government & related institutions should be responsible to educate & train the farmers on regular basis
- Information regarding the standards and quality required by industry & international market
- Information regarding the types of packaging materials and innovative techniques
- Skill Development program, Capacity building program, Productivity Enhancement Program
- Asian Productivity Council, NSDC, and NHB should invest in training for workers and operators
- Need Infrastructure in place to provide training and education to farmers for improving agronomic practices.
- Need to make training and certification mandatory while also emphasising the setting of benchmarks and standards.
- Need to develop institutions which provide scientific training regarding sorting, grading processes.
- Sorting, grading and packaging techniques relating to size selection, shape selection, packing techniques, container space optimization and division of labour.
- Preparation & dissemination of manuals or guides with diagram and pictures
- Farm visits of horticulture officers when packing activities are in progress

**Lack of proper planning for harvesting** → **Measures**

- Exert strict supervision on the harvesting operation.
- Consideration of following factor for proper planning & necessary arrangements:
  - Harvesting tools, Hand gloves, and Containers;
  - Correct time of harvesting;
  - Type of tools to be used;
  - Manpower requirements;
  - Stage of maturity;
  - Number of days for harvesting/harvesting frequency (harvesting ahead and not waiting until a demand occurs);
  - Check on available resources;
  - Market price and place to supply and distance;
  - Availability of transport and other facilities for the day;
  - Weather and environmental conditions;
  - Human factors as well as market demands
- Ensure that crop maturity coincides with market demand.
- Collaborative Supply Chain Planning to integrate farmers and other stakeholders in the chain

**Lack of mechanical sorting, grading and packaging facility** → **Measures**

- Identification of strategic locations for agri cluster development
- Establishment of facilities by farmer's association & cooperative societies
- Packing houses needs to be developed by state government
- Financial institutions like ADB, NABARD, and World Bank would play a vital role
- Development of semi processing unit at major production areas
- Mini food and technology parks in predominant production area at district levels
- Development of infrastructure including Quality assurance laboratories, Sorting and Grading machineries, Packaging equipments, and common effluent treatment plants
- Government regulated minimum charges for accessibility
- Encourage entrepreneurship for development of processing units
- Subsidized loan on prime lending rate for entrepreneurs
- PPP model would also play a vital role in developing facilities

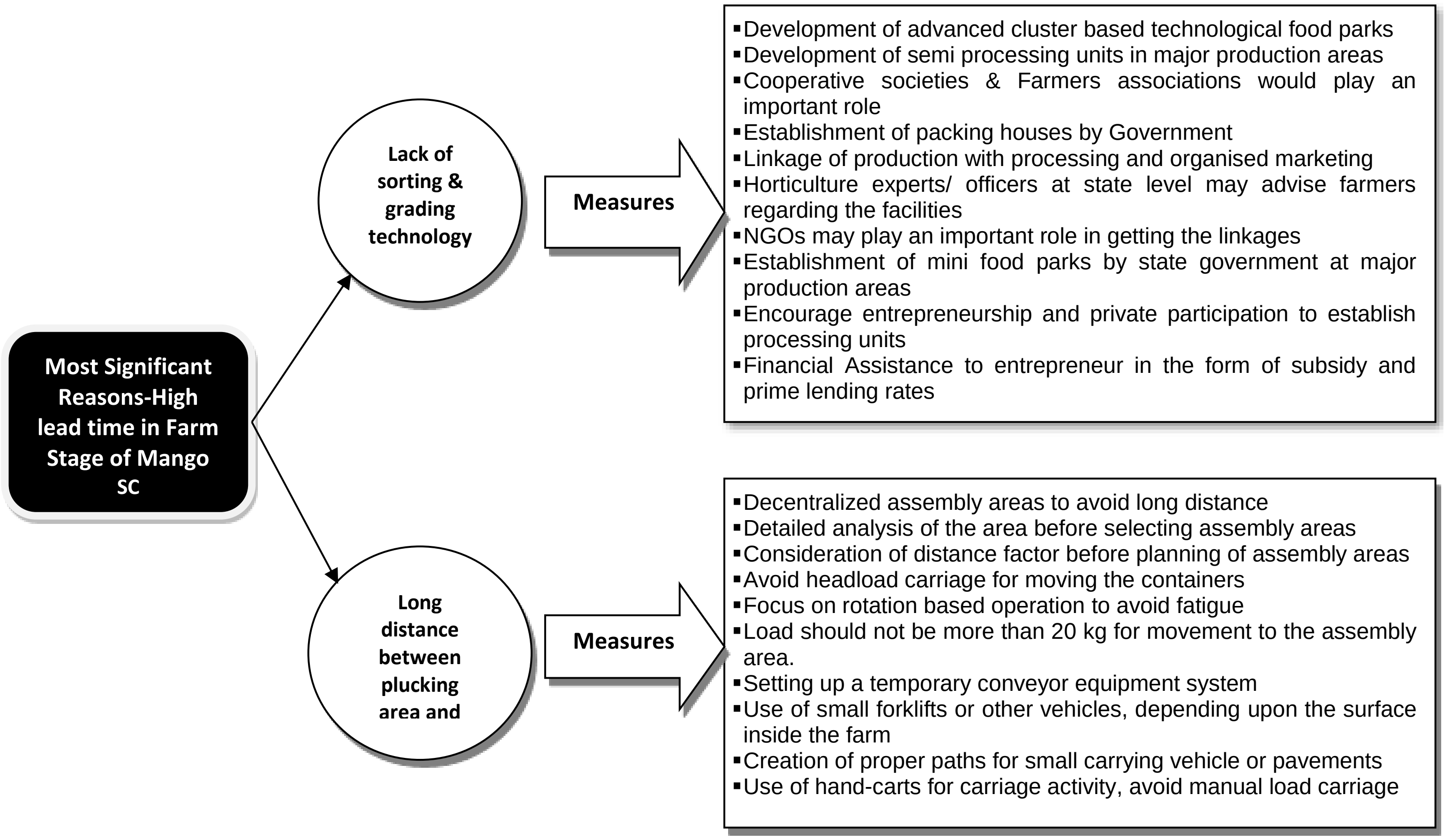



**Figure 5.23: Measures to improve SC Efficiency (with respect to Time) in Farm Stage of Mango SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-Poor Quality in Farm Stage of Mango SC**

**Exposure to high temperature during plucking &**

- Harvesting operations should be avoided during high temperature
- Temporary tent must be constructed from large tarpaulins or plastic sheets for collection activity
- Do not left out the produce in heat and sunlight after plucking
- Field bins should be placed in the shade or loosely covered with light coloured canvas, leafy plant materials, straw or an inverted empty container
- Proper planning of harvesting day and time
- Avoid plucking activity during day time
- Consider Weather and environmental conditions
- Harvest early in the day, keeping fruit in shade, dumping into cold water and placing fruit straight into pre-cooler, if fruit cannot be processed immediately.
- Exert strict supervision on the harvesting operation.

**Open Air area which expose to direct sunlight**

- Avoid Open Air operations
- Temporary tent must be constructed from large tarpaulins or plastic sheets to avoid direct sunlight/heat.
- Use fans inside the tent to recirculate the air
- Use beach umbrellas arranged side by side to provide acceptable shade to the produce during sorting, grading activity
- Cemented floor with roof of corrugated G.I. sheet may be constructed at farm which can be used for other activities also
- Shade can be created using locally available material, such as shade cloth, woven mats, plastic tarps or a canvas sheet hung from temporary poles.
- Need Government support to develop small packing house at farm area
- Development of Cooperative packing houses
- Field sheds or mobile packing facilities may suffice for small scale

**Timely non-availability of packaging material**

- Reuse of cartons, wooden boxes or crates that have been used for other commodities.
- Ensure that the Second-hand containers are clean.
- Devise suitable system for returning the boxes to the field from the market
- Invest & Use plastic containers (crates) which are reusable and last longer (Cost can be recovered in 10-15 trips)
- Support by government through subsidy to buy packaging crates (like, Maharashtra govt. provides 50% subsidy)
- Supply chain solution incorporating equipment pooling
- Private company manages the network, providing customers with equipment when necessary
- Utilisation of equipments without making a capital investment
- Strategic alliances between farmers and food processing companies
- Clear understanding of the wide range of packaging options available in market
- Need a distribution model to provide packaging materials by the government in a minimum rate
- Role of NGOs and Farmer cooperatives

**Most Significant Reasons-Poor Quality in Farm Stage of Mango SC**

**Mishandling and carelessness while plucking and collection**

**Measures**

- Strict supervision of the operation performed by worker/labour
- Need appropriate harvest containers and constant management of labour
- Instructions to harvest with appropriate techniques to trim fingernails, and be monitored to verify proper handling
- Check the performance & system for reward for careful handling
- Harvest containers and bulk bins should have smooth sides and be kept free of debris
- Clean & Sanitize harvest containers prior to re-use
- A cushioning material should be placed around the tree to prevent damage to the fruit when dropping from high trees while plucking
- Use of harvesting bags with shoulder or waist slings while plucking
- Cut or broken ends of stems should never be placed in direct contact with the soil, nor placed in containers contaminated with dirt or decaying plant material
- Inexpensive inner made from fiberboard can be used to protect produce from damage during handling
- Continuous field supervision to apply the most appropriate combination of handling techniques
- Careful instructions must be given on the correct method of cutting, twisting or pulling to remove a crop
- Training on general principles and crop specific techniques relating to maturity selection, detachment method, maintenance of equipment, and field hygiene
- Precaution is to be taken to leave a four-inch stem to avoid the spurt of milky/resinous sap that exudes if the stem is cut close.
- Training and knowledge development programme
- Dissemination of manuals or guides (with diagram and pictures) published by govt. institutions/authorities on handling of perishable fresh produce
- Minimise drops while plucking and collection

**Lack of knowledge pertaining to sorting & grading processes**

**Measures**

- Supply Chain Collaboration between farmer and private companies
- Contract farming needs to be emphasised
- Government & related institutions should be responsible to educate & train the farmers on regular basis
- Information regarding the standards and quality required by industry & international market
- Information regarding the types of packaging materials and innovative techniques
- Skill Development program, Capacity building program, Productivity Enhancement Program
- Asian Productivity Council, NSDC, and NHB should invest in training for workers and operators
- Need Infrastructure in place to provide training and education to farmers for improving agronomic practices.
- Need to make training and certification mandatory while also emphasising the setting of benchmarks and standards.
- Need to develop institutions which provide scientific training regarding sorting, grading processes.
- Sorting, grading and packaging techniques relating to size selection, shape selection, packing techniques, container space optimization and division of labour.
- Preparation & dissemination of manuals or guides with diagram and pictures
- Farm visits of horticulture officers when packing activities are in progress

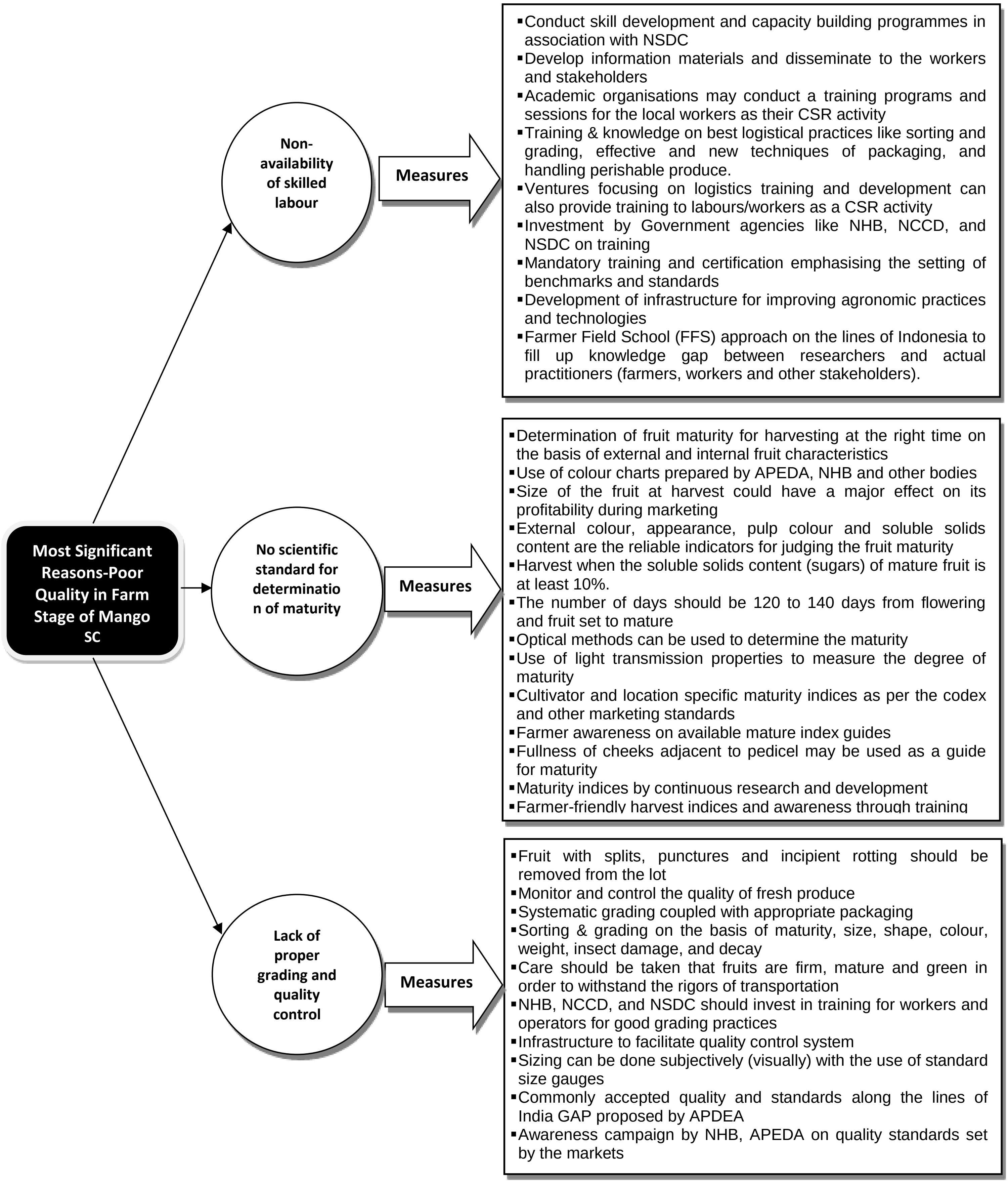



**Figure 5.24: Measures to improve SC Efficiency (with respect to Quality) in Farm Stage of Mango**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High Cost in Local Trader Stage of Mango SC**

**Non-usage of Sorting & Grading Technology** → **Measures**

- Grading machinery should be used to reduce manpower
- Maximum number of mini pack houses at major production areas
- Development of sorting & grading facilities
- Support from Government & Supporting institutions for development
- Sharing between the users and Cooperative societies
- Technology intensive processing units by with assistance from NHB, MoFPI, and ADB
- Subsidy on the purchase of grading and packaging machineries
- Encourage to use technological advanced equipments to reduce operational cost
- Try to minimise manual process in the supply chain
- Development by cooperatives or associations with the help of government support
- Primary processing units focusing on sorting machineries, auto-grading equipments on the basis of size, and colours

**High manual labour charges** → **Measures**

- Encourage and develop skilled local labour
- Focus on near or local sourcing of labours
- Intervention of Govt. support institutions for development
- Shift to local sourcing instead of outsourcing at higher cost
- Training & development of local labour
- Role of NSDC, NGOs for training & development
- Shift to process of mechanization.
- Use of Mobile truck loader and unloader, truck loading-unloading conveyors, and fork-lifts
- Provision of buying mechanized item in subsidized form

**Repeated handling, grading & repackaging** → **Measures**

- Supply chain collaboration between the suppliers i.e. farmers and the food processing units
- Provision of direct selling to the food processing units
- Adoption of contract farming strategy
- One-time Sorting, grading & packaging as per food standards
- Eliminate extensive and complex linkages between farmers and retailers
- Select the channel which distributes the produce appropriately at low expense
- Select the channel which secure the desired volume of disposal
- Need of reduction in the length of the supply chain
- Adoption of new (organised) system of distribution
- Farmers should be encouraged to form their own marketing co-operative societies
- Replication of cross docking concept in this case with minimum operations

**Lack of mechanical sorting, grading and packaging facility** → **Measures**

- Identification of strategic locations for agri cluster development
- Establishment of facilities by associations & cooperative societies
- Packing houses needs to be developed by state government
- Financial institutions like ADB, NABARD, and World Bank would play a vital role
- Development of semi processing unit nearby major production areas
- Mini food and technology parks in predominant production areas at district levels
- Development of infrastructure including Quality assurance laboratories, Sorting and Grading machineries, Packaging equipments, and common effluent treatment plants
- Government regulated minimum charges for accessibility
- Encourage entrepreneurship for development of processing units
- Subsidized loan on prime lending rate for entrepreneurs

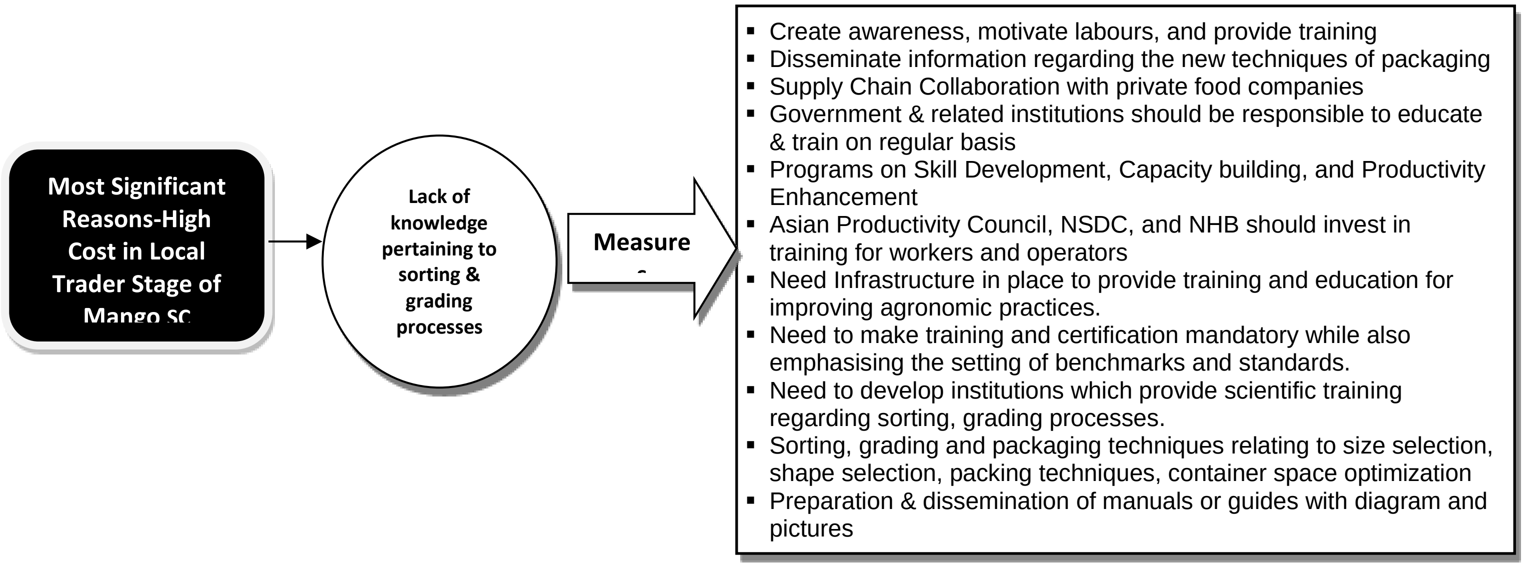



**Figure 5.25: Measures to improve SC Efficiency (with respect to Cost) in Local Trader/Middlemen Stage of Mango SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High Lead time in Local Trader Stage of Mango**

**Non-availability of skilled labour for sorting & grading** — **Measures**

- Conduct skill development and capacity building programmes in association with NSDC
- Develop information materials and disseminate to the workers and stakeholders
- Academic organisations may conduct a training programs and sessions for the local workers as their CSR activity
- Training & knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce
- Ventures focusing on logistics training and development can also provide training to labours/workers as a CSR activity
- Investment by Government agencies like NHB, NCCD, and NSDC on training
- Mandatory training and certification emphasising the setting of benchmarks and standards
- Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners

**Time Ignorance during sorting, grading and packaging** — **Measures**

- Awareness on the importance of time utility in perishable produce
- Monitoring and closed supervision on the operations of workers
- System of penalty for high lead time in operations
- Conduct training & development program
- Emphasis on time bound operations
- Value stream mapping should be done
- Eliminate non value added activities
- A specific timeframe should be created for each activity
- Team leader should be appointed and made responsible for any delays
- Proper planning and necessary arrangements in advance to avoid hindrance during operation

**Lack of sorting & grading technology** — **Measures**

- Development of advanced cluster based technological food parks
- Development of semi processing units near major production belt
- Cooperative societies & Farmers associations would play an important role
- Linkage of trader with processing and organised marketing
- NGOs may play an important role in getting the linkages
- Establishment of mini food parks & packing houses by state government at major production areas
- Encourage entrepreneurship and private participation to establish processing units
- Financial Assistance to entrepreneur in the form of subsidy and prime lending rates

**Lack of mechanical sorting, grading and packaging facility** — **Measures**

- Identification of strategic locations for agri cluster development
- Establishment of facilities by associations & cooperative societies
- Identification of strategic locations for infrastructure development
- Packing houses needs to be developed by state government
- Financial institutions like ADB, NABARD, and World Bank would play a vital role
- Development of semi processing unit nearby major production areas
- Mini food and technology parks in predominant production areas at district levels
- Development of infrastructure including Quality assurance laboratories, Sorting and Grading machineries, Packaging equipments, and common effluent treatment plants
- Government regulated minimum charges for accessibility
- Encourage entrepreneurship for development of processing units
- Subsidized loan on prime lending rate for entrepreneurs

**Figure 5.26: Measures to improve SC Efficiency (with respect to Time) in Local trader/middlemen Stage of Mango SC**

**Reasons for Inefficiency**

**Measures to Improve Efficiency**

**Most Significant Reasons-Poor Quality in Local trader Stage of Mango SC**

**Exposure to high temperature during fruits unloading & loading in crate**

**Measures**

- Operations should be avoided during high temperature
- Avoid direct exposure to the sun and heat
- Temporary tent must be constructed from large tarpaulins or plastic sheets for unloading & loading fruits in crate
- Fans should be used to recirculate the air through the produce during the operations
- Packaging containers should be placed in shade or loosely covered with light coloured canvas, leafy plant materials, straw or an inverted empty container
- Improvise beach umbrellas arranged around the operation area to provide acceptable shade to the produce
- Exert strict supervision on fruits unloading & loading operation
- Cemented floor with roof of corrugated G.I. sheet may be constructed to perform operations
- Temporary shade can be created using locally available material, such as shade cloth, woven mats, plastic tarps or a canvas sheet hung from temporary poles

**Insufficient storage and temperature controlled facilities**

**Measures**

- Concept of Top Icing/Contact Icing can be applied for short term storage which would result in quicker cooling
- Optimum temperature for crop as quickly as possible after harvest
- Need of cold chain network from farm to point of sale
- Access to low-cost handling and storage technologies (e.g., evaporative coolers, storage bags, crates)
- Use of Zero energy cool chamber/Evaporative coolers to extend the shelf life of food and avoid spoilage
- Encourage Cooperatives societies and other agencies to develop cold storage facilities
- Realistic rental rates and payments after the sale of product could attract the users to use the facility
- Use of Low-cost, low-energy, environmental friendly cool chambers made from locally available materials
- Room cooling technique consisting refrigeration unit
- Use of Night ventilation technique where variation between day and night temperatures can be used to keep stores cool
- Subsidy by government on the cost of building cold-storage
- Focus on development of micro cold chain solutions
- Need of Good policy environment promoting investment and formation of alliances/commodity based clusters
- Establish multi- chamber/ multi- commodity cold storage

**Non-usage of skilled labour**

**Measures**

- Proper handling and safety of produce should be the prime importance
- Conduct skill development and capacity building programmes in association with NSDC
- Develop information materials and disseminate to the workers and stakeholders
- Academic organisations & Ventures focusing on logistics training and development may conduct a training programs and sessions for the local workers as their CSR activity
- Training & knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce
- Investment by Government agencies like NHB, NCCD, and NSDC on training
- Mandatory training and certification emphasising the setting of benchmarks and standards
- Development of infrastructure for improving agronomic practices and technologies
- Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners (farmers, workers and other stakeholders)

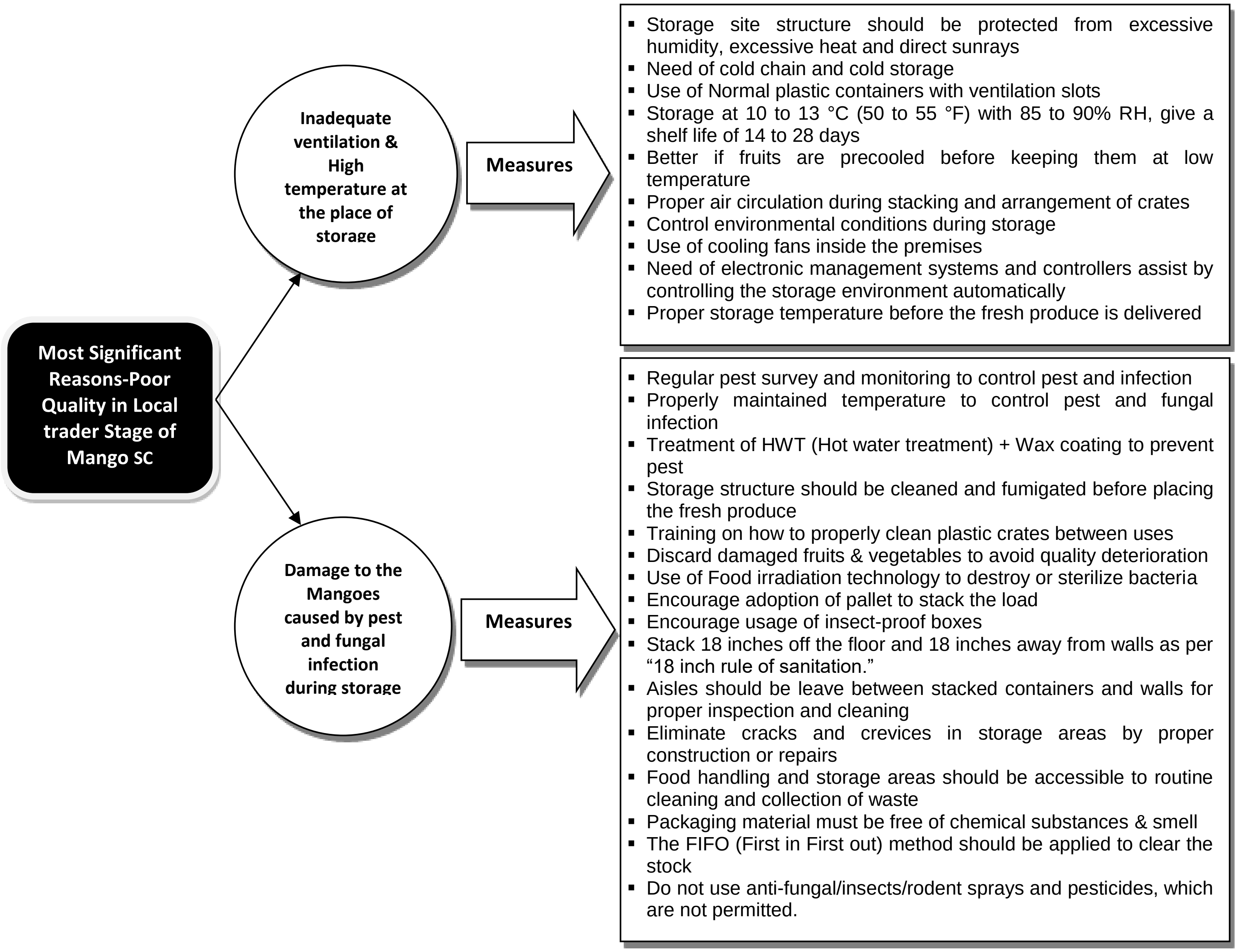



**Figure 5.27: Measures to improve SC Efficiency (with respect to Quality) in Local trader/Middlemen Stage of Mango SC**

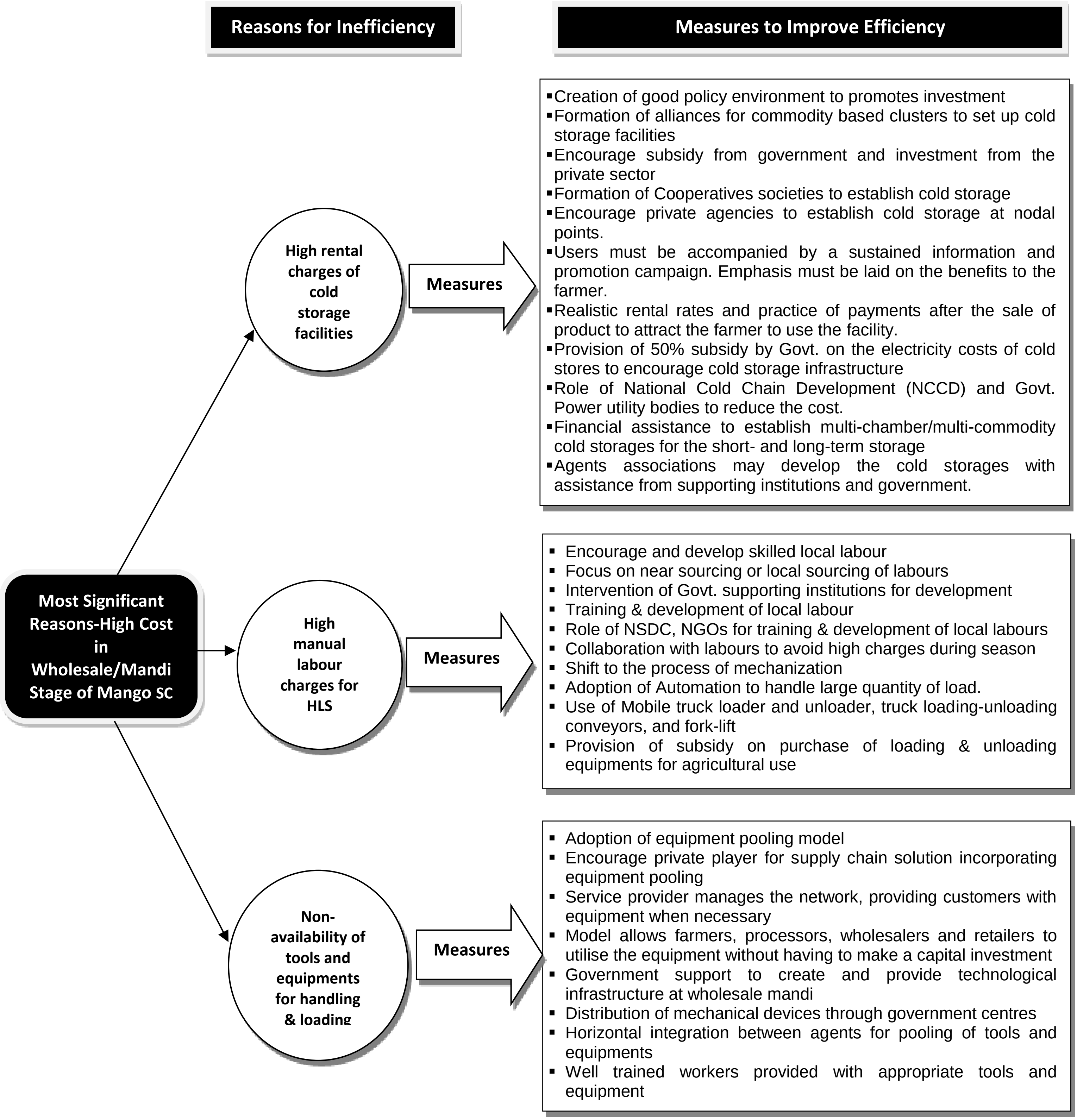



**Figure 5.28: Measures to improve SC Efficiency (with respect to Cost) in Wholesale/Mandi Stage of Mango SC**

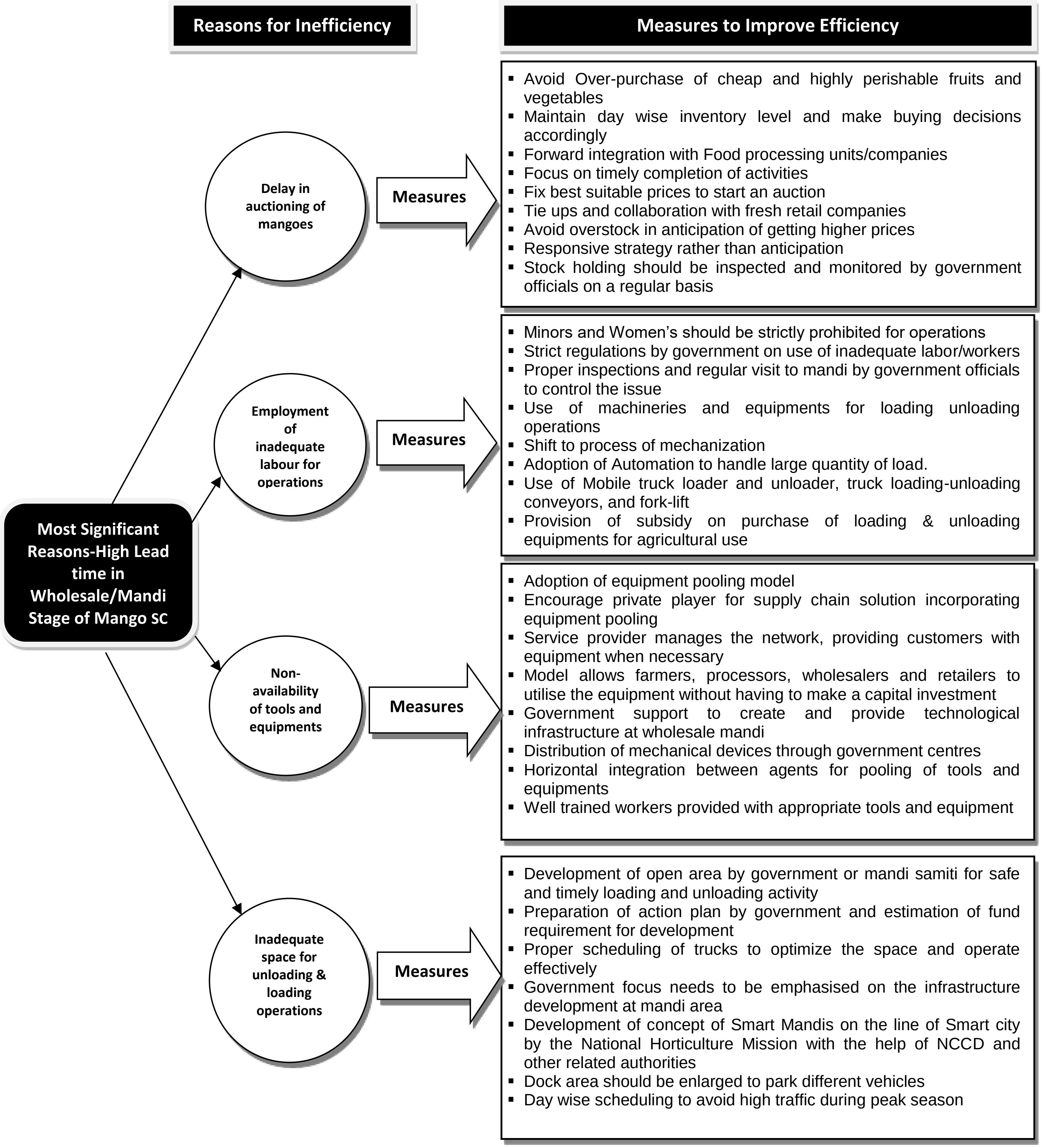



**Figure 5.29: Measures to improve SC Efficiency (with respect to Time) in Wholesale/Mandi Stage of Mango SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-Poor Quality in Wholesale/Mandi Stage of Mango SC**

**Damage to the Mangoes caused by pest and fungal infection during storage** → **Measures**

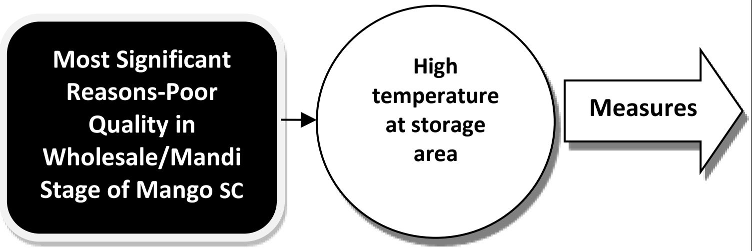
- Regular pest survey and monitoring to control pest and infection
- Properly maintained temperature to control pest and fungal infection
- Treatment of HWT (Hot water treatment) + Wax coating to prevent pest
- Storage structure should be cleaned and fumigated before placing the fresh produce
- Training on how to properly clean plastic crates between uses
- Discard damaged fruits & vegetables to avoid quality deterioration
- Use of Food irradiation technology to destroy or sterilize bacteria
- Encourage adoption of pallet to stack the load
- Encourage usage of insect-proof boxes
- Stack 18 inches off the floor and 18 inches away from walls as per "18 inch rule of sanitation."
- Aisles should be leave between stacked containers and walls for proper inspection and cleaning
- Eliminate cracks and crevices in storage areas by proper construction or repairs
- Food handling and storage areas should be accessible to routine cleaning and collection of waste
- Packaging material must be free of chemical substances & smell
- The FIFO (First in First out) method should be applied to clear the stock
- Do not use anti-fungal/insects/rodent sprays and pesticides, which are not permitted.

**Lack of cold storage facilities** → **Measures**

- Concept of Top Icing/Contact Icing can be applied for short term storage which would result in quicker cooling
- Optimum temperature for crop as quickly as possible
- Need of cold chain network from farm to point of sale
- Access to low-cost handling and storage technologies (e.g., evaporative coolers, storage bags, crates)
- Use of Zero energy cool chamber/Evaporative coolers to extend the shelf life of food and avoid spoilage
- Encourage APMC and other agencies to develop cold storage facilities at wholesale market
- Realistic rental rates and payments after the sale of product to attract the users to use the facility
- Use of Low-cost, low-energy, environmental friendly cool chambers made from locally available materials
- Room cooling technique consisting refrigeration unit
- Use of Night ventilation technique where variation between day and night temperatures can be used to keep stores cool
- Subsidy by government on the cost of building cold-storage
- Focus on development of micro cold chain solutions
- Need of Good policy environment promoting investment and formation of alliances/commodity based clusters
- Establish multi- chamber/ multi- commodity cold storage

**Non-availability of skilled labour for unloading** → **Measures**

- Proper handling and safety of produce should be the prime importance
- Conduct skill development and capacity building programmes in association with NSDC
- Develop information materials and disseminate to the workers and stakeholders
- Academic organisations & Ventures focusing on logistics training and development may conduct a training programs and sessions for the local workers as their CSR activity
- Training & knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce
- Investment by Government agencies like NHB, NCCD, and NSDC on training
- Mandatory training and certification emphasising the setting of benchmarks and standards
- Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners (farmers, workers and other stakeholders)




- Storage site structure should be protected from excessive humidity, excessive heat and direct sunrays
- Need of cold chain and cold storage
- Use of Normal plastic containers with ventilation slots
- Storage at 10 to 13 °C (50 to 55 °F) with 85 to 90% RH, give a shelf life of 14 to 28 days
- Better if fruits are precooled before keeping them at low temperature
- Proper air circulation during stacking and arrangement of crates
- Control environmental conditions during storage
- Use of cooling fans inside the premises
- Need of electronic management systems and controllers assist by controlling the storage environment automatically
- Proper storage temperature before the fresh produce is delivered

**Figure 5.30: Measures to improve SC Efficiency (with respect to Quality) in Wholesale/Mandi Stage of Mango SC**

**Reasons for Inefficiency**

**Measures to Improve Efficiency**

**Most Significant Reasons-High Cost in Local Trader/Mashakhor Stage of Mango SC**

**Non-usage of Sorting & Grading Technology** → **Measures**

- Grading machinery should be used to reduce manpower
- Development of mini pack houses at mandi areas
- Development of sorting & grading facilities at mandi
- Support from Government & Supporting institutions for development
- Sharing practices between the users and Cooperative societies
- Technology intensive processing units with assistance from NHB, MoFPI, and ADB
- Subsidy on the purchase of grading and packaging machineries
- Encourage to use technological advanced equipments to reduce operational cost
- Try to minimise manual process in the supply chain
- Development by cooperatives or associations with the help of government support
- Primary processing units focusing on sorting machineries, auto-grading equipments on the basis of size, and colours

**Damage to crates/box while unloading** → **Measures**

- Use of plastic or paper corner tabs in corners of packages
- Package must be unloaded gently and handled with care
- Careful instructions on the correct method of handling and unloading, and maintenance of crates
- Performance of each worker should be checked
- Sufficient mechanical strength of the package to protect the contents
- Unsuitable quality packaging materials (large sacks, rough wooden boxes, second-hand cartons, bamboo baskets, or rattan containers) should not be used
- Avoid purchasing cheapest and most readily available containers
- Prefer unit load to handle the produce rather handling individually
- Awareness on proper handling system management
- Training, seminars by National Productivity Council or State Productivity Council
- Develop information materials and disseminate to the workers, stakeholders for better operations
- Packages should not be dumped and thrown during unloading
- Investment by bodies like NHB, NCCD, and NSDC on training
- Constant and strict supervision to prevent careless handling
- Guidelines with pictures and diagrams for easy understanding & learning of general principles and specific techniques
- Use of unloading aids such as, roller conveyors, pallet or forklift to reduce the handling of individual packages

**High rental charges of cold storage facilities** → **Measures**

- Creation of good policy environment to promotes investment
- Formation of alliances for commodity based clusters to set up cold storage facilities
- Encourage subsidy from government and investment from the private sector
- Formation of Cooperatives societies to establish cold storage
- Encourage private agencies to establish cold storage at nodal points.
- Users must be accompanied by a sustained information and promotion campaign. Emphasis must be laid on the benefits to the farmer.
- Realistic rental rates and practice of payments after the sale of product to attract the users to use the facility.
- Provision of 50% subsidy by Govt. on the electricity costs of cold stores to encourage cold storage infrastructure
- Role of National Cold Chain Development (NCCD) and Govt. Power utility bodies to reduce the cost.
- Financial assistance to establish multi-chamber/multi-commodity cold storages for the short- and long-term storage
- Development of cold storages by Agents associations with assistance from supporting institutions

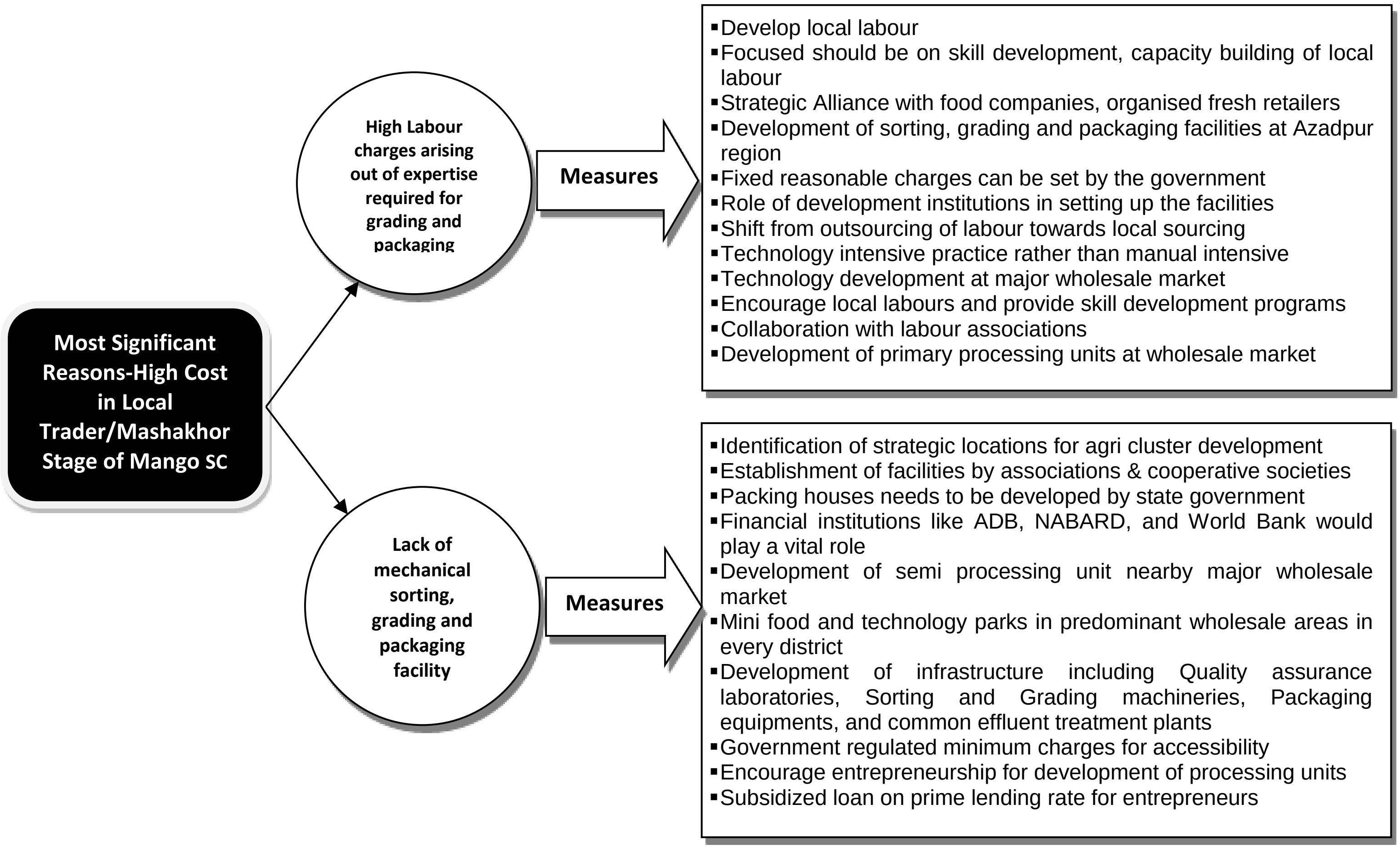



**Figure 5.31: Measures to improve SC Efficiency (with respect to Cost) in Local trader/Mashakhor Stage of Mango**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High Lead time in Local Trader/Mashakhor Stage of Mango SC**

**Non-availability of skilled labour for sorting & grading** → **Measures**

- Conduct skill development and capacity building programmes in association with NSDC
- Develop information materials and disseminate to the workers and stakeholders
- Training programs and sessions by academic organisation for the local workers as their CSR activity
- Training & knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce
- Ventures focusing on logistics training and development can also provide training to labors/workers as a CSR activity
- Investment by Government agencies like NHB, NCCD, and NSDC on training
- Mandatory training and certification emphasising the setting of benchmarks and standards
- Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners

**Manual sorting, grading & packaging** → **Measures**

- Development of mini food parks nearby wholesale region
- Availability and access to semi processing units
- Development of Fruits pack houses with assistance from horticulture department
- Encourage entrepreneurs and private players to set up processing facilities and packing houses
- Technology intensive practice rather than labour intensive
- Formation of associations or cooperative societies for development of technological facilities
- Strict control and supervision of the manual operations
- Access near-by facilities for grading & packaging operations
- Need of Research & Development on cost efficient technology for sorting & grading operations

**Lack of sorting & grading technology** → **Measures**

- Development of advanced cluster based technological food parks
- Development of semi processing units near major production belt
- Cooperative societies & Farmers associations would play an important role
- Linkage of trader with processing and organised marketing
- NGOs may play an important role in getting the linkages
- Establishment of mini food parks & packing houses by state government at major production areas
- Encourage entrepreneurship and private participation to establish processing units
- Financial Assistance to entrepreneur in the form of subsidy and prime lending rates

**Poor information regarding market demand** → **Measures**

- Adequate time to keep the produce without decline in value
- Continuous and Transparent communication between the stakeholders
- Establishment of National/Regional information networking system
- Mobile Application for continuous information regarding demand and production
- Improve supply chain communications
- Proper coordination with suppliers and customers
- Actual information regarding market demand for quick movement
- Supply Chain Collaboration to improve communications
- Need for high level of trust among the supply chain partners
- The ideal transfer point must be determined before starting the ripening process
- Procurement based on actual market demand, not in anticipation
- Pull based supply chain rather than push supply chain
- Concept of Just in Time (JIT) can be applied as the distance between the partners is short
- ICT Portal to provide market information
- Updates on local, state and national level market information by Market Committees and Marketing Boards

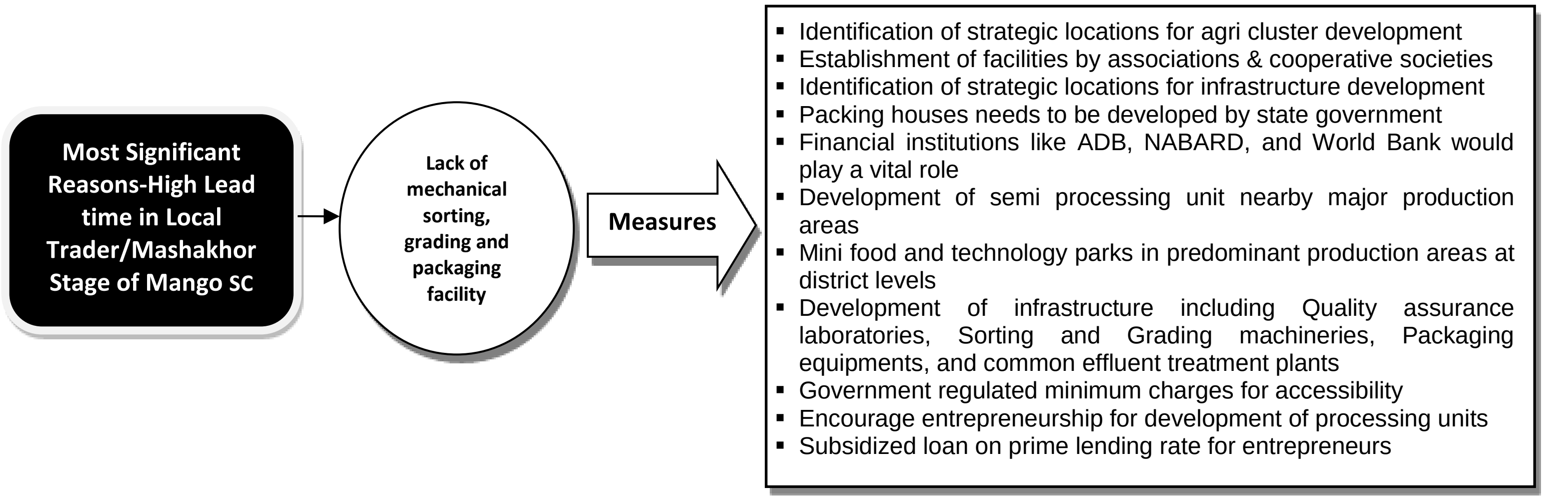



**Figure 5.32: Measures to improve SC Efficiency (with respect to Time) in Local trader/Mashakhor Stage of Mango SC**

| Reasons for Inefficiency | Measures to Improve Efficiency |
|---|---|

**Most Significant Reasons-Poor Quality in Local Trader/Mashakhor Stage of Mango SC**

**Lack of proper and uniform grading which hinder to achieve uniform ripening** → **Measures**

- Do not mixed up fresh produce with the fully ripe or three-quarters ripe produce
- Separate different varieties if they are distinguishable
- Remove deformed produce and those with splits, punctures and incipient rotting from the lot
- Remove traces of chemicals before sorting & grading
- Produce must be categorised and graded uniformly as per the quality
- Close attention under good lighting and strict supervision and monitoring
- Sorting & grading on the basis of maturity, size, shape, colour, weight, freedom from insects and pests, pesticide residues and ripeness
- Disseminate agency wise and state wise grading parameters developed by support institutions and horticulture board
- Uniform contents and contain only mangoes of the same origin, variety, quality and size
- Training on categorisation, selection and placing the produce gently
- Place examples of the smallest and largest acceptable size for easy reference
- Set commonly accepted Quality and Standards along the lines of India GAP proposed by APDEA
- Remove unmarketable pieces or unripe/overripe mangoes in preliminary sorting

**Non-availability of cooling shed** → **Measures**

- A temporary tent must be constructed from large tarpaulins or plastic sheets
- Use of fans to recirculate the air through the produce while storing
- Encourage and promote public private partnerships to invest in infrastructure
- Develop controlled atmosphere cold storage facilities
- Establish cooling shed to keep mangoes for further processing
- Assistance from National Horticulture Board, NCCD and other supporting institution
- Financial assistant from government to build cooling shed or procure the material on a concessional rate
- Action plan by government and estimate requirements of funds for building cooling sheds at mandis

**High temperature at Storage area** → **Measures**

- Storage site structure should be protected from excessive humidity, excessive heat and direct sunrays
- Need of cold chain and cold storage
- Use of Normal plastic containers with ventilation slots
- Storage at 10 to 13 °C (50 to 55 °F) with 85 to 90% RH, give a shelf life of 14 to 28 days
- Better if fruits are precooled before keeping them at low temperature
- Proper air circulation during stacking and arrangement of crates
- Control environmental conditions during storage
- Use of cooling fans inside the premises
- Need of electronic management systems and controllers assist by controlling the storage environment automatically
- Proper storage temperature before the fresh produce is delivered

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-Poor Quality in Local Trader/Mashakhor Stage of Mango SC**

**Inadequate and non-availability of timely demand information** → **Measures**

- Adequate time to keep the produce without decline in value
- Continuous and Transparent communication between the stakeholders
- Establishment of National/Regional information networking system
- Mobile Application for continuous information regarding demand and production
- Improve supply chain communications
- Proper coordination with suppliers and customers
- Actual information regarding market demand for quick movement
- Supply Chain Collaboration to improve communications
- Need for high level of trust among the supply chain partners
- Determination of ideal transfer point before starting the ripening process
- Procurement based on actual market demand, not in anticipation
- Pull based supply chain rather than push supply chain
- Concept of Just in Time (JIT) can be applied as the distance between the trade partners is short
- ICT Portal to provide market information
- Updates on local, state and national level market information by Market Committees and Marketing Boards

**Inadequate equipment and ripening method** → **Measures**

- Primary aim on improving the quality rather than appearance for sales
- Use of equipment fitted with aroma sensors for postharvest measurement of fruit ripeness
- Calcium Carbide should not be used for ripening
- Treat the fruits with ethylene gas (100 ppm) in airtight room by exposing them for 24–48 hrs. under controlled conditions of temperature and humidity
- Dip treatment of ethrel/ ethephon solution (250 –750 ppm) in hot water (52±20C) for 5 minutes
- Premature fruits can be ripened to an acceptance quality by dipping the fruits in 750-ppm ethrel solution
- Less mature and mature fruits can be ripened by dipping the fruits in 500 and 250-ppm ethrel solution
- Encourage stakeholders for the use of ripening chambers
- Ripening chamber helps maintain precise conditions specific to the product's requirement
- Use of ripening chambers results in less food wastage and higher price realization
- Hold the fruit in the temperature range 20oc to 23oc. It provides the best appearance, palatability and decay control
- Research & Development by knowledge supporting institutions on equipments

**Non-availability of skilled labour for unloading** → **Measures**

- Proper handling and safety of produce should be the prime importance
- Conduct skill development and capacity building programmes in association with NSDC
- Develop information materials and disseminate to the workers and stakeholders
- Academic organisations & Ventures focusing on logistics training and development may conduct a training programs and sessions for the local workers as their CSR activity
- Training & knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce
- Investment by Government agencies like NHB, NCCD, and NSDC on training
- Mandatory training and certification emphasising the setting of benchmarks and standards
- Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners (farmers, workers and other stakeholders)

**Figure 5.33: Measures to improve SC Efficiency (with respect to Quality in Local trader/Mashakhor Stage of Mango**

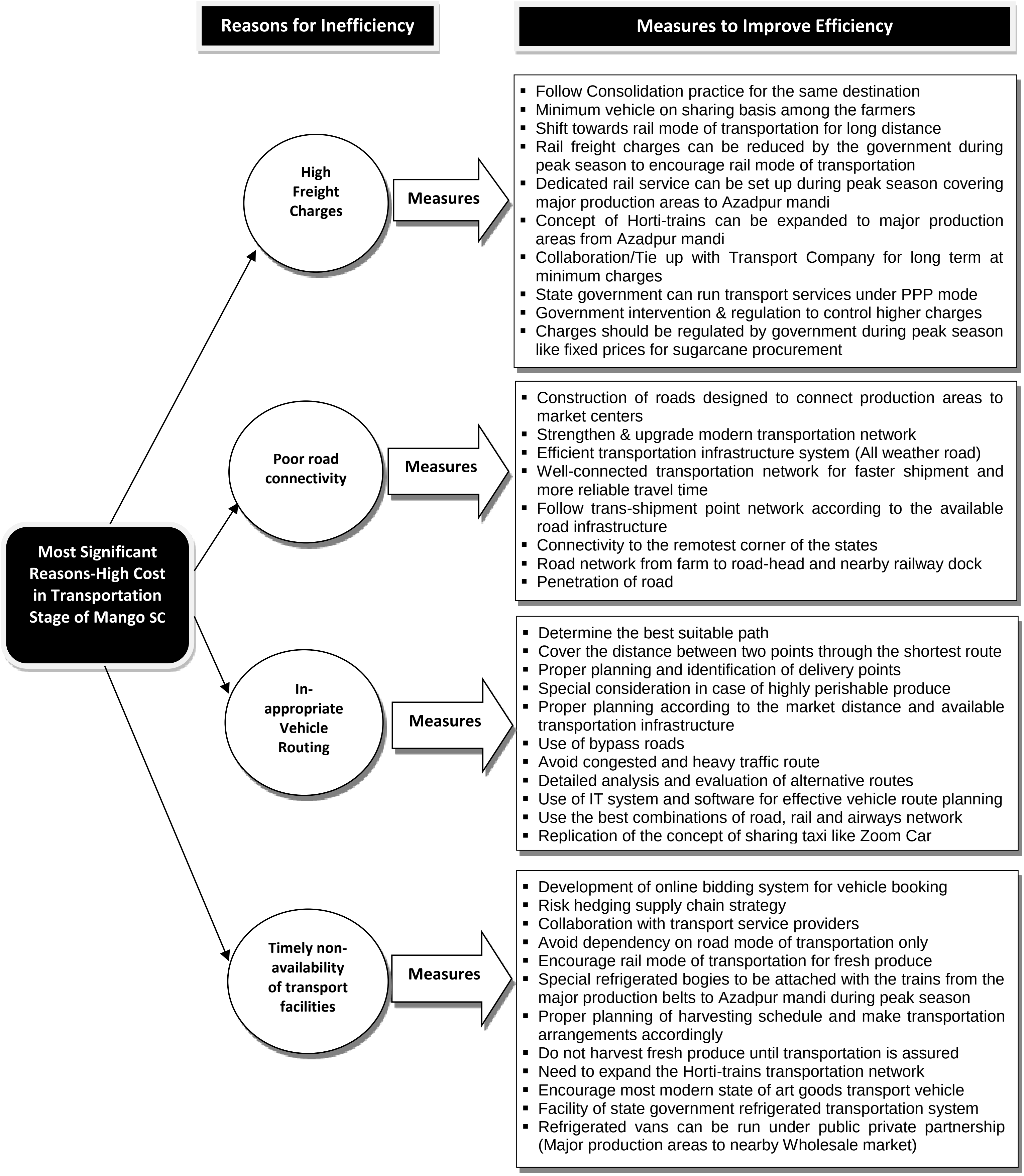
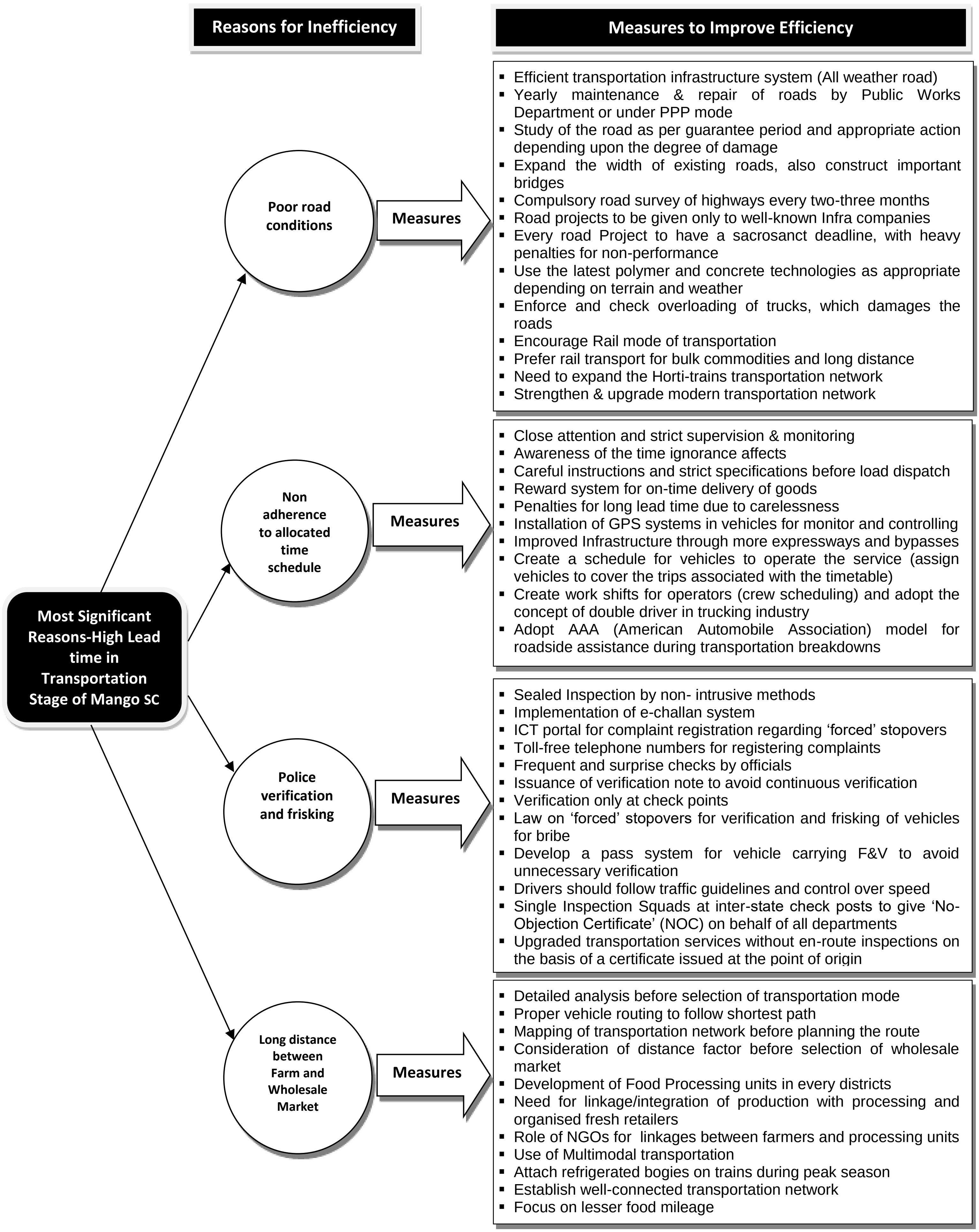



**Figure 5.34: Measures to improve SC Efficiency (with respect to Cost) in Transportation Stage of Mango SC**


Reasons for Inefficiency
Measures to Improve Efficiency
Most Significant Reasons-High Lead time in Transportation Stage of Mango SC
Poor road conditions
Measures
▪ Efficient transportation infrastructure system (All weather road)
▪ Yearly maintenance & repair of roads by Public Works Department or under PPP mode
▪ Study of the road as per guarantee period and appropriate action depending upon the degree of damage
▪ Expand the width of existing roads, also construct important bridges
▪ Compulsory road survey of highways every two-three months
▪ Road projects to be given only to well-known Infra companies
▪ Every road Project to have a sacrosanct deadline, with heavy penalties for non-performance
▪ Use the latest polymer and concrete technologies as appropriate depending on terrain and weather
▪ Enforce and check overloading of trucks, which damages the roads
▪ Encourage Rail mode of transportation
▪ Prefer rail transport for bulk commodities and long distance
▪ Need to expand the Horti-trains transportation network
▪ Strengthen & upgrade modern transportation network
Non adherence to allocated time schedule
Measures
▪ Close attention and strict supervision & monitoring
▪ Awareness of the time ignorance affects
▪ Careful instructions and strict specifications before load dispatch
▪ Reward system for on-time delivery of goods
▪ Penalties for long lead time due to carelessness
▪ Installation of GPS systems in vehicles for monitor and controlling
▪ Improved Infrastructure through more expressways and bypasses
▪ Create a schedule for vehicles to operate the service (assign vehicles to cover the trips associated with the timetable)
▪ Create work shifts for operators (crew scheduling) and adopt the concept of double driver in trucking industry
▪ Adopt AAA (American Automobile Association) model for roadside assistance during transportation breakdowns
Police verification and frisking
Measures
▪ Sealed Inspection by non- intrusive methods
▪ Implementation of e-challan system
▪ ICT portal for complaint registration regarding ‘forced’ stopovers
▪ Toll-free telephone numbers for registering complaints
▪ Frequent and surprise checks by officials
▪ Issuance of verification note to avoid continuous verification
▪ Verification only at check points
▪ Law on ‘forced’ stopovers for verification and frisking of vehicles for bribe
▪ Develop a pass system for vehicle carrying F&V to avoid unnecessary verification
▪ Drivers should follow traffic guidelines and control over speed
▪ Single Inspection Squads at inter-state check posts to give ‘No-Objection Certificate’ (NOC) on behalf of all departments
▪ Upgraded transportation services without en-route inspections on the basis of a certificate issued at the point of origin
Long distance between Farm and Wholesale Market
Measures
▪ Detailed analysis before selection of transportation mode
▪ Proper vehicle routing to follow shortest path
▪ Mapping of transportation network before planning the route
▪ Consideration of distance factor before selection of wholesale market
▪ Development of Food Processing units in every districts
▪ Need for linkage/integration of production with processing and organised fresh retailers
▪ Role of NGOs for linkages between farmers and processing units
▪ Use of Multimodal transportation
▪ Attach refrigerated bogies on trains during peak season
▪ Establish well-connected transportation network
▪ Focus on lesser food mileage

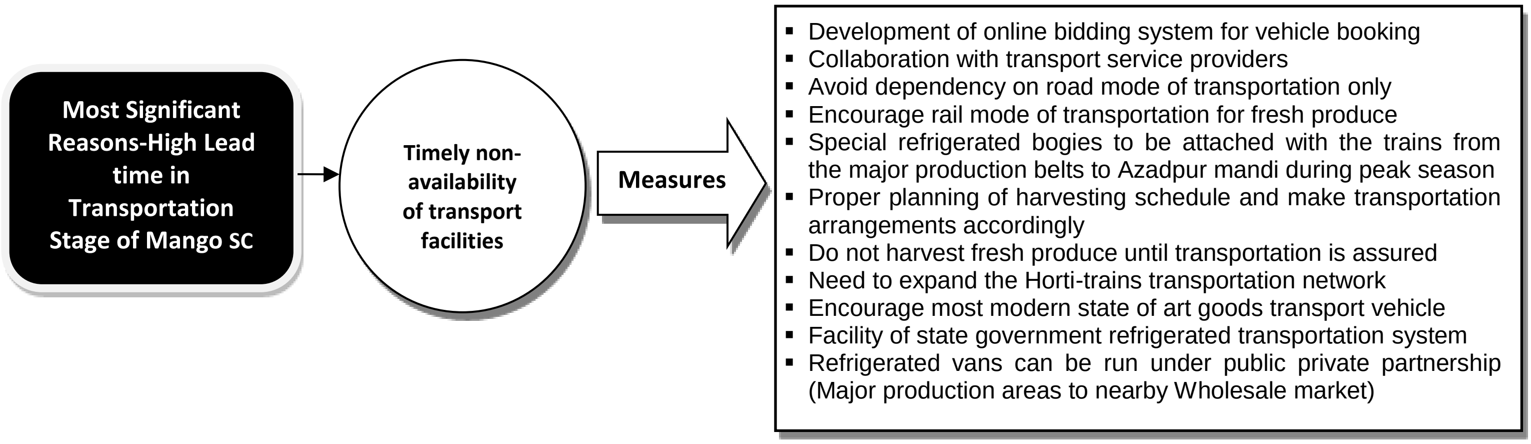
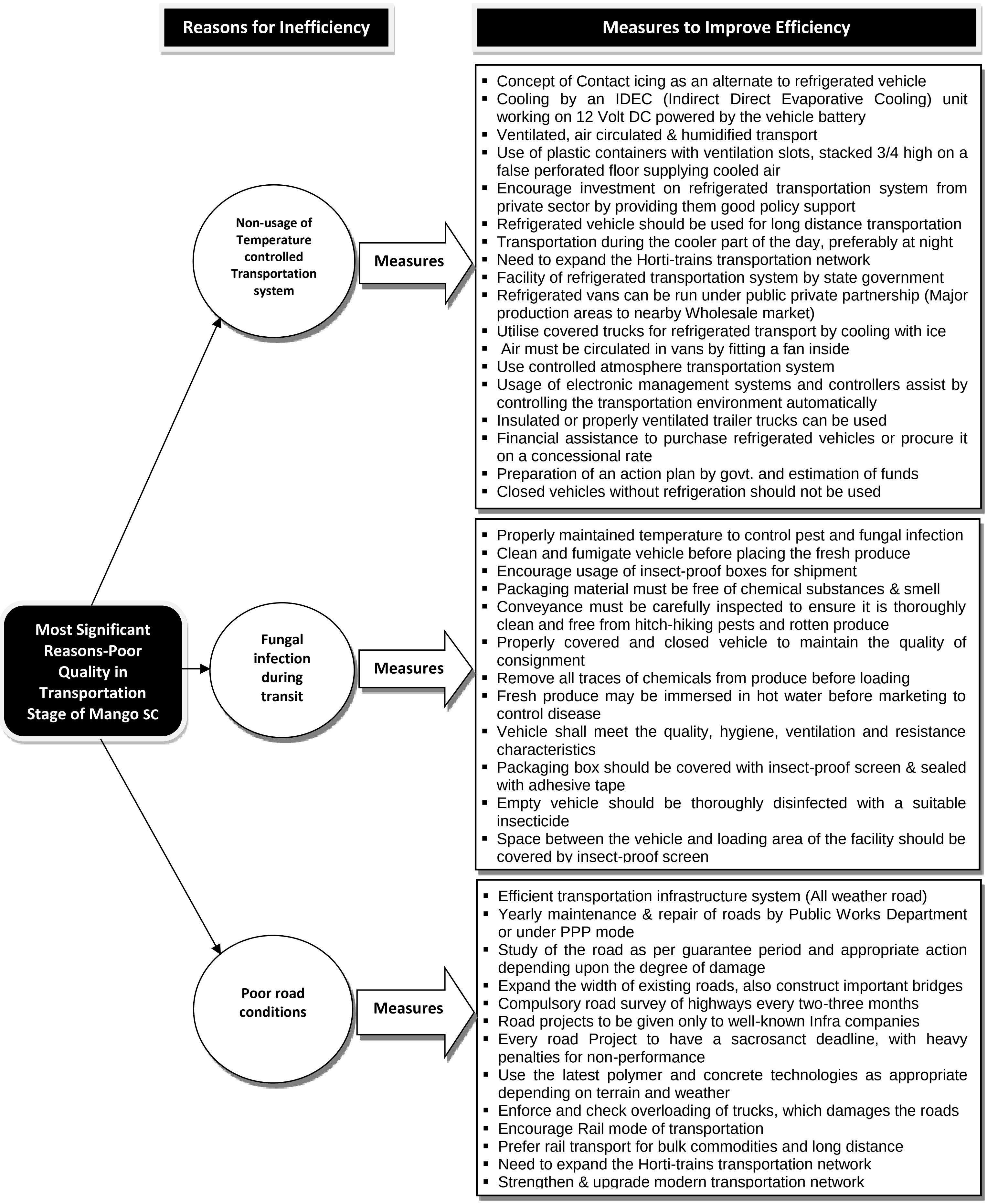



**Figure 5.35: Measures to improve SC Efficiency (with respect to Time) in Transportation Stage of Mango SC**


Reasons for Inefficiency
Measures to Improve Efficiency
Most Significant Reasons-Poor Quality in Transportation Stage of Mango SC
Non-usage of Temperature controlled Transportation system
Measures
▪ Concept of Contact icing as an alternate to refrigerated vehicle
▪ Cooling by an IDEC (Indirect Direct Evaporative Cooling) unit working on 12 Volt DC powered by the vehicle battery
▪ Ventilated, air circulated & humidified transport
▪ Use of plastic containers with ventilation slots, stacked 3/4 high on a false perforated floor supplying cooled air
▪ Encourage investment on refrigerated transportation system from private sector by providing them good policy support
▪ Refrigerated vehicle should be used for long distance transportation
▪ Transportation during the cooler part of the day, preferably at night
▪ Need to expand the Horti-trains transportation network
▪ Facility of refrigerated transportation system by state government
▪ Refrigerated vans can be run under public private partnership (Major production areas to nearby Wholesale market)
▪ Utilise covered trucks for refrigerated transport by cooling with ice
▪ Air must be circulated in vans by fitting a fan inside
▪ Use controlled atmosphere transportation system
▪ Usage of electronic management systems and controllers assist by controlling the transportation environment automatically
▪ Insulated or properly ventilated trailer trucks can be used
▪ Financial assistance to purchase refrigerated vehicles or procure it on a concessional rate
▪ Preparation of an action plan by govt. and estimation of funds
▪ Closed vehicles without refrigeration should not be used
Fungal infection during transit
Measures
▪ Properly maintained temperature to control pest and fungal infection
▪ Clean and fumigate vehicle before placing the fresh produce
▪ Encourage usage of insect-proof boxes for shipment
▪ Packaging material must be free of chemical substances & smell
▪ Conveyance must be carefully inspected to ensure it is thoroughly clean and free from hitch-hiking pests and rotten produce
▪ Properly covered and closed vehicle to maintain the quality of consignment
▪ Remove all traces of chemicals from produce before loading
▪ Fresh produce may be immersed in hot water before marketing to control disease
▪ Vehicle shall meet the quality, hygiene, ventilation and resistance characteristics
▪ Packaging box should be covered with insect-proof screen & sealed with adhesive tape
▪ Empty vehicle should be thoroughly disinfected with a suitable insecticide
▪ Space between the vehicle and loading area of the facility should be covered by insect-proof screen
Poor road conditions
Measures
▪ Efficient transportation infrastructure system (All weather road)
▪ Yearly maintenance & repair of roads by Public Works Department or under PPP mode
▪ Study of the road as per guarantee period and appropriate action depending upon the degree of damage
▪ Expand the width of existing roads, also construct important bridges
▪ Compulsory road survey of highways every two-three months
▪ Road projects to be given only to well-known Infra companies
▪ Every road Project to have a sacrosanct deadline, with heavy penalties for non-performance
▪ Use the latest polymer and concrete technologies as appropriate depending on terrain and weather
▪ Enforce and check overloading of trucks, which damages the roads
▪ Encourage Rail mode of transportation
▪ Prefer rail transport for bulk commodities and long distance
▪ Need to expand the Horti-trains transportation network
▪ Strengthen & upgrade modern transportation network

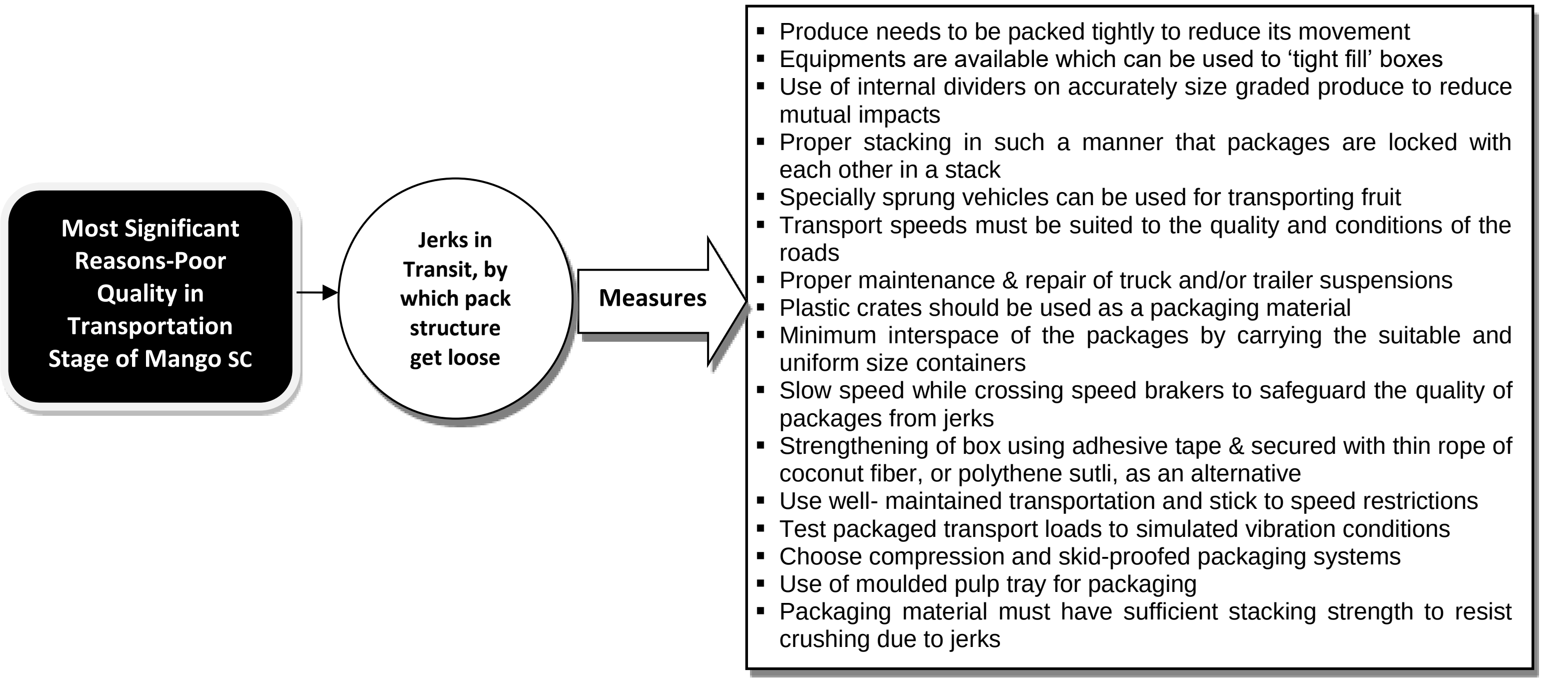



**Figure 5.36: Measures to improve SC Efficiency (with respect to Quality) in Transportation Stage of Mango**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High Cost in Farm Stage of Tomato SC**

**Large number of Labour required for carriage activity** → Measures

- Follow mechanization process to carry produce from farm to the place of aggregation
- Involvement of Agriculture supporting institution for research on new methods/techniques for carriage
- Need of technology intervention/ innovation
- Use of Mechanical cableways to move the produce
- Use of Hand cart to move the produce to the collection area
- Installation of ropeways trolleys to facilitate farmers
- Identification of spot/location for installation as per major production belt
- Need of technical support from knowledge support institutions
- Proper planning of manpower requirement
- Proper utilisation of manpower resources
- Use of cattle to carry the produce

**High labour charges for carriage** → Measures

- Encourage and develop skilled local labour
- Focus on near or local sourcing of labours
- Intervention of Govt. supporting institutions for development
- Training & development of local labour
- Role of NSDC, NGOs for training & development
- Shift to process of mechanization.
- Use Mechanical cableways
- Shift to local sourcing instead of outsourcing at higher cost
- Use of cattle for hilly terrain

**Poor farm connectivity by road** → Measures

- Construction of roads designed to connect major production areas to market centers
- Use of conveyor equipment
- Installation of ropeways trolleys to facilitate farmers
- Use of small carts depending upon the condition of path
- Government intervention on development of infrastructure
- Expand rural connectivity through the rehabilitation of roads
- Upgrade rural link roads
- Investment in roads
- Development of financing models- including a public-private partnership at the local level

**Manual operations for Handling, Loading and Stacking** → Measures

- Use of loading aids such as trolleys, roller conveyors, pallet or forklift trucks where possible
- Introduction of palletization
- Shift to the process of mechanization
- Adoption of Automation practices to handle large quantity of load.
- Use of mechanical loading and unloading
- Use of Mobile truck loader and unloader
- Use of Unit load to handle the produce pallets rather than handling individual containers
- Support from agriculture department
- Provision of subsidy on purchase of loading & unloading equipments for agricultural use
- Reduce the number of manpower involved in operations
- Proper planning of manpower as per the actual requirement
- Sharing manpower between the farmers
- Adopt equipment pooling model

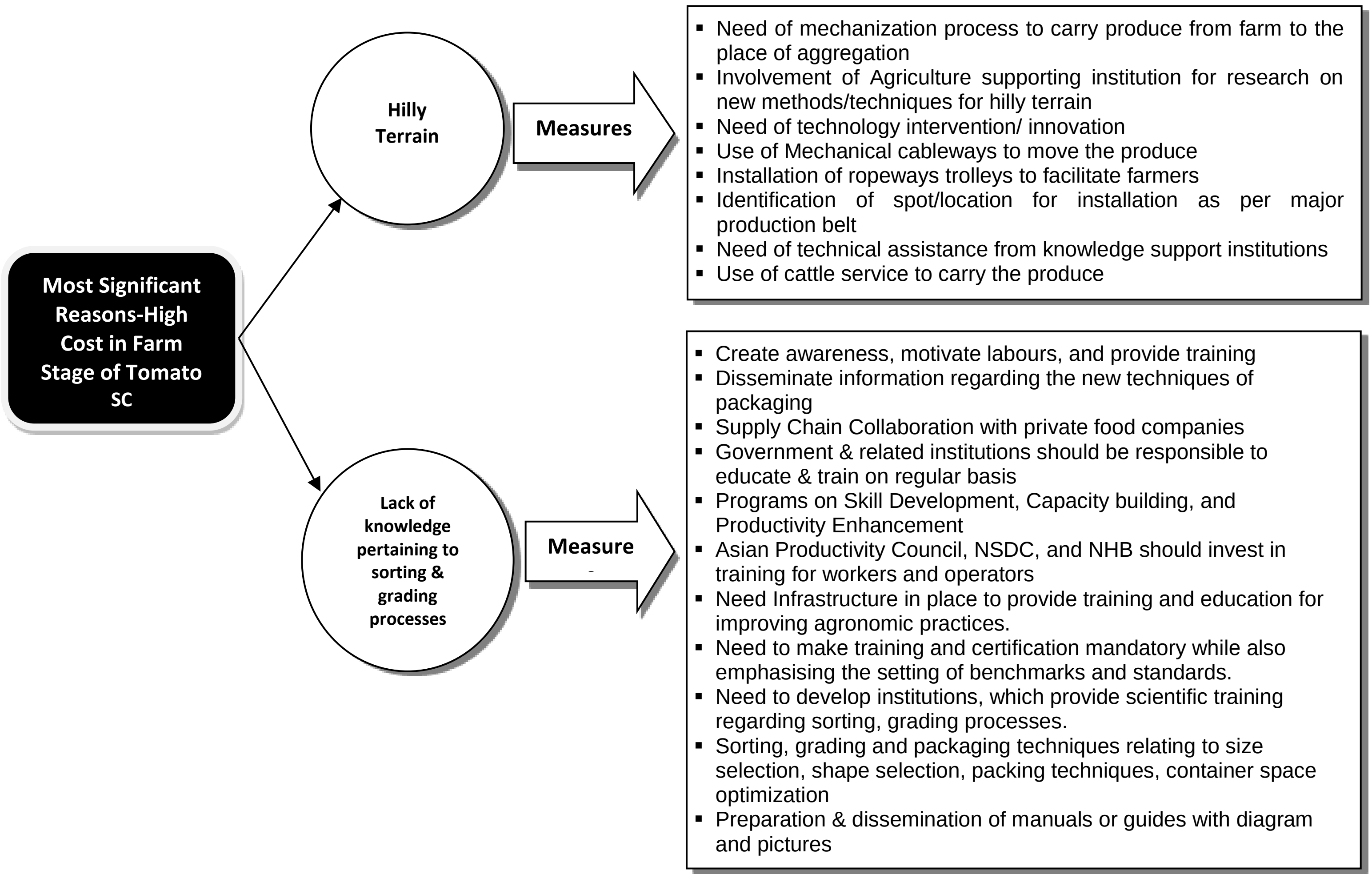



**Figure 5.37: Measures to improve SC Efficiency (with respect to Cost) in Farm Stage of Tomato SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High Lead Time in Farm Stage of Tomato SC**

**Manual sorting, grading & packaging** → **Measures**

- Development of mini food parks nearby the major production belt
- Availability and access to semi processing units
- Development of packing houses with assistance from horticulture department
- Encourage entrepreneurs and private players to set up processing facilities and packing houses
- Technology intensive practice rather than labour intensive
- Formation of associations or cooperative societies for development of technological facilities
- Strict control and supervision of the manual operations
- Access near-by facilities for grading & packaging operations
- Need of Research & Development on cost efficient technology for sorting & grading operations
- Policy to encourage private investors

**Non-availability of skilled labour for Sorting, Grading** → **Measures**

- Conduct skill development and capacity building programmes in association with NSDC
- Develop information materials and disseminate to the workers and stakeholders
- Academic organisations may conduct a training programs and sessions for the local workers as their CSR activity
- Training & knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce
- Ventures focusing on logistics training and development can also provide training to labours/workers as a CSR activity
- Investment by Government agencies like NHB, NCCD, and NSDC on training
- Mandatory training and certification emphasising the setting of benchmarks and standards
- Development of infrastructure for improving agronomic practices and technologies
- Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners (farmers, workers and other stakeholders).

**Poor condition of path used for carriage** → **Measures**

- Repair paths connecting farm and collection area
- Establishment of proper and well connectivity between farm and collection area
- Construct the paths before planning for harvesting operations
- Clear paths and the surface should not be uneven
- Strengthen & upgrade the paths connecting collection area
- Annual maintenance of paths used for carriage
- Government support for rural infrastructure development
- Role of Panchayats, Pradhan
- Encourage NGO for sustainable rural development

**Lack of sorting & grading technology** → **Measures**

- Development of advanced cluster based technological food parks
- Development of semi processing units in major production areas
- Cooperative societies & Farmers associations would play an important role
- Establishment of packing houses by Government
- Linkage of production with processing and organised marketing
- Horticulture experts/ officers at state level may advise farmers regarding the facilities
- NGOs may play an important role in getting the linkages
- Establishment of mini food parks by state government at major production areas
- Encourage entrepreneurship and private participation to establish processing units
- Financial Assistance to entrepreneur in the form of subsidy and prime lending rates

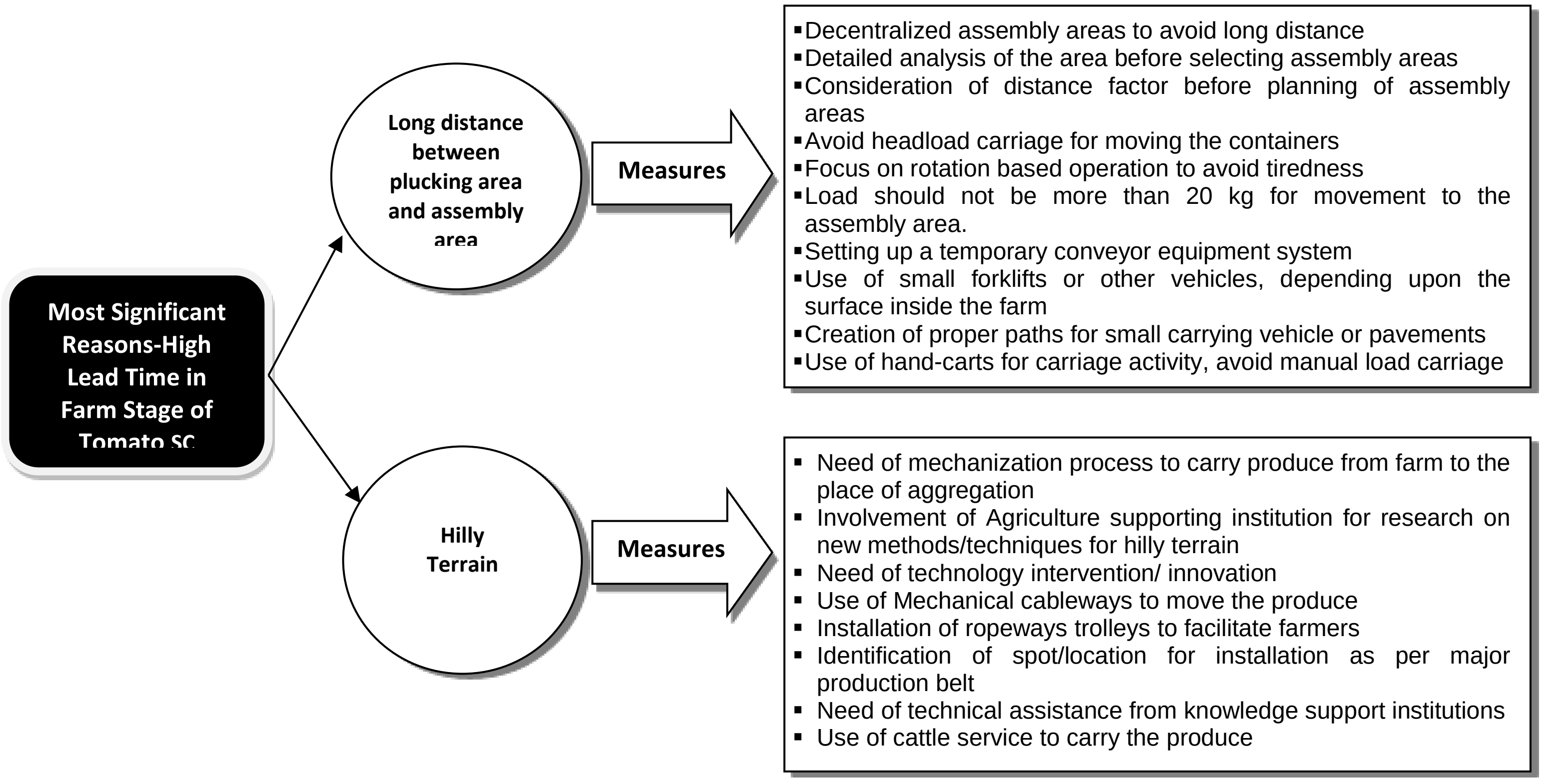
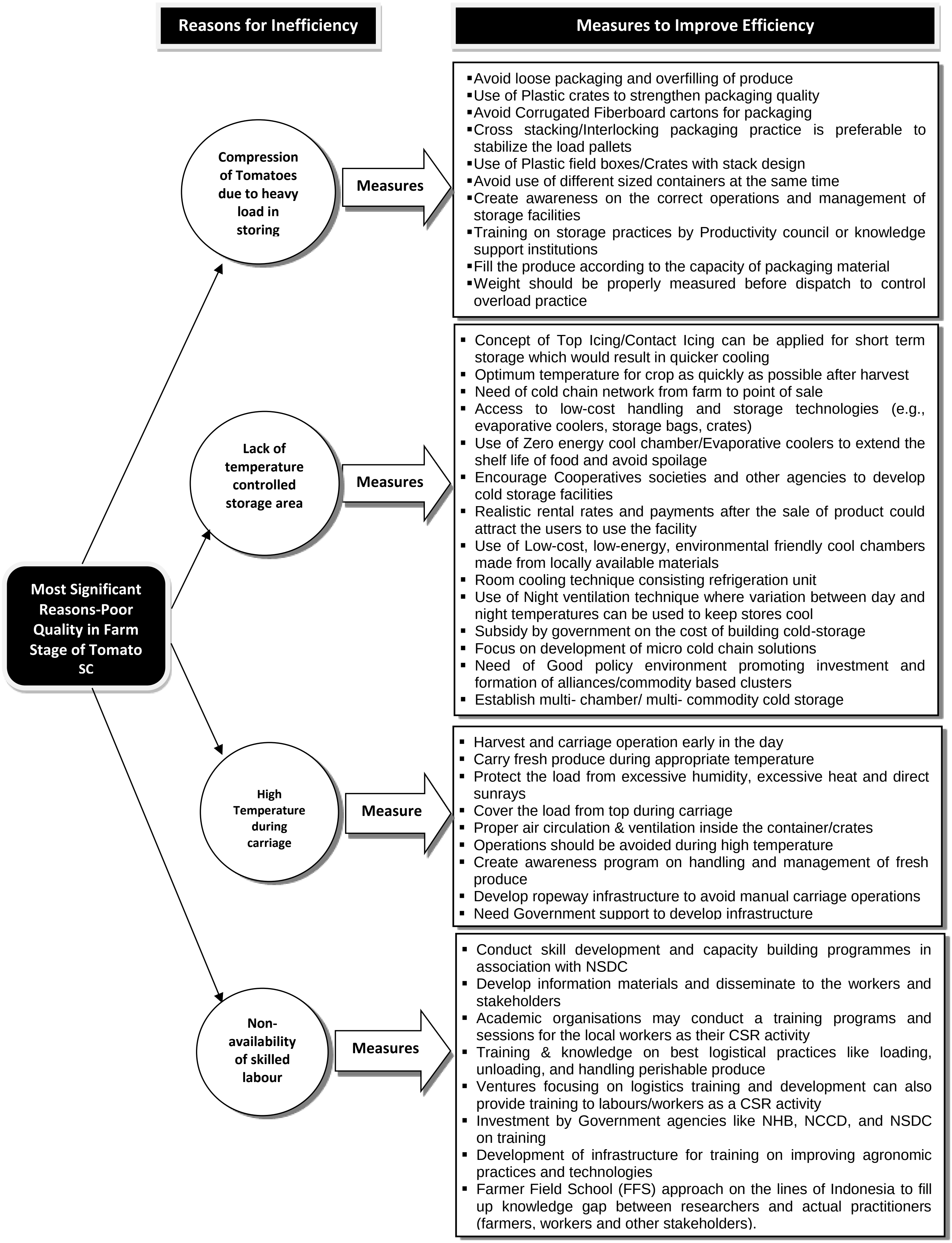



**Figure 5.38: Measures to improve SC Efficiency (with respect to Time) in Farm Stage of Tomato SC**


Reasons for Inefficiency
Measures to Improve Efficiency
Most Significant Reasons-Poor Quality in Farm Stage of Tomato SC
Compression of Tomatoes due to heavy load in storing
Measures
▪ Avoid loose packaging and overfilling of produce
▪ Use of Plastic crates to strengthen packaging quality
▪ Avoid Corrugated Fiberboard cartons for packaging
▪ Cross stacking/Interlocking packaging practice is preferable to stabilize the load pallets
▪ Use of Plastic field boxes/Crates with stack design
▪ Avoid use of different sized containers at the same time
▪ Create awareness on the correct operations and management of storage facilities
▪ Training on storage practices by Productivity council or knowledge support institutions
▪ Fill the produce according to the capacity of packaging material
▪ Weight should be properly measured before dispatch to control overload practice
Lack of temperature controlled storage area
Measures
▪ Concept of Top Icing/Contact Icing can be applied for short term storage which would result in quicker cooling
▪ Optimum temperature for crop as quickly as possible after harvest
▪ Need of cold chain network from farm to point of sale
▪ Access to low-cost handling and storage technologies (e.g., evaporative coolers, storage bags, crates)
▪ Use of Zero energy cool chamber/Evaporative coolers to extend the shelf life of food and avoid spoilage
▪ Encourage Cooperatives societies and other agencies to develop cold storage facilities
▪ Realistic rental rates and payments after the sale of product could attract the users to use the facility
▪ Use of Low-cost, low-energy, environmental friendly cool chambers made from locally available materials
▪ Room cooling technique consisting refrigeration unit
▪ Use of Night ventilation technique where variation between day and night temperatures can be used to keep stores cool
▪ Subsidy by government on the cost of building cold-storage
▪ Focus on development of micro cold chain solutions
▪ Need of Good policy environment promoting investment and formation of alliances/commodity based clusters
▪ Establish multi- chamber/ multi- commodity cold storage
High Temperature during carriage
Measure
▪ Harvest and carriage operation early in the day
▪ Carry fresh produce during appropriate temperature
▪ Protect the load from excessive humidity, excessive heat and direct sunrays
▪ Cover the load from top during carriage
▪ Proper air circulation & ventilation inside the container/crates
▪ Operations should be avoided during high temperature
▪ Create awareness program on handling and management of fresh produce
▪ Develop ropeway infrastructure to avoid manual carriage operations
▪ Need Government support to develop infrastructure
Non-availability of skilled labour
Measures
▪ Conduct skill development and capacity building programmes in association with NSDC
▪ Develop information materials and disseminate to the workers and stakeholders
▪ Academic organisations may conduct a training programs and sessions for the local workers as their CSR activity
▪ Training & knowledge on best logistical practices like loading, unloading, and handling perishable produce
▪ Ventures focusing on logistics training and development can also provide training to labours/workers as a CSR activity
▪ Investment by Government agencies like NHB, NCCD, and NSDC on training
▪ Development of infrastructure for training on improving agronomic practices and technologies
▪ Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners (farmers, workers and other stakeholders).

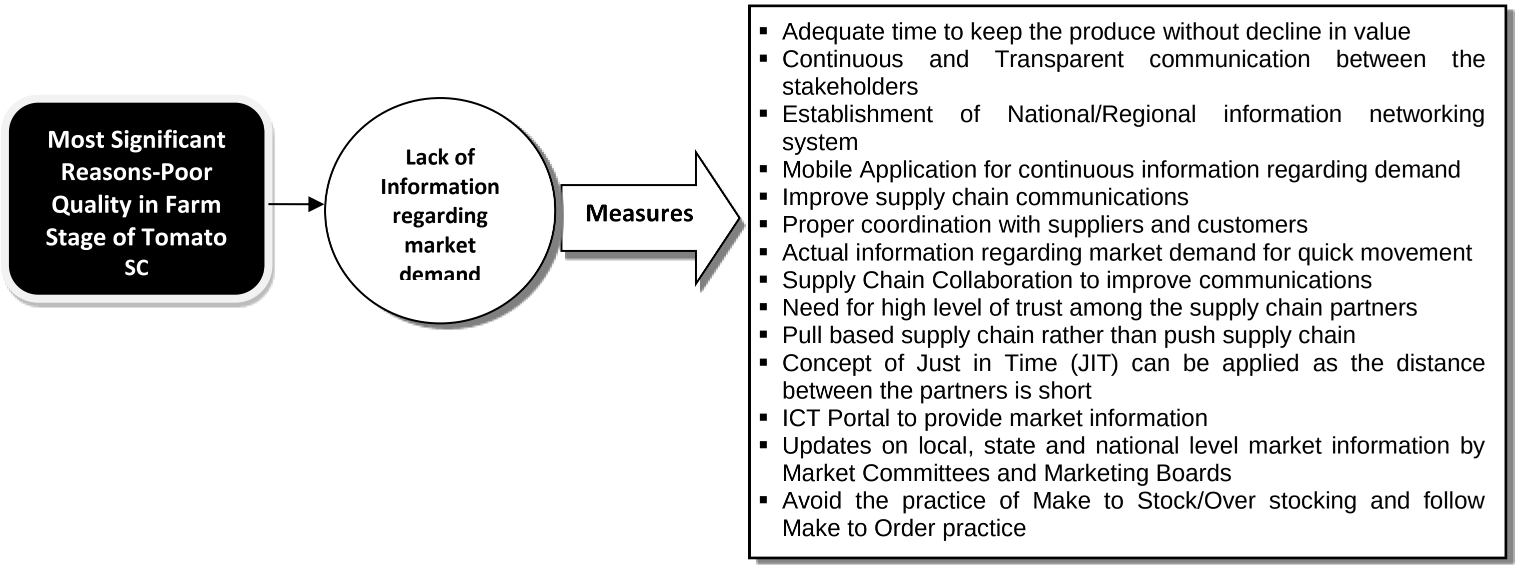



**Figure 5.39: Measures to improve SC Efficiency (with respect to Quality) in Farm Stage of Tomato SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High Cost in Local Mandi Stage of Tomato SC**

**High manual labour charges for HLS**

**Measures**

- Encourage and develop skilled local labour
- Focus on near sourcing or local sourcing of labours
- Intervention of Govt. supporting institutions for development
- Training & development of local labour
- Role of NSDC, NGOs for training & development of local labours
- Collaboration with labours to avoid high charges during season
- Shift to the process of mechanization
- Adoption of Automation to handle large quantity of load.
- Use of Mobile truck loader and unloader, truck loading-unloading conveyors, and fork-lift
- Provision of subsidy on purchase of loading & unloading equipments for agricultural use

**Large number of Labour required for HLS**

**Measures**

- Follow mechanization process for handling and loading
- Use of Loading aids such as trolleys, roller conveyors, pallet or forklift trucks
- Need of technology intervention/ innovation
- Need of technical support from knowledge support institutions
- Proper planning of manpower requirement
- Proper utilisation of manpower resources
- Introduction of palletization
- Use of Pallet boxes/unit load for efficient handling
- Automation processes at warehouses
- Smart Mandis on the line of Smart cities
- Use of mobile truck loader and unloader
- Availability of loading aids in customized specifications
- Institutional support for the purchase of mechanized loaders
- Adopt equipment pooling model/resource pooling model

**Damage to crates/boxes while unloading**

**Measures**

- Use of plastic or paper corner tabs in corners of packages
- Package must be unloaded gently and handled with care
- Careful instructions on the correct method of handling and unloading, and maintenance of crates
- Performance of each worker should be checked
- Sufficient mechanical strength of the package to protect the contents
- Unsuitable quality packaging materials (large sacks, rough wooden boxes, second-hand cartons, bamboo baskets, or rattan containers) should not be used
- Avoid purchasing cheapest and most readily available containers
- Prefer unit load to handle the produce rather handling individually
- Packages should not be dumped and thrown during unloading
- Awareness on proper handling system management
- Training, seminars by National Productivity Council or State Productivity Council
- Develop information materials and disseminate to the workers, stakeholders for better operations
- Investment by bodies like NHB, NCCD, and NSDC on training
- Constant and strict supervision to prevent careless handling
- Guidelines with pictures and diagrams for easy understanding & learning of general principles and specific techniques
- Use of unloading aids such as, roller conveyors, pallet or forklift to reduce the handling of individual packages

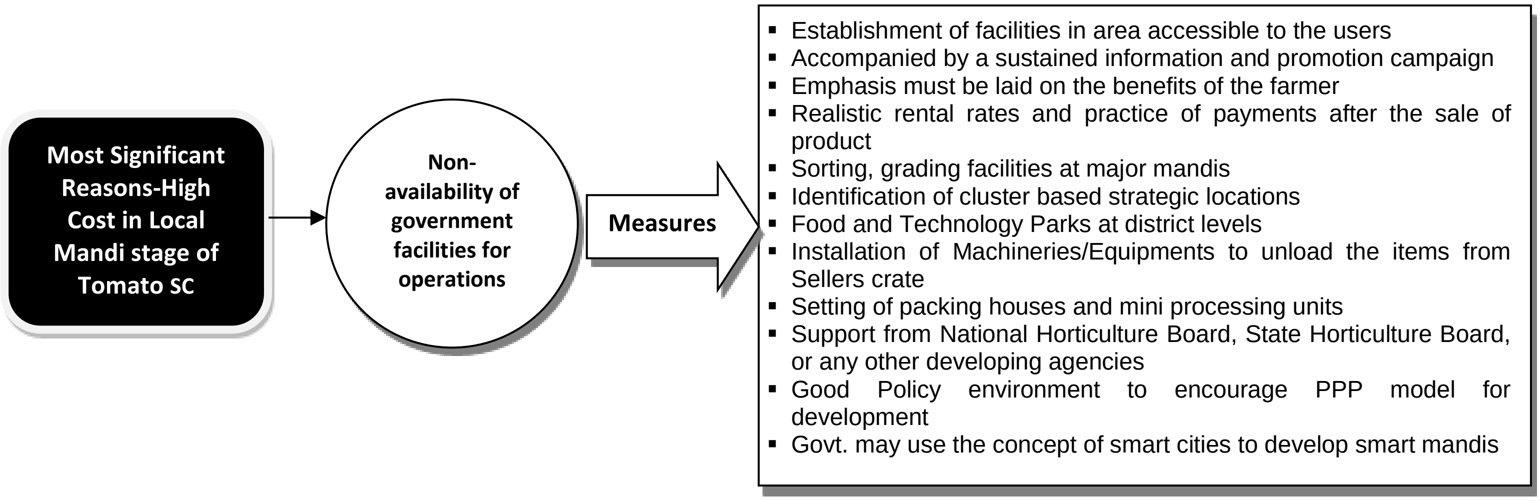



**Figure 5.40: Measures to improve SC Efficiency (with respect to Cost) in Local Mandi Stage of Tomato SC**

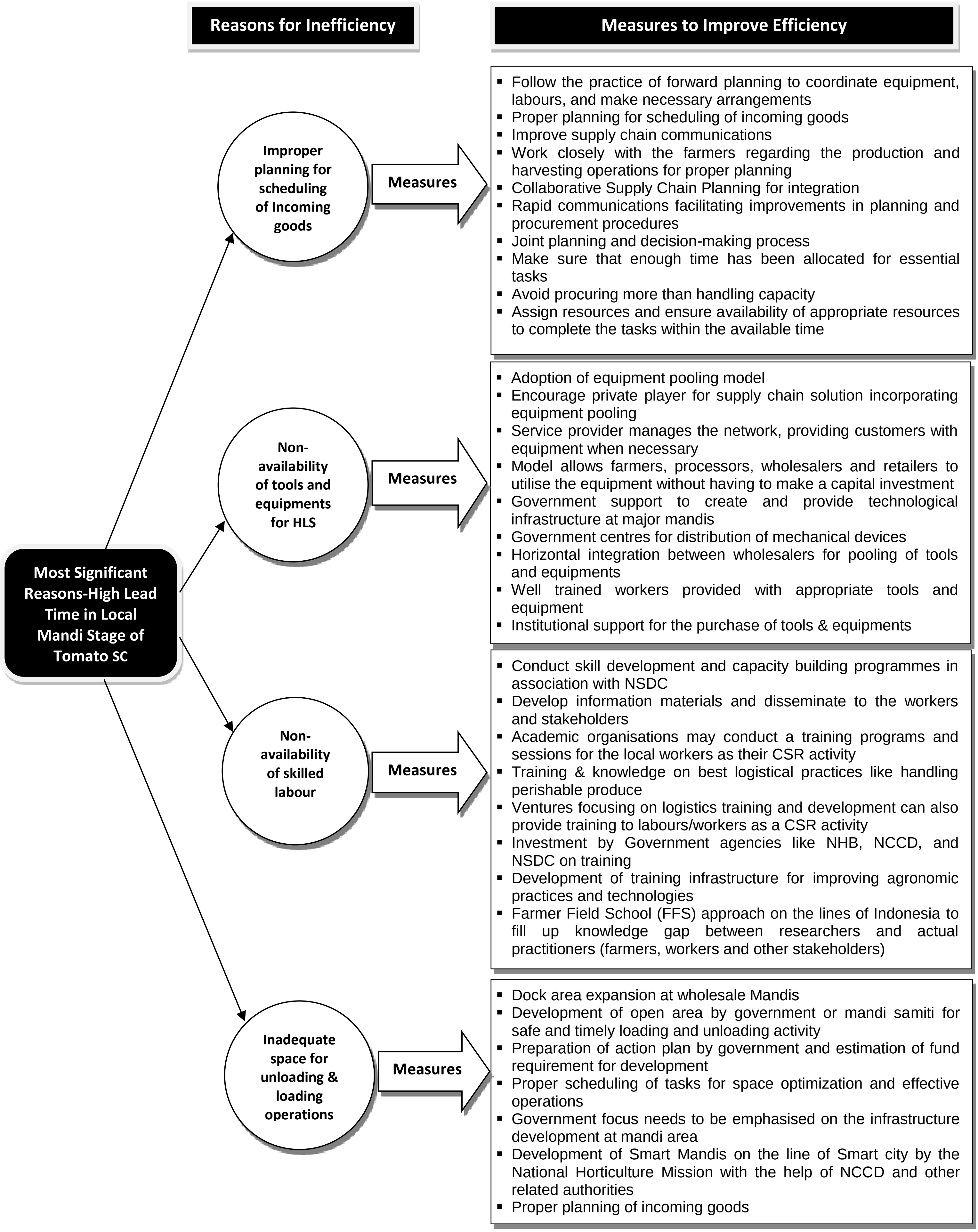



**Figure 5.41: Measures to improve SC Efficiency (with respect to Time) in Local Mandi Stage of Tomato SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-Poor Quality in Local Mandi Stage of Tomato SC**

**Rough handling while storing** → **Measures**

- Strict supervision of the operation performed by worker/labour
- Check the performance & system for reward for careful handling
- Create awareness on techniques & proper handling system management in storage area
- Inexpensive inner made from fiberboard can be used to protect produce from damage during handling
- Careful instructions must be given on the correct method of handling
- Dissemination of manuals or guides (with diagram and pictures) published by govt. institutions/authorities on handling of perishable fresh produce
- Avoid forcibly placing of crates to fix them in stack
- Packages should not be thrown during handling and stacking
- Investment by government agencies like NHB, NCCD, and NSDC in training
- Use of Palletization or unitized handling (stacking containers on standard size pallets)

**Insufficient storage and temperature controlled facilities** → **Measures**

- Concept of Top Icing/Contact Icing can be applied for short term storage which would result in quicker cooling
- Optimum temperature for crop as quickly as possible after harvest
- Need of cold chain network from farm to point of sale
- Access to low-cost handling and storage technologies (e.g., evaporative coolers, storage bags, crates)
- Use of Zero energy cool chamber/Evaporative coolers to extend the shelf life of food and avoid spoilage
- Encourage Cooperatives societies and other agencies to develop cold storage facilities
- Realistic rental rates and payments after the sale of product could attract the users to use the facility
- Use of Low-cost, low-energy, environmental friendly cool chambers made from locally available materials
- Room cooling technique consisting refrigeration unit
- Use of Night ventilation technique where variation between day and night temperatures can be used to keep stores cool
- Subsidy by government on the cost of building cold-storage
- Focus on development of micro cold chain solutions
- Need of Good policy environment promoting investment and formation of alliances/commodity based clusters
- Establish multi- chamber/ multi- commodity cold storage

**Damage to Tomatoes caused by pest and fungal infection during storage** → **Measures**

- Regular pest survey and monitoring to control pest and infection
- Properly maintained temperature to control pest and fungal infection
- Storage structure should be cleaned and fumigated before placing the fresh produce
- Training on how to properly clean plastic crates between uses
- Discard damaged fruits & vegetables to avoid quality deterioration
- Use of Food irradiation technology to destroy or sterilize bacteria
- Encourage adoption of pallet to stack the load
- Encourage usage of insect-proof boxes
- Stack 18 inches off the floor and 18 inches away from walls as per "18 inch rule of sanitation."
- Aisles should be leave between stacked containers and walls for proper inspection and cleaning
- Eliminate cracks and crevices in storage areas by proper construction or repairs
- Food handling and storage areas should be accessible to routine cleaning and collection of waste
- Packaging material must be free of chemical substances & smell
- The FIFO (First in First out) method should be applied to clear the stock
- Do not use anti-fungal/insects/rodent sprays and pesticides, which are not permitted

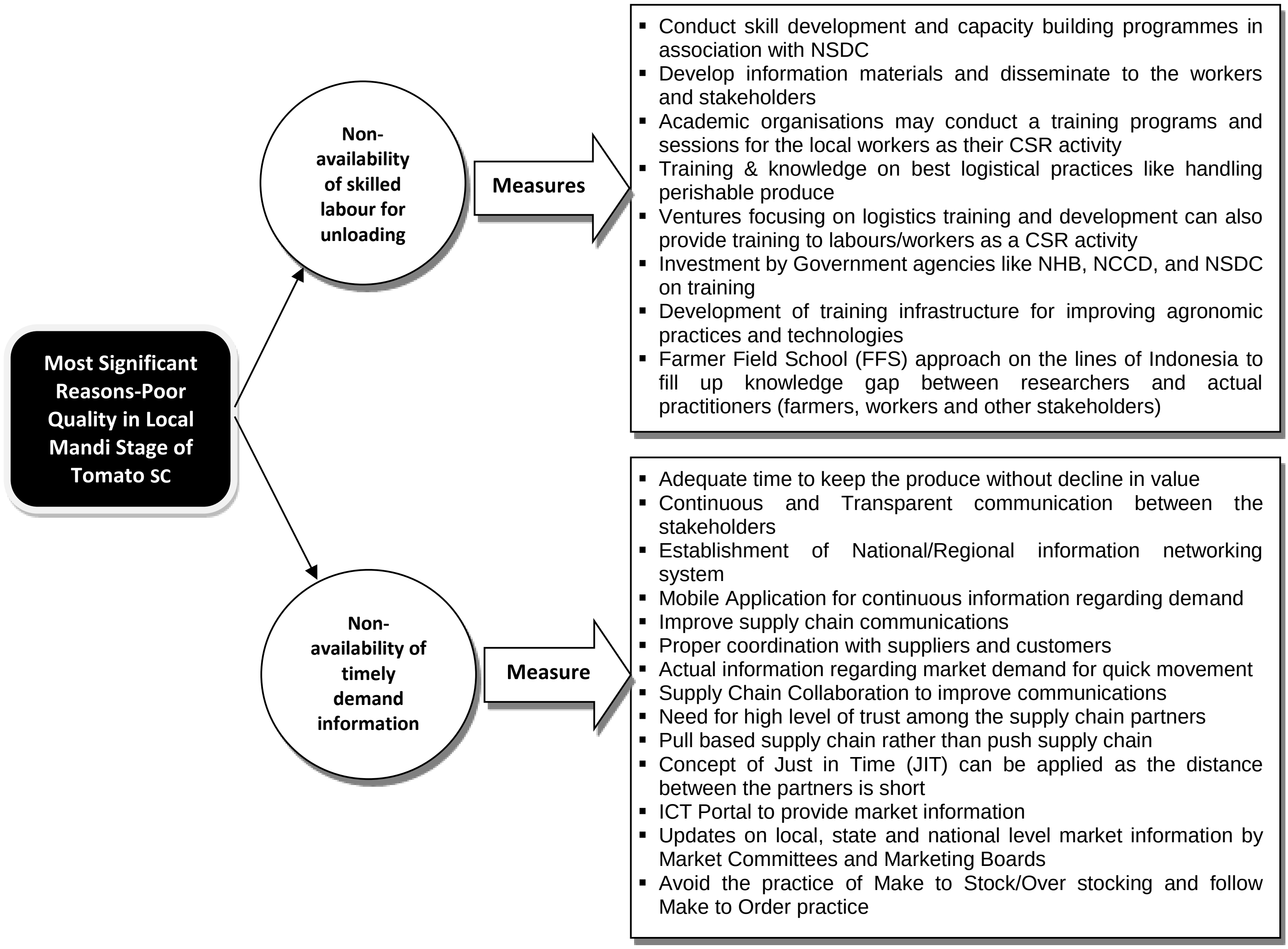



**Figure 5.42: Measures to improve SC Efficiency (with respect to Quality) in Local Mandi Stage of Tomato SC**

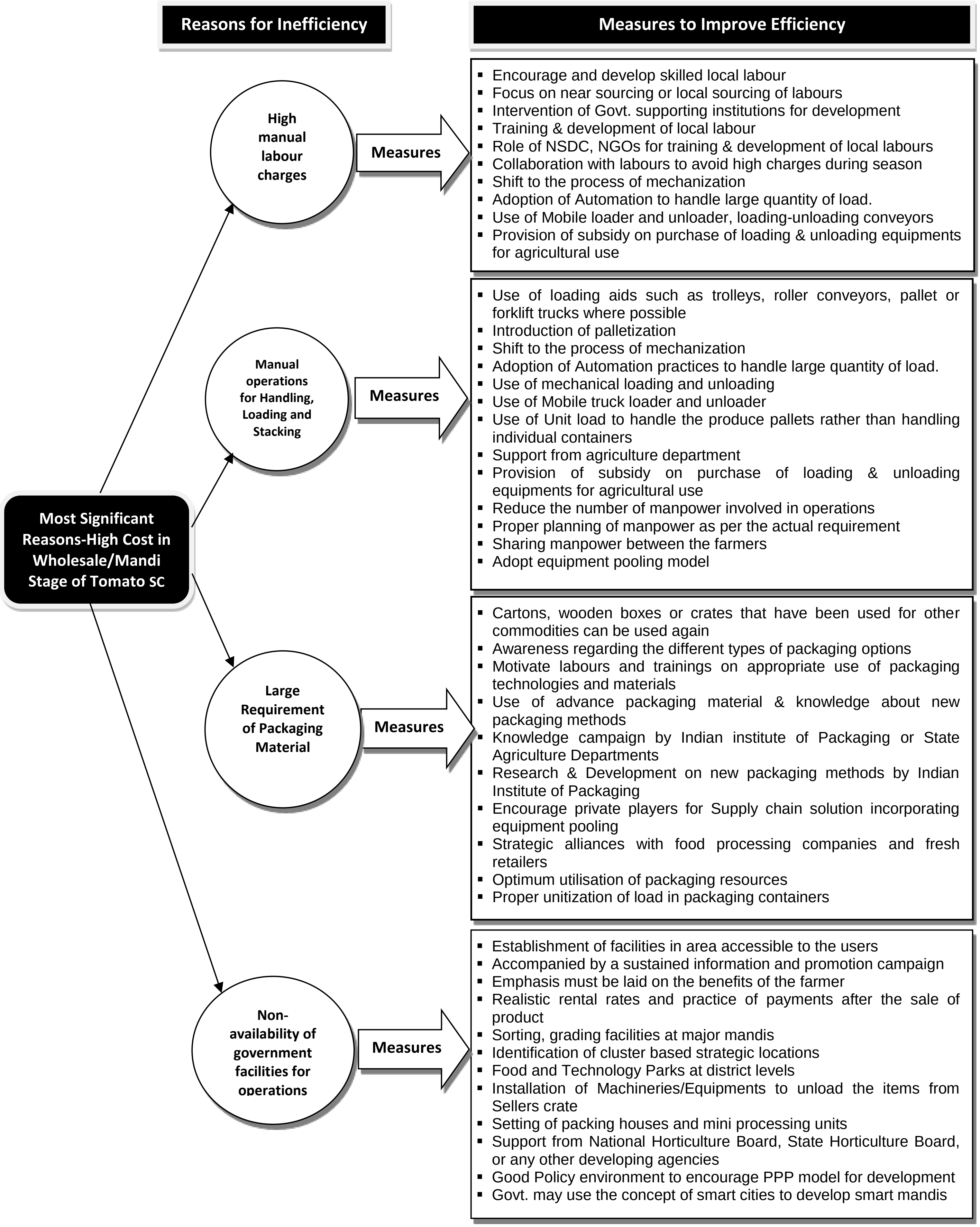



**Figure 5.43: Measures to improve SC Efficiency (with respect to Cost) in Wholesale/Mandi Stage of Tomato**

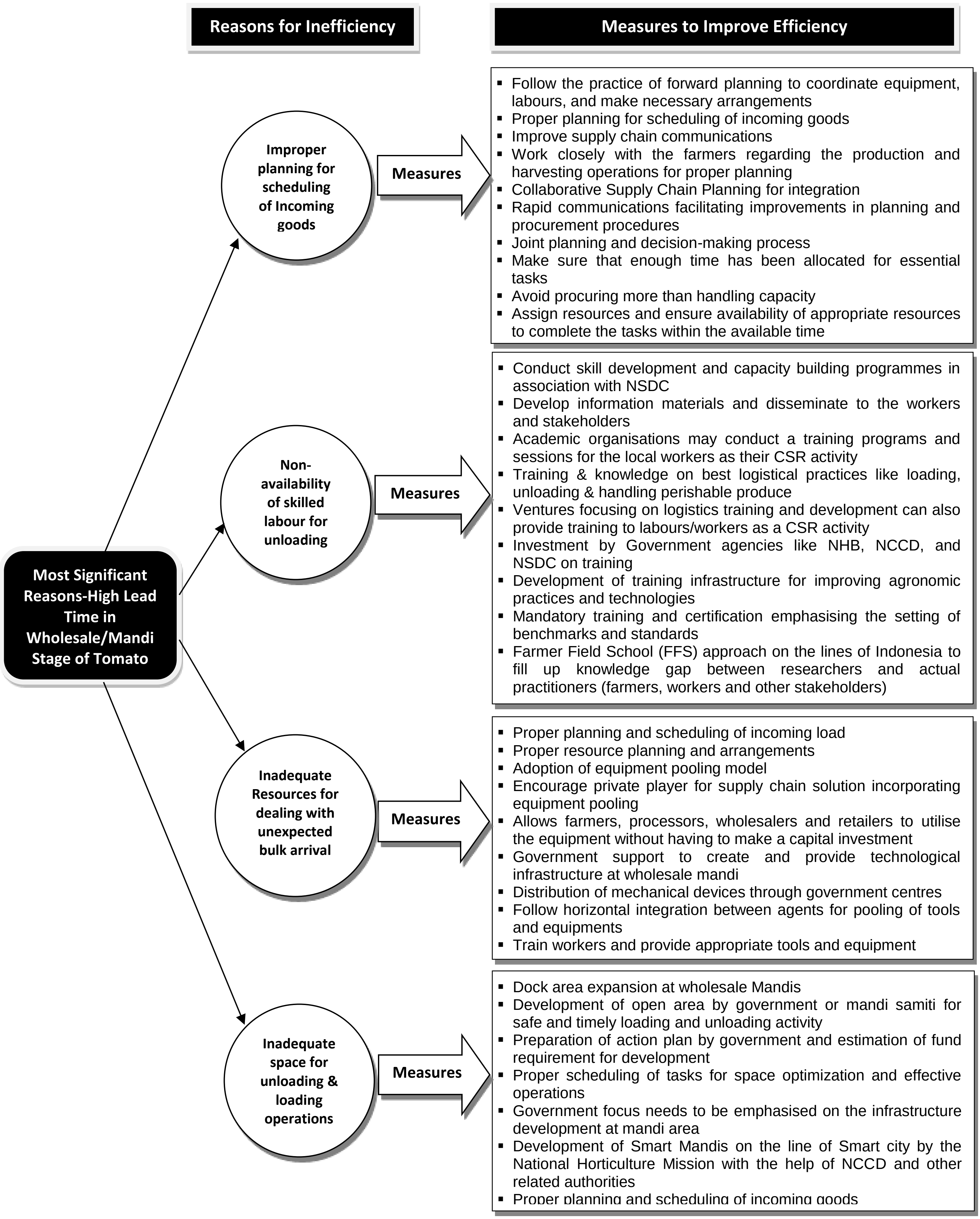



**Figure 5.44: Measures to improve SC Efficiency (with respect to Time) in Wholesale/Mandi Stage of Tomato**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-Poor Quality in Wholesale/Mandi Stage of Tomato SC**

**Holding of goods in anticipation of high prices** → **Measures**

- Adequate time to keep the produce without decline in value
- Establishment of National/Regional information networking system
- Mobile Application for continuous information regarding prices
- Pull based supply chain rather than push supply chain
- Follow response based model rather than anticipation
- Concept of Just in Time (JIT) can be applied as the distance between the partners is short
- Updates on local, state and national level market information/prices by Market Committees and Marketing Boards
- Avoid the practice of Make to Stock/Over stocking and follow Make to Order practice
- Apply FIFO (First in First out) method to clear the stock
- Avoid the practice of holding in case of perishable commodity
- Supply Chain collaboration with food processing companies, hotel industry, & fresh retailers

**Open area for unloading exposing to direct sunlight/heat** → **Measures**

- Avoid Open Air operations during high temperatures
- Covered dock area at Mandi level to protect fresh produce
- Government support for infrastructural development of APMC market
- Roof of corrugated G.I. sheet may be constructed at mandis
- Conduct unloading operation early in the day
- Carry fresh produce during appropriate temperature
- Protect the load from excessive humidity, excessive heat and direct sunrays
- Cover the load/vehicle from the top with heavy-duty waterproof cloth (tarpaulins) to avoid direct heat/sunrays
- Proper air circulation & ventilation inside the container/crates
- Create awareness program on handling and management of fresh produce
- Establishment of modern dock area with sheltered environment

**Damage to Tomatoes caused by pest and fungal infection** → **Measures**

- Regular pest survey and monitoring to control pest and infection
- Properly maintained temperature to control pest and fungal infection
- Storage structure should be cleaned and fumigated before placing the fresh produce
- Training on how to properly clean plastic crates between uses
- Discard damaged fruits & vegetables to avoid quality deterioration
- Use of Food irradiation technology to destroy or sterilize bacteria
- Encourage adoption of pallet to stack the load
- Encourage usage of insect-proof boxes
- Stack 18 inches off the floor and 18 inches away from walls as per “18 inch rule of sanitation.”
- Aisles should be leave between stacked containers and walls for proper inspection and cleaning
- Eliminate cracks and crevices in storage areas by proper construction or repairs
- Food handling and storage areas should be accessible to routine cleaning and collection of waste
- Packaging material must be free of chemical substances & smell
- The FIFO (First in First out) method should be applied to clear the stock
- Do not use anti-fungal/insects/rodent sprays and pesticides, which are not permitted.

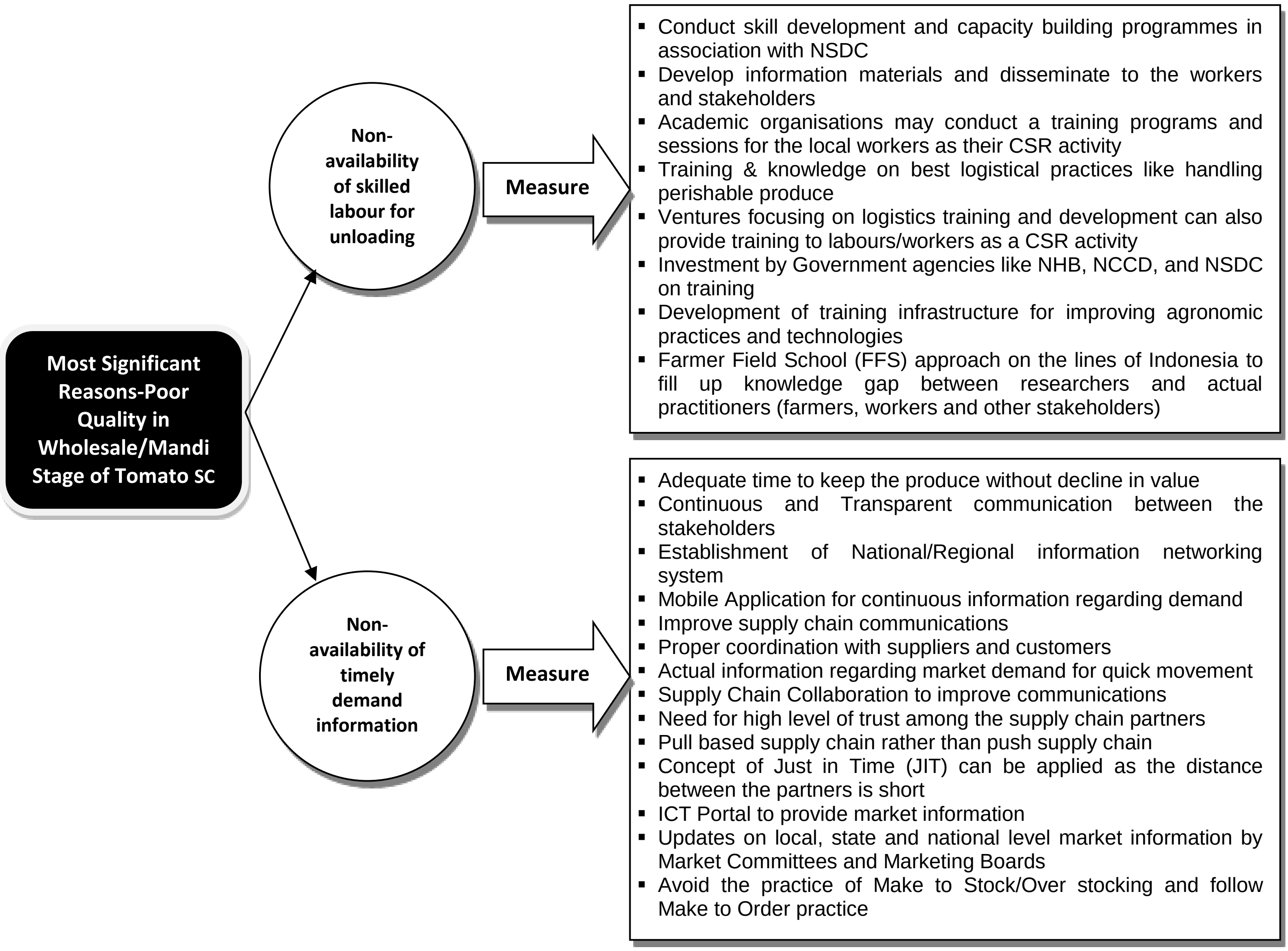



**Figure 5.45: Measures to improve SC Efficiency (with respect to Quality) in Wholesale/Mandi Stage of Tomato**

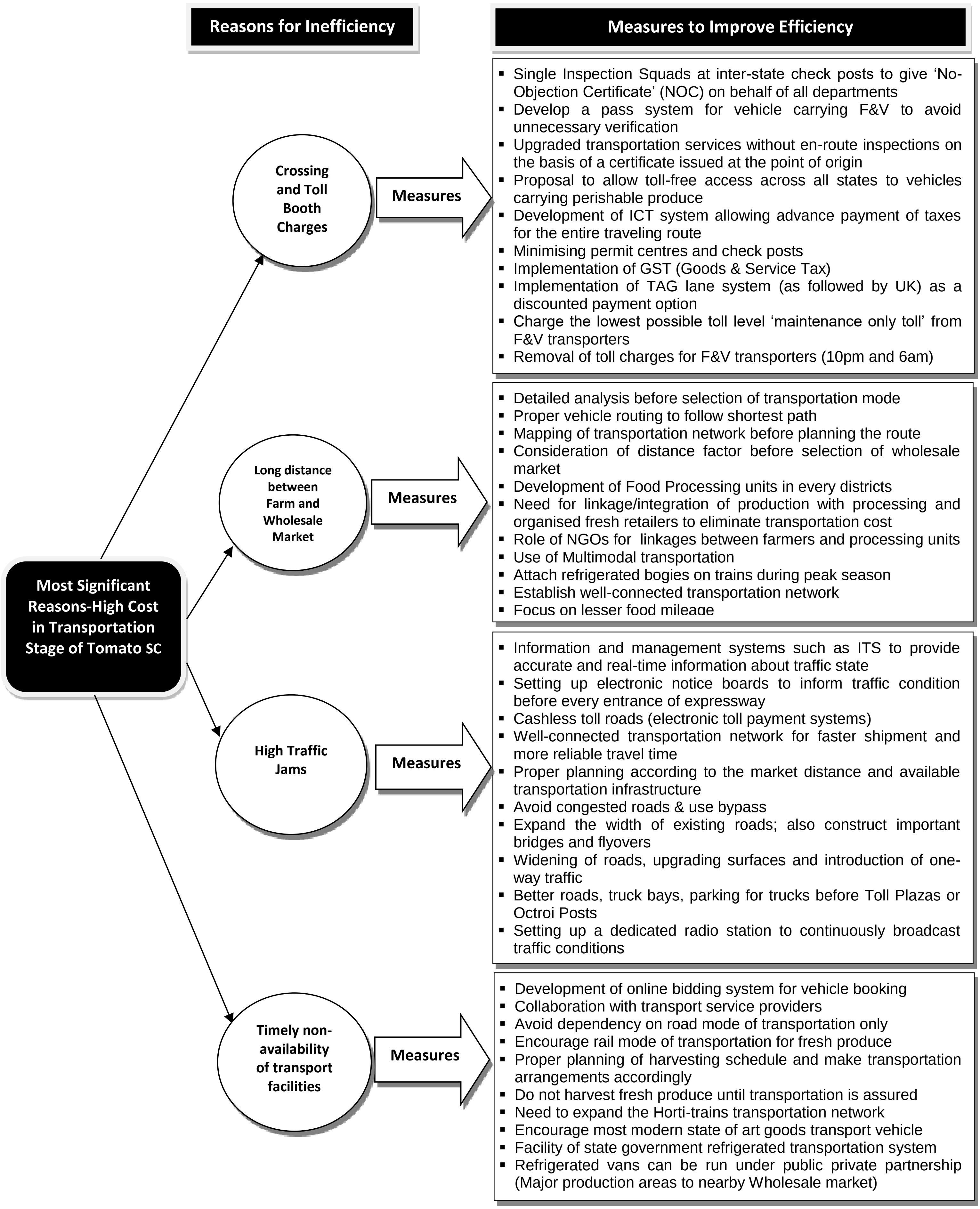



**Figure 5.46: Measures to improve SC Efficiency (with respect to Cost) in Transportation Stage of Tomato SC**

**Reasons for Inefficiency** | **Measures to Improve Efficiency**

**Most Significant Reasons-High Lead time in Transportation Stage of Tomato SC**

**Hilly terrain** → **Measures**

- Installation of ropeways trolleys to facilitate farmers
- Identification of spot/location for installation as per major production belt
- Need of research on transportation methods in hilly terrain
- Follow transshipment point transportation network
- Encourage alternate mode of transport like cable cars
- Expand the width of existing roads
- Proper carrier evaluation before selection of transportation mode
- Development of good transportation network
- Strengthen and upgrade road network connectivity and accessibility of remote areas
- Improve quality of roads in hilly areas

**Congestion and Traffic Jams** → **Measures**

- Information and management systems such as ITS to provide accurate and real-time information about traffic state
- Setting up electronic notice boards to inform traffic condition before every entrance of expressway
- Cashless toll roads (electronic toll payment systems)
- Well-connected transportation network for faster shipment and more reliable travel time
- Proper planning according to the market distance and available transportation infrastructure
- Avoid congested roads & use bypass
- Expand the width of existing roads; also construct important bridges and flyovers
- Widening of roads, upgrading surfaces and introduction of one-way traffic
- Better roads, truck bays, parking for trucks before Toll Plazas or Octroi Posts
- Setting up a dedicated radio station to continuously broadcast traffic conditions

**Police verification and frisking** → **Measures**

- Sealed Inspection by non- intrusive methods
- Implementation of e-challan system
- ICT portal for complaint registration regarding ‘forced’ stopovers
- Toll-free telephone numbers for registering complaints
- Frequent and surprise checks
- Issuance of verification note to avoid continuous verification
- Verification only at check points
- Law on ‘forced’ stopovers for verification and frisking of vehicles for bribe
- Develop a pass system for vehicle carrying F&V to avoid unnecessary verification
- Drivers should follow traffic guidelines and control over speed
- Single Inspection Squads at inter-state check posts to give ‘No-Objection Certificate’ (NOC) on behalf of all departments
- Upgraded transportation services without en-route inspections on the basis of a certificate issued at the point of origin

**Irresponsible and Careless driving** → **Measures**

- Close attention and strict supervision & monitoring
- Awareness of the time ignorance affects
- Sensitization of Drivers-Awareness, Training and knowledge development programme
- Careful instructions and strict specifications before load dispatch
- Reward system for on-time delivery of goods
- Penalties for long lead time due to carelessness
- Installation of GPS systems in vehicles for monitor and controlling
- Avoid unscheduled stops during the journey
- Introduction of double driver concept
- Adopt AAA (American Automobile Association) model for roadside assistance during transportation breakdowns

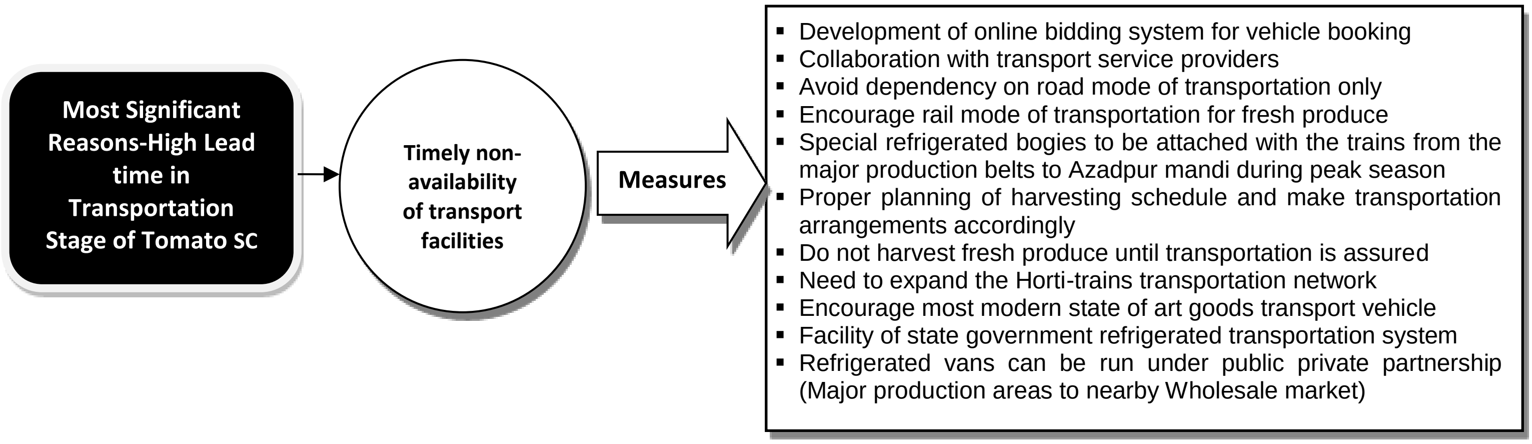



**Figure 5.47: Measures to improve SC Efficiency (with respect to Time) in Transportation Stage of Tomato SC**

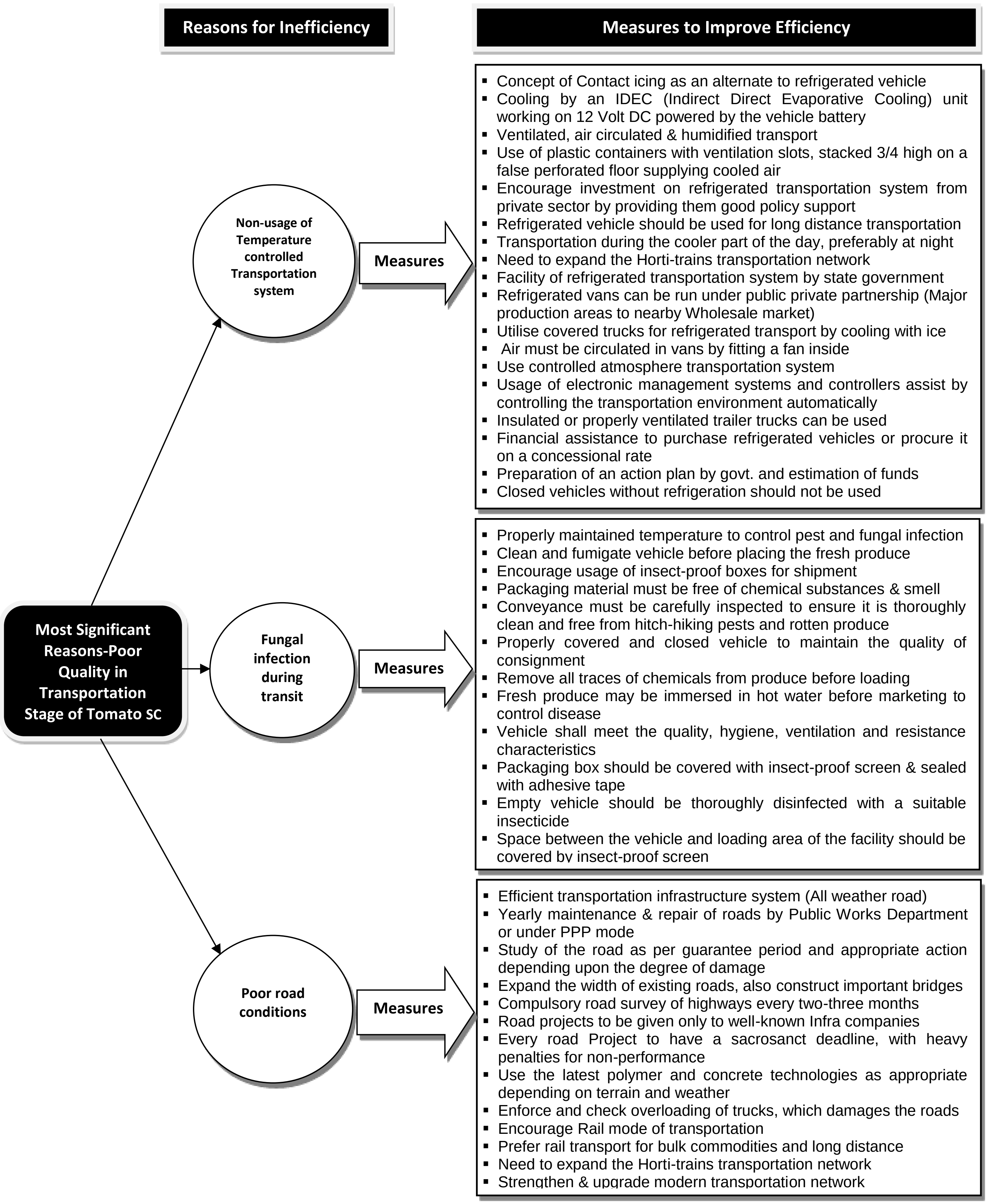



**Figure 5.48: Measures to improve SC Efficiency (with respect to Quality) in Transportation Stage of Tomato SC**

## 5.4. Findings-At a Glance

**5.4.1. Findings- Research Objective 1:** *To identify the most significant activities contributing to supply chain inefficiency (with respect to cost, time and quality) in different stages of fruits and vegetables supply chain with specific reference to mango and tomato*

The three most important activities contributing to supply chain inefficiency with respect to cost, time, and quality in each stage of F&V supply chain is depicted in Figure 5.49-Figure 5.54.

| Stage I | Stage II | Stage III | Stage IV | Transportation Stage |
|---|---|---|---|---|
| Plucking & Collection of Mangoes in Crates/Baskets | Sorting, Grading & Repackaging of Mango (as per the Grades) in another Crates by the buyer (Local trader) for further selling | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | Sorting, Grading & Repackaging of Mangoes by the Local traders at Adarshnagar, Azadpur for further sale | Transportation (During transit) of Mangoes from Farm to Wholesale Mandi |
| Sorting, Grading & Packaging and Tying | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's area at Adarshnagar, Azadpur mandi | |
| Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/Mini Trucks | Unloading of Box/Carton/Crates/ Bags from Tractor/Bullock cart/Truck/Mini Trucks to the area of Local Agents/ local market | Storing of Crates/ Cartons /Wooden Box at Mandi | Storing & Ripening of Mangoes | |

**Figure 5.49: Activities Contributing to Supply Chain Inefficiency (with respect to Cost) in Fruits (Mango) SC**

| Stage I | Stage II | Stage III | Stage IV | Transportation Stage |
|---|---|---|---|---|
| Sorting, Grading & Packaging and Tying | Sorting, Grading & Repackaging of Mango (as per the Grades) in another Crates by the buyer (Local trader) | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | Storing & Ripening of Mangoes | Transportation (During transit) of Mangoes from Farm to Wholesale Mandi |
| Plucking & Collection of Mangoes in Crates/Baskets | Unloading of mango from seller's crates (at Local Market) and loading to the buyer's crate (Local trader) | Storing of Crates/ Cartons /Wooden Box at Mandi | Sorting, Grading & Repackaging of Mangoes by the Local traders at Adarshnagar, Azadpur for further sale | |
| Carriage of Crates/Baskets to the Collection Area | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | |

**Figure 5.50: Activities Contributing to Supply Chain Inefficiency (with respect to Time) in Fruits (Mango) SC**

| Stage I | Stage II | Stage III | Stage IV | Transportation |
|---|---|---|---|---|
| Sorting, Grading & Packaging and Tying | Storing of Fresh Produce | Storing of Crates/ Cartons /Wooden Box at Mandi | Storing & Ripening of Mangoes | |
| Plucking & Collection of Mangoes in Crates/Baskets | Unloading of mango from seller's crates (at Local Market) and loading to the buyer's crate (Local trader) | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | Storing of Mangoes | Transportation (During transit) of Mangoes from Farm to Wholesale Mandi |
| Handling, Loading & Stacking of Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks | Handling, Loading & Stacking of Box/Carton/Crates | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | |

**Figure 5.51: Activities Contributing to Supply Chain Inefficiency (with respect to Quality) in Fruits (Mango) SC**

| Stage I | Stage II | Stage III | Transportation Stage |
|---|---|---|---|
| Carriage of Crates to the Collection Area/Collection Centre | Unloading of Tomato and Loading to the buyer's Crate | Unloading of Tomato from seller's crates and Loading to the buyer's crates | |
| Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | Unloading of Tomato Crates from Trucks at Mandi Level | Transportation (During transit) of Tomatoes from Farm to Wholesale Mandi |
| Sorting & Grading of Tomatoes and Packing in Crates as per the grade | Unloading of Box/Crates from Truck/Mini Trucks to the area of Local Agents/ local market | Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | |

**Figure 5.52: Activities Contributing to Supply Chain Inefficiency (with respect to Cost) in Vegetables (Tomato) SC**

| Stage I | Stage II | Stage III | Transportation Stage |
|---|---|---|---|
| Carriage of Crates to the Collection Area/Collection Centre | Unloading of Tomato and Loading to the buyer's Crate | Unloading of Tomato from seller's crates and Loading to the buyer's crates | |
| Sorting & Grading of Tomatoes and Packing in Crates as per the grade | Unloading of Crates from Truck/Mini Vehicles to the Local Mandi | Unloading of Tomato Crates from Trucks at Mandi Level | Transportation (During transit) of Tomatoes from Farm to Wholesale Mandi |
| Plucking & Collecting Tomato in Bucket/ Basket | Handling, Loading & Stacking of Box/Carton/Crates in Trucks | Handling, Loading & Stacking of Tomato Crates in Trucks | |

**Figure 5.53: Activities Contributing to Supply Chain Inefficiency (with respect to Time) in Vegetables (Tomato) SC**

| Stage I | Stage II | Stage III | Transportation |
|---|---|---|---|
| Storing of Goods | Storing of Fresh Produce | Storing of Fresh Produce at Local Mandi | |
| Carriage of Crates to the Collection Area/Collection Centre | Unloading of Tomato from seller's crates (at Local Market) and loading to the buyer's crate (Local trader) | Unloading of Tomato from seller's crates and loading to the buyer's crate | Transportation (During transit) of Tomatoes from Farm to Wholesale Mandi |
| Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | Unloading of Tomato Crates from Truck at Wholesale Mandi | |

**Figure 5.54: Activities Contributing to Supply Chain Inefficiency (with respect to Quality) in Vegetables (Tomato) SC**

**5.4.2. Findings- Research Objective 2:** *To identify the factors leading to supply chain inefficiency (with respect to cost, time and quality) in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato.*

The identified factors leading to supply chain inefficiency in F&V sector are as follows:

- ***Factors leading to supply chain inefficiency in fruits (mango) supply chain***

*With respect to Cost:*

Resources, Labour & Material Charges, Infrastructure, Labour's Knowledge, Operational issues, Operational charges, and Labour charges.

*With respect to Time:*

Labour, Operational issues, Infrastructure, Resources, Connectivity, Market Uncertainties, Imprudence, and Verification & Frisking.

*With respect to Quality:*

Operational issues, Infrastructure, Resources, Imprudence, Labour's Knowledge, Labour Availability, Quality Control System, Standardisation, Ambience, Preservation, Labour, Information, Techniques, Transit Ease.

- ***Factors leading to supply chain inefficiency in vegetables (tomato) supply chain***

*With respect to Cost:*

Resources, Operational & Labour Charges, Infrastructure, Geography, Operational issues, Labour's Knowledge, Rates & Charges, and Connectivity.

*With respect to Time:*

Operational issues, Labour, Infrastructure, Connectivity, Geography, Technical Resources, Transport Facility, Verification & Frisking, and Imprudence.

*With respect to Quality:*

Operational issues, Infrastructure, Ambience, Information, Labour Availability, and Preservation.

The overall factors and reasons for supply chain inefficiency in F&V sector with respect to cost, time and quality are depicted in Figure 5.55 to Figure 5.60.

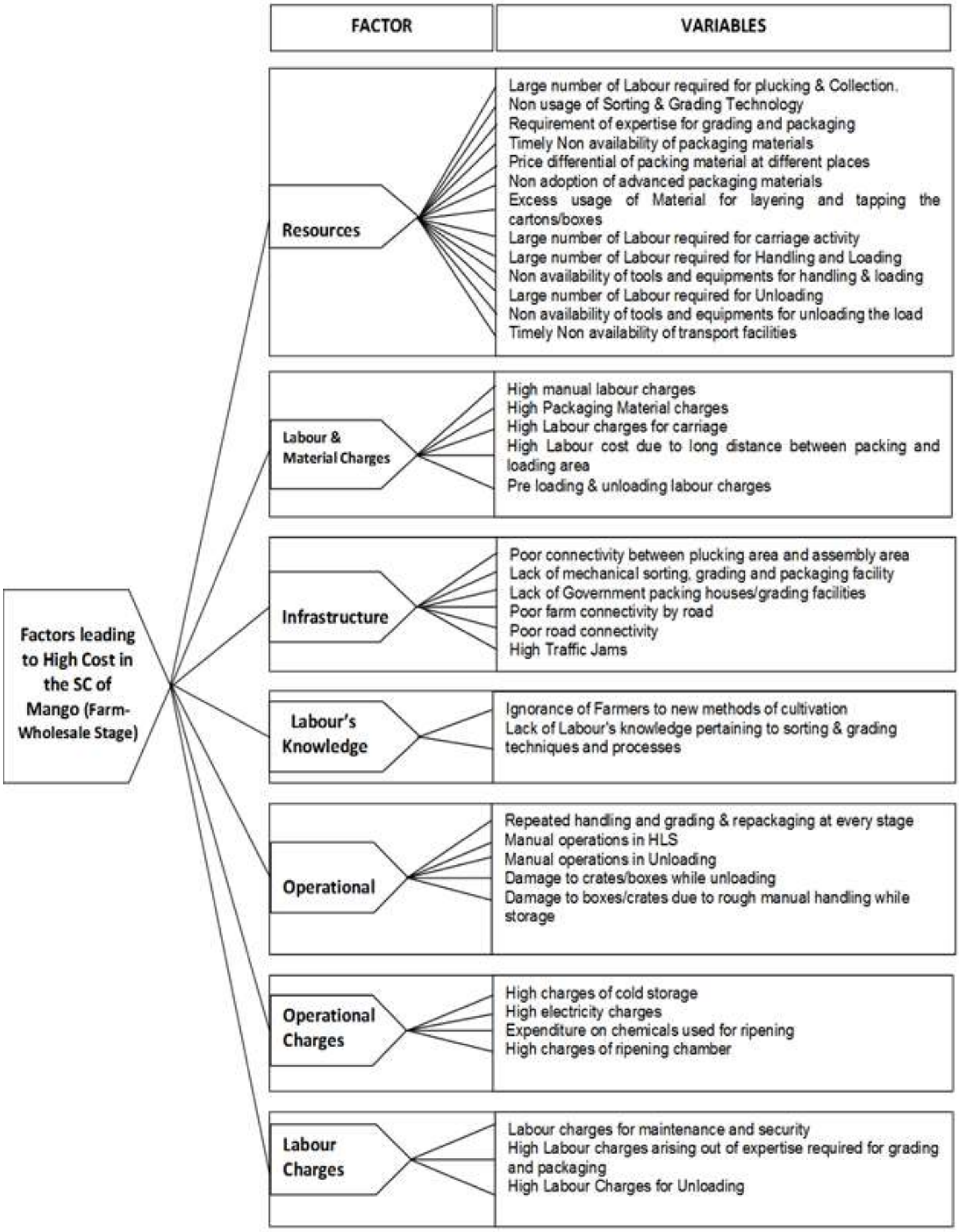
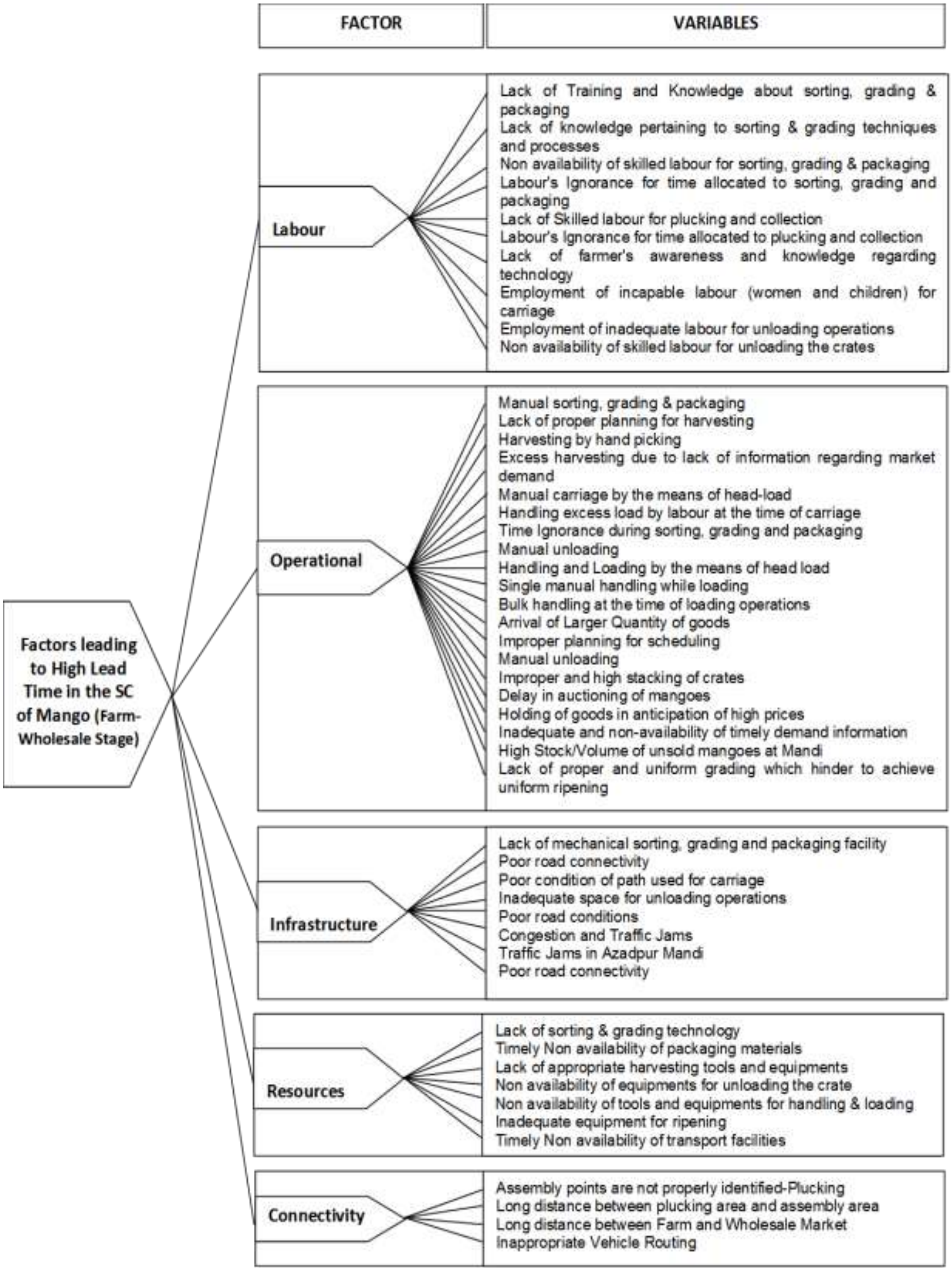



**Figure 5.55: Factors and reasons leading to high cost in Fruits SC**


FACTOR
VARIABLES
Factors leading to High Lead Time in the SC of Mango (Farm-Wholesale Stage)
Labour
Lack of Training and Knowledge about sorting, grading & packaging
Lack of knowledge pertaining to sorting & grading techniques and processes
Non availability of skilled labour for sorting, grading & packaging
Labour's Ignorance for time allocated to sorting, grading and packaging
Lack of Skilled labour for plucking and collection
Labour's Ignorance for time allocated to plucking and collection
Lack of farmer's awareness and knowledge regarding technology
Employment of incapable labour (women and children) for carriage
Employment of inadequate labour for unloading operations
Non availability of skilled labour for unloading the crates
Operational
Manual sorting, grading & packaging
Lack of proper planning for harvesting
Harvesting by hand picking
Excess harvesting due to lack of information regarding market demand
Manual carriage by the means of head-load
Handling excess load by labour at the time of carriage
Time Ignorance during sorting, grading and packaging
Manual unloading
Handling and Loading by the means of head load
Single manual handling while loading
Bulk handling at the time of loading operations
Arrival of Larger Quantity of goods
Improper planning for scheduling
Manual unloading
Improper and high stacking of crates
Delay in auctioning of mangoes
Holding of goods in anticipation of high prices
Inadequate and non-availability of timely demand information
High Stock/Volume of unsold mangoes at Mandi
Lack of proper and uniform grading which hinder to achieve uniform ripening
Infrastructure
Lack of mechanical sorting, grading and packaging facility
Poor road connectivity
Poor condition of path used for carriage
Inadequate space for unloading operations
Poor road conditions
Congestion and Traffic Jams
Traffic Jams in Azadpur Mandi
Poor road connectivity
Resources
Lack of sorting & grading technology
Timely Non availability of packaging materials
Lack of appropriate harvesting tools and equipments
Non availability of equipments for unloading the crate
Non availability of tools and equipments for handling & loading
Inadequate equipment for ripening
Timely Non availability of transport facilities
Connectivity
Assembly points are not properly identified-Plucking
Long distance between plucking area and assembly area
Long distance between Farm and Wholesale Market
Inappropriate Vehicle Routing

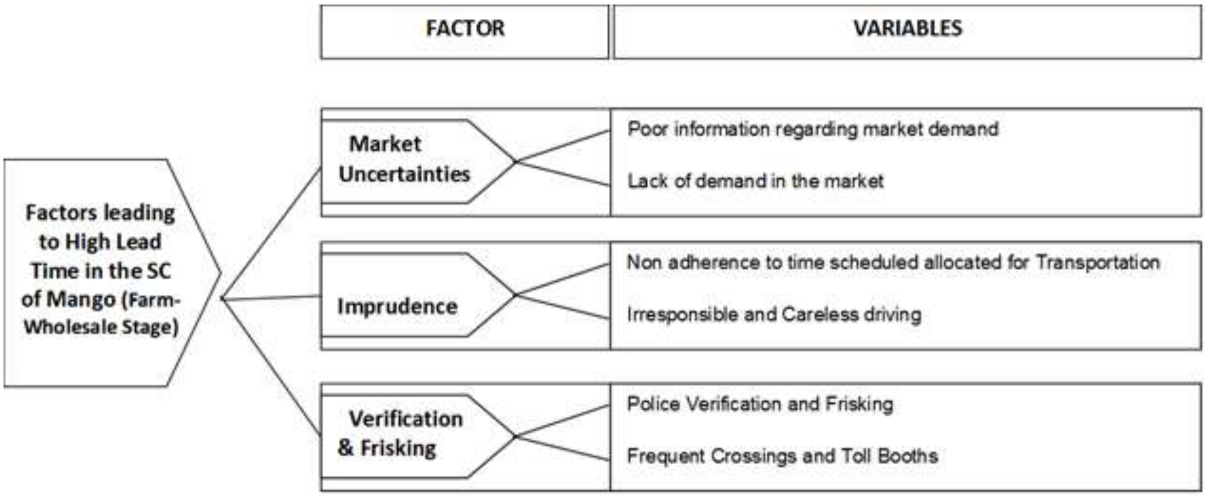
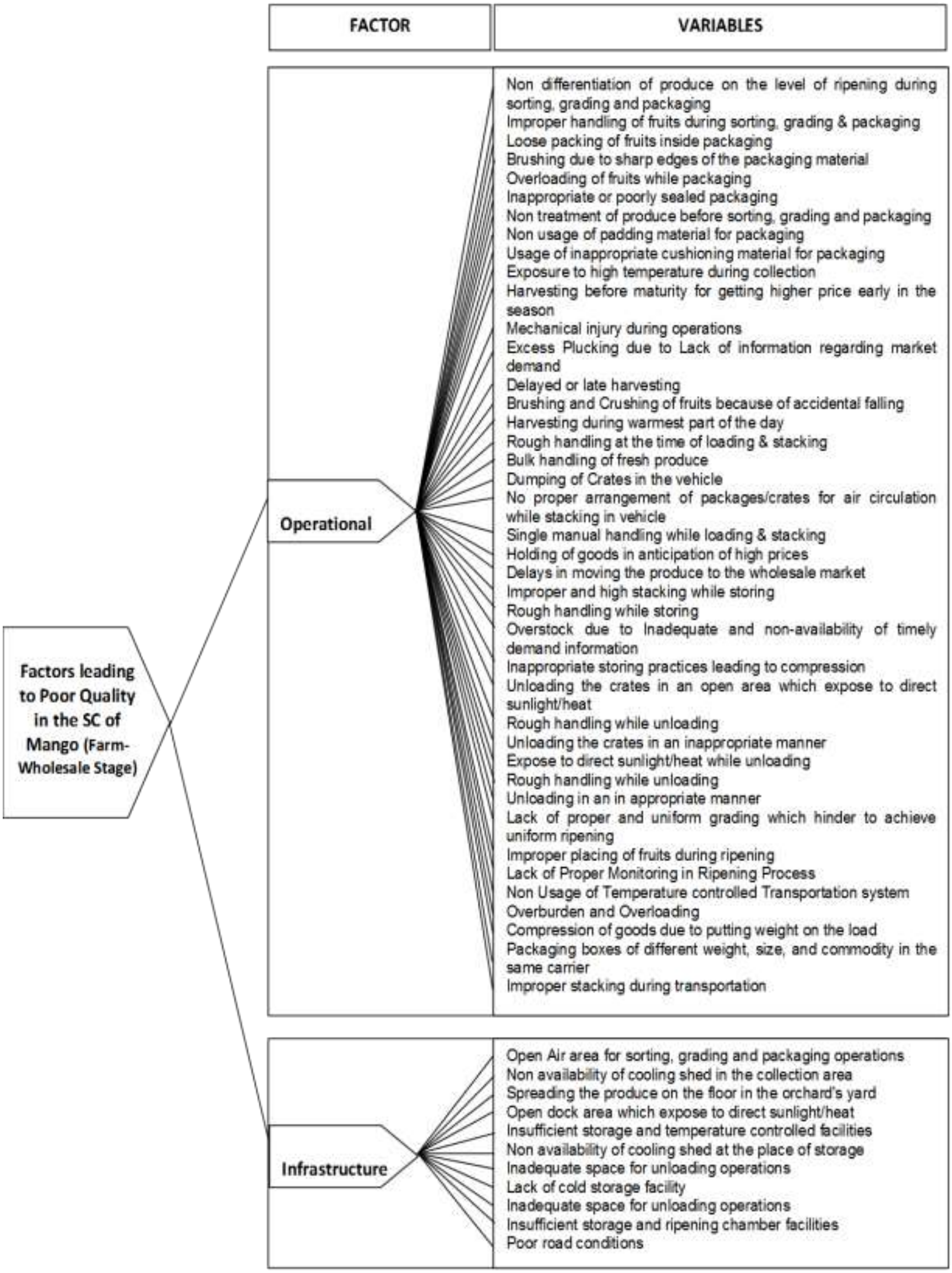



**Figure 5.56: Factors and reasons leading to high lead time in Fruits SC**


FACTOR
VARIABLES
Factors leading to Poor Quality in the SC of Mango (Farm-Wholesale Stage)
Operational
Non differentiation of produce on the level of ripening during sorting, grading and packaging
Improper handling of fruits during sorting, grading & packaging
Loose packing of fruits inside packaging
Brushing due to sharp edges of the packaging material
Overloading of fruits while packaging
Inappropriate or poorly sealed packaging
Non treatment of produce before sorting, grading and packaging
Non usage of padding material for packaging
Usage of inappropriate cushioning material for packaging
Exposure to high temperature during collection
Harvesting before maturity for getting higher price early in the season
Mechanical injury during operations
Excess Plucking due to Lack of information regarding market demand
Delayed or late harvesting
Brushing and Crushing of fruits because of accidental falling
Harvesting during warmest part of the day
Rough handling at the time of loading & stacking
Bulk handling of fresh produce
Dumping of Crates in the vehicle
No proper arrangement of packages/crates for air circulation while stacking in vehicle
Single manual handling while loading & stacking
Holding of goods in anticipation of high prices
Delays in moving the produce to the wholesale market
Improper and high stacking while storing
Rough handling while storing
Overstock due to Inadequate and non-availability of timely demand information
Inappropriate storing practices leading to compression
Unloading the crates in an open area which expose to direct sunlight/heat
Rough handling while unloading
Unloading the crates in an inappropriate manner
Expose to direct sunlight/heat while unloading
Rough handling while unloading
Unloading in an in appropriate manner
Lack of proper and uniform grading which hinder to achieve uniform ripening
Improper placing of fruits during ripening
Lack of Proper Monitoring in Ripening Process
Non Usage of Temperature controlled Transportation system
Overburden and Overloading
Compression of goods due to putting weight on the load
Packaging boxes of different weight, size, and commodity in the same carrier
Improper stacking during transportation
Infrastructure
Open Air area for sorting, grading and packaging operations
Non availability of cooling shed in the collection area
Spreading the produce on the floor in the orchard's yard
Open dock area which expose to direct sunlight/heat
Insufficient storage and temperature controlled facilities
Non availability of cooling shed at the place of storage
Inadequate space for unloading operations
Lack of cold storage facility
Inadequate space for unloading operations
Insufficient storage and ripening chamber facilities
Poor road conditions

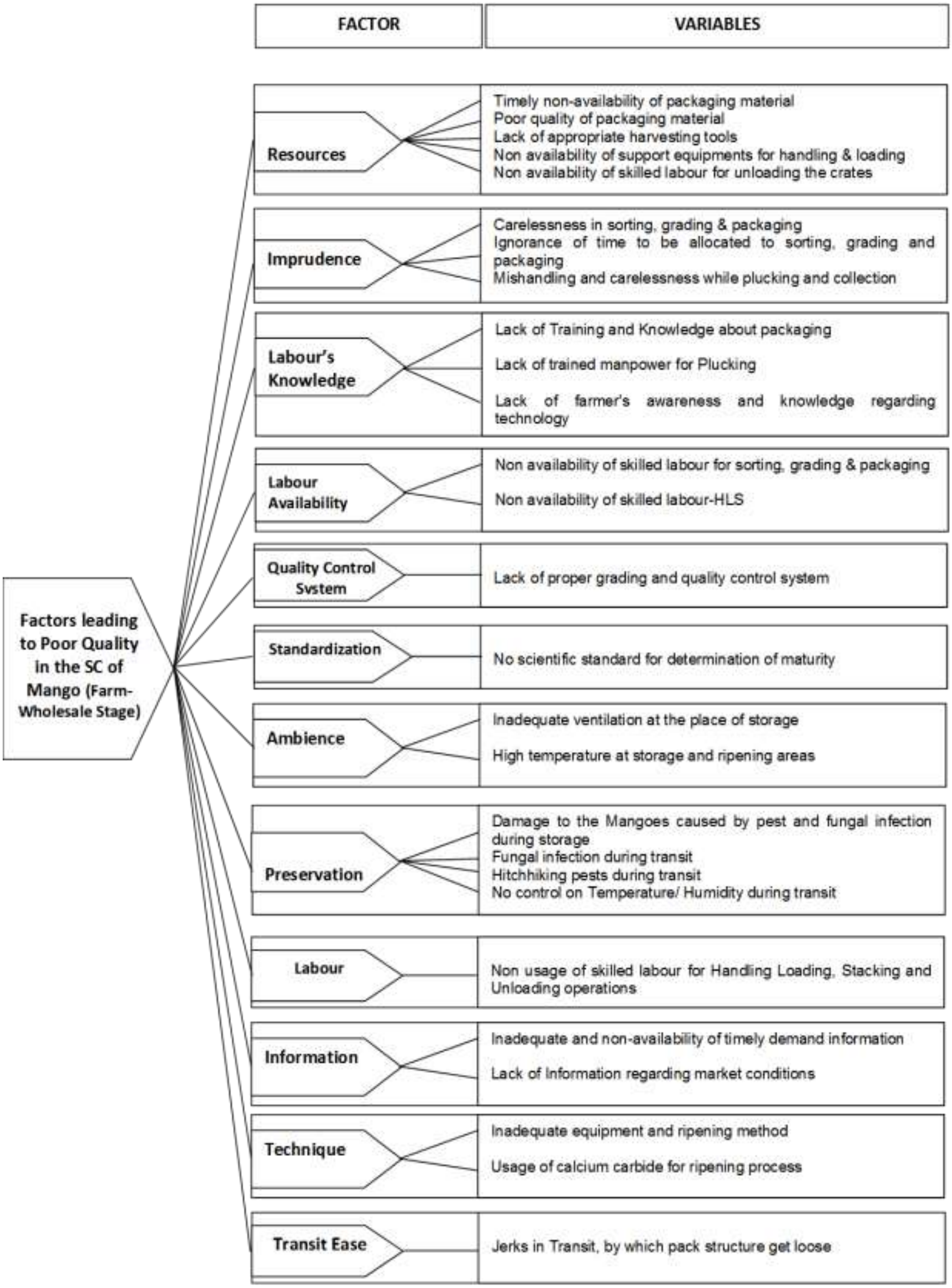


Figure-Factors and reasons leading to poor quality in fruits supply chain

**Figure 5.57: Factors and reasons leading to poor quality in Fruits SC**

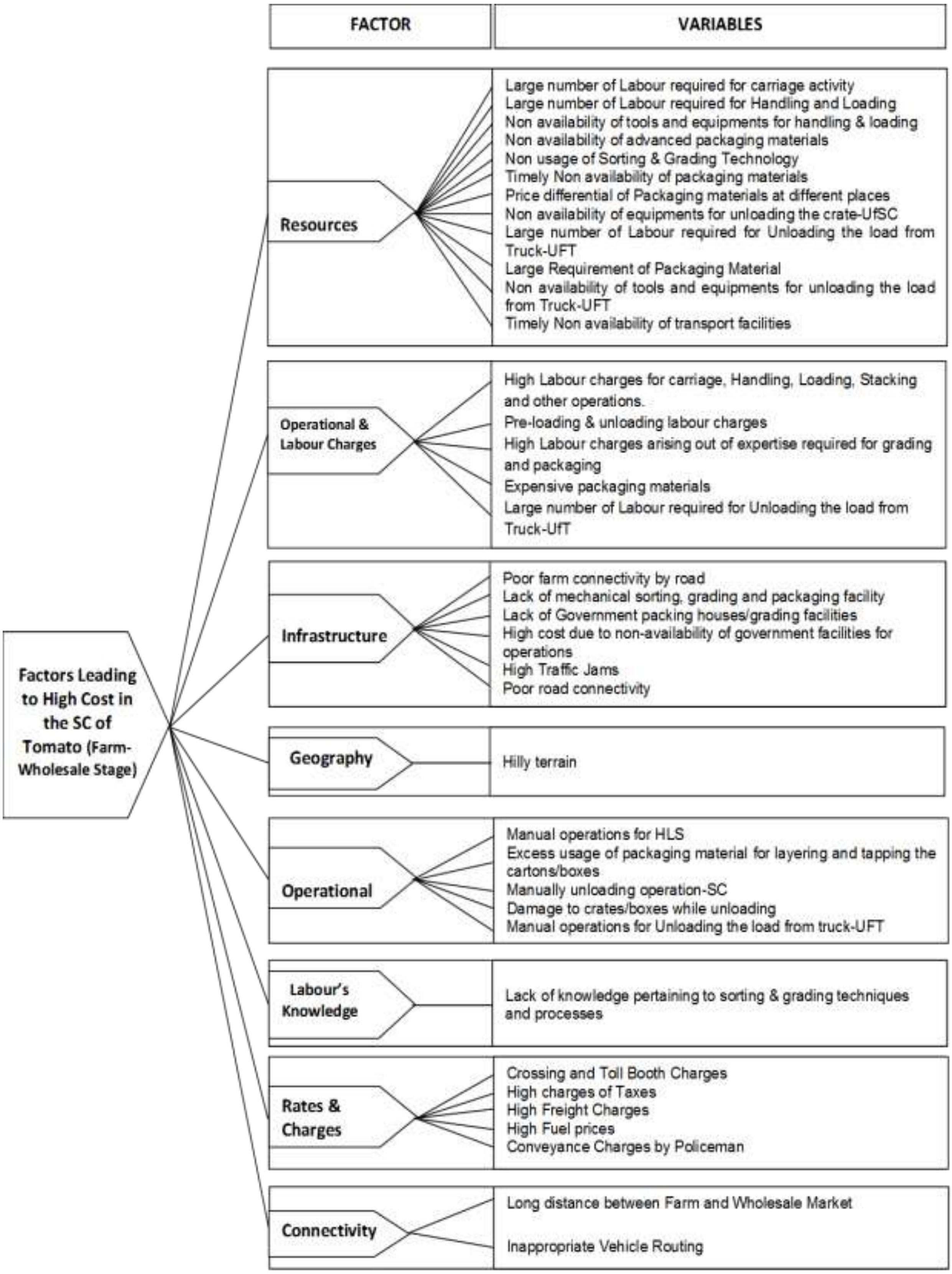



Figure-Factors and reasons leading to high cost in vegetables supply chain

**Figure 5.58: Factors and reasons leading to high cost in Vegetables SC**

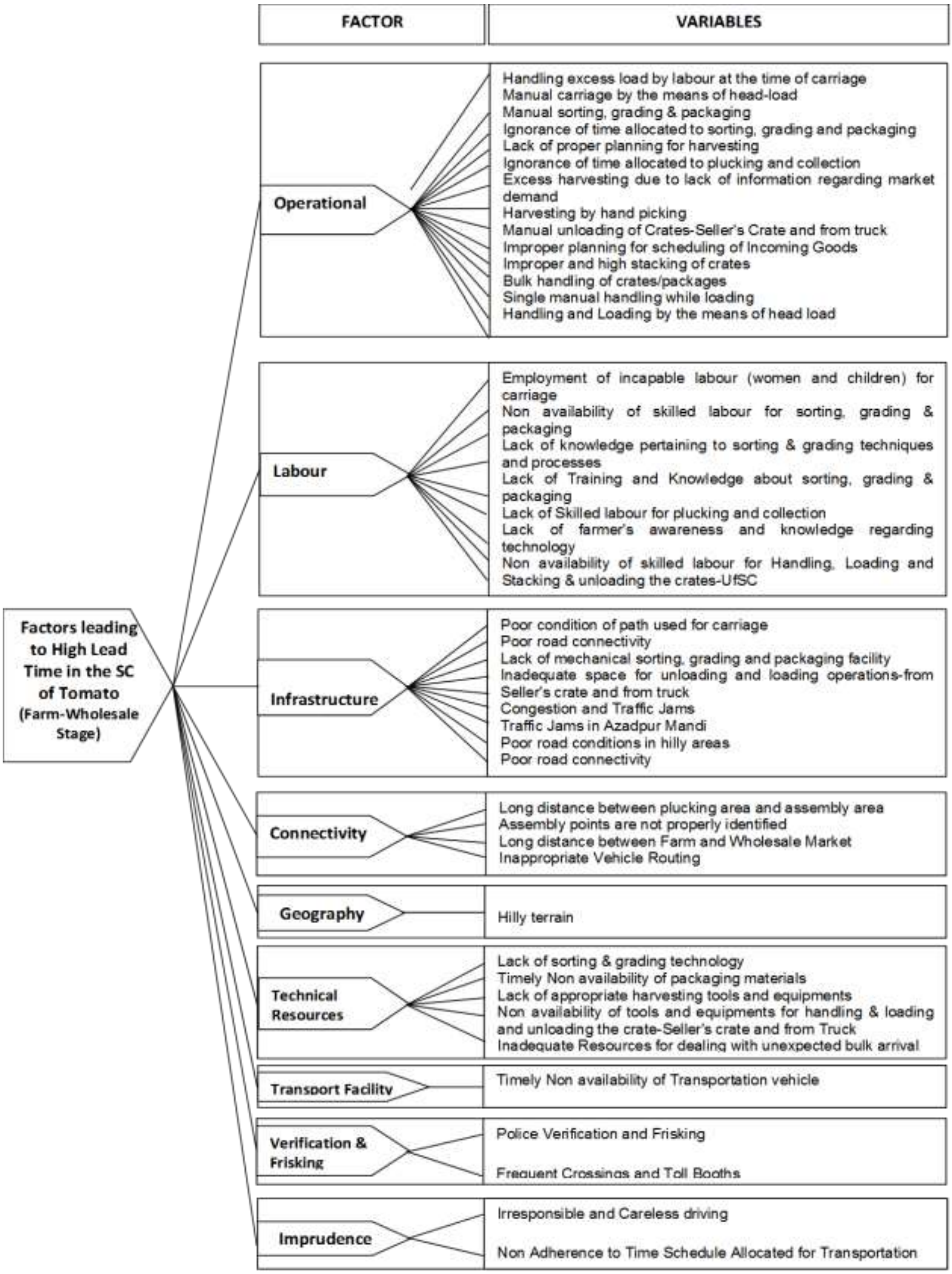



Figure-Factors and reasons leading to high lead time in vegetables supply chain

**Figure 5.59: Factors and reasons leading to high lead time in Vegetables SC**

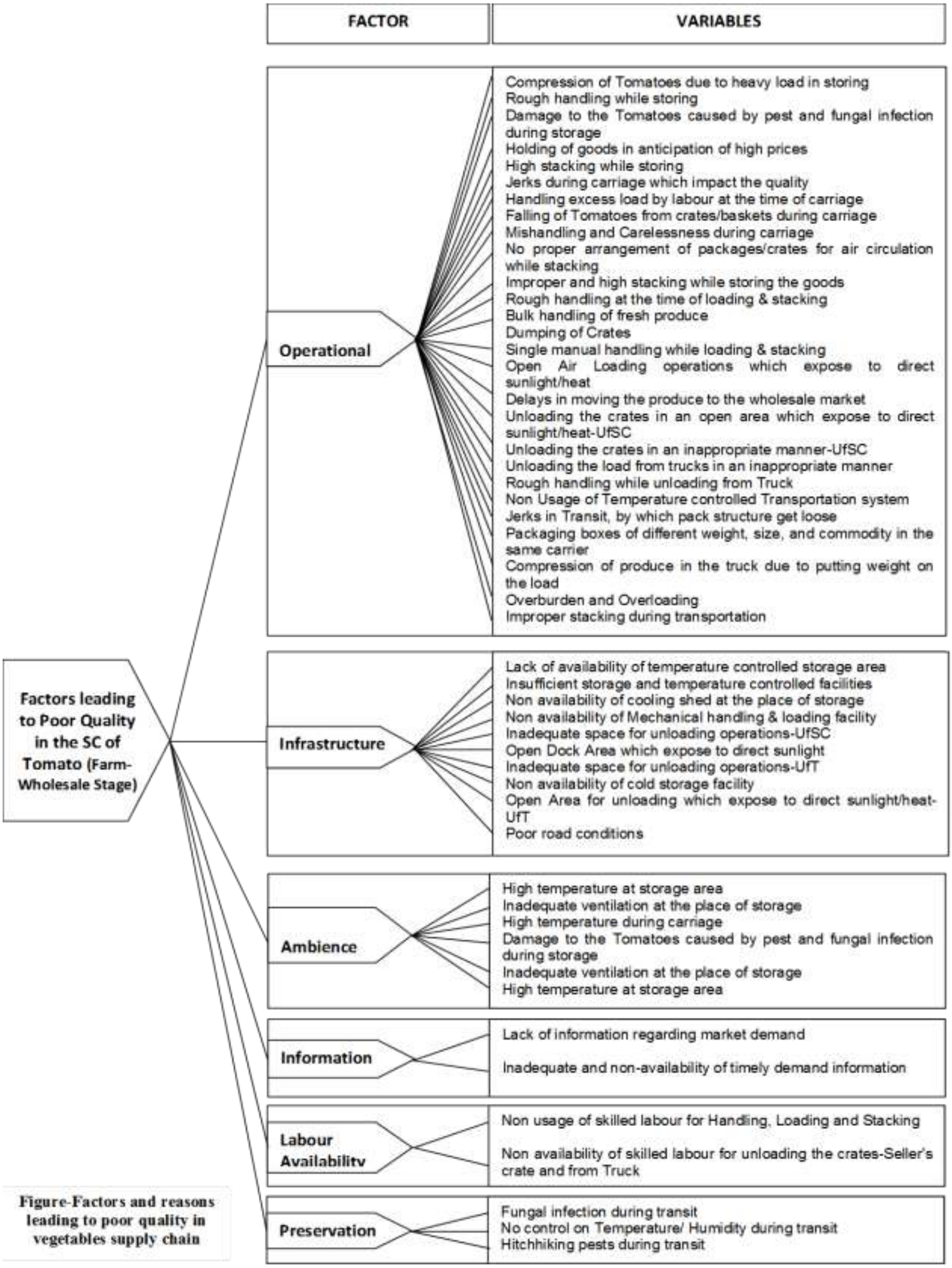



**Figure 5.60: Factors and reasons leading to poor quality in Vegetables SC**

**5.4.3. Findings- Research Objective 3:** *To develop a framework for improving supply chain efficiency of fruits and vegetables sector with specific reference to mango and tomato*

The framework, which has been developed based on the measures suggested by the experts in the area of food supply chain, cold chain, logistics management, and horticulture supply chain is discussed in the next chapter in detail.

**Concluding Remarks**

This chapter concludes the discussion on data analysis and findings of the study. It includes sample profile of the respondents, reliability testing to check the consistency and validity of the questionnaire, and sampling adequacy test through Cronbach alpha. The next chapter discusses the framework, which has been developed based on the findings of the study.

# 6. FRAMEWORK TO IMPROVE SUPPLY CHAIN EFFICIENCY OF FRUITS AND VEGETABLES SECTOR

*This chapter discusses the framework developed for improving supply chain efficiency of F&V sector based upon the measures suggested by the experts through interview method of qualitative research. Further, this chapter presents the interpretation of the framework.*

On the basis of the suggested measures by experts (*as discussed in the previous chapter*), a framework has developed for F&V supply chain with specific reference to mango and tomato. The same is presented in Figure 6.1 and 6.2.

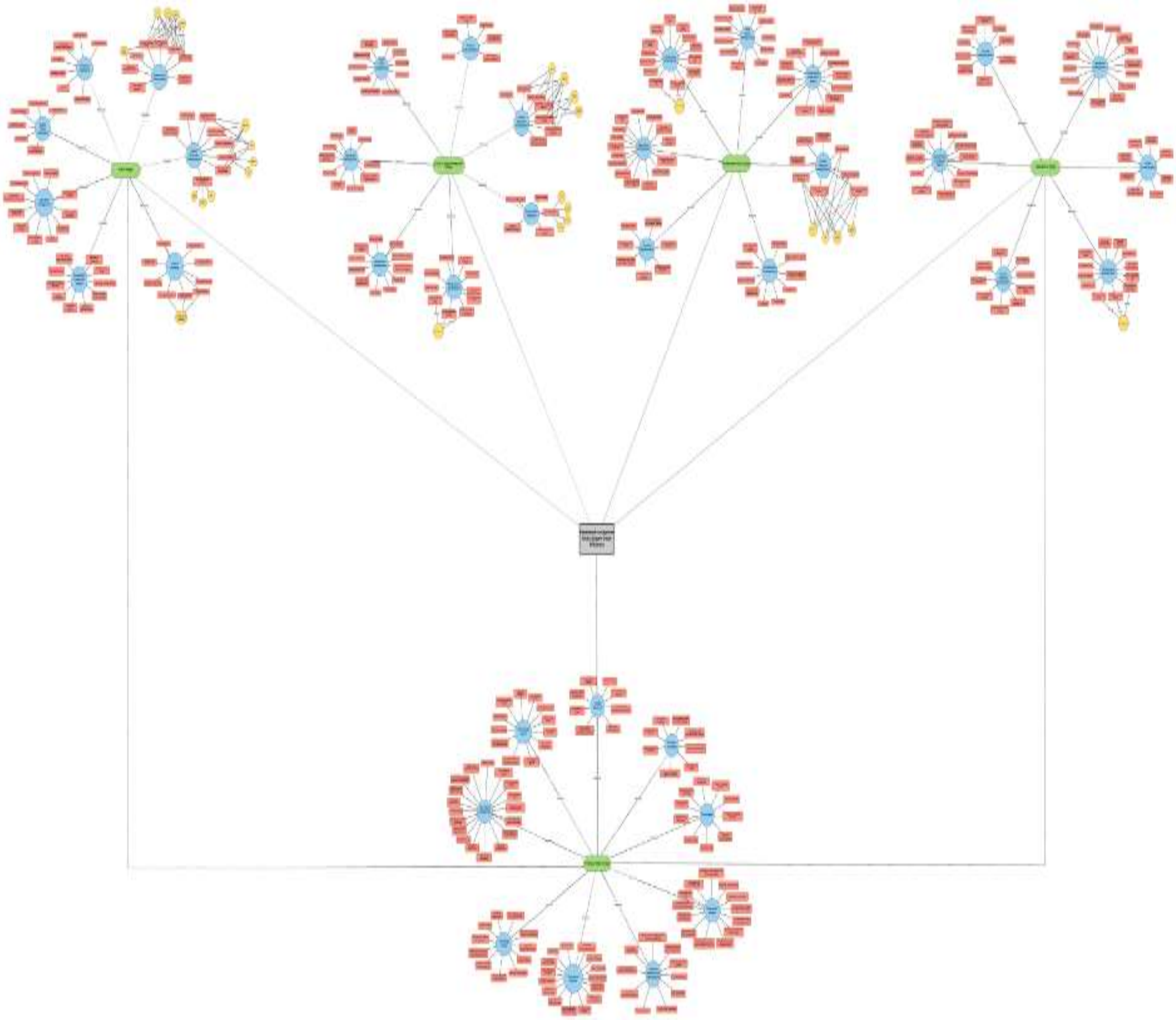


**Figure 6.1: Framework to Improve Supply Chain Efficiency of Fruits with reference to Mango**

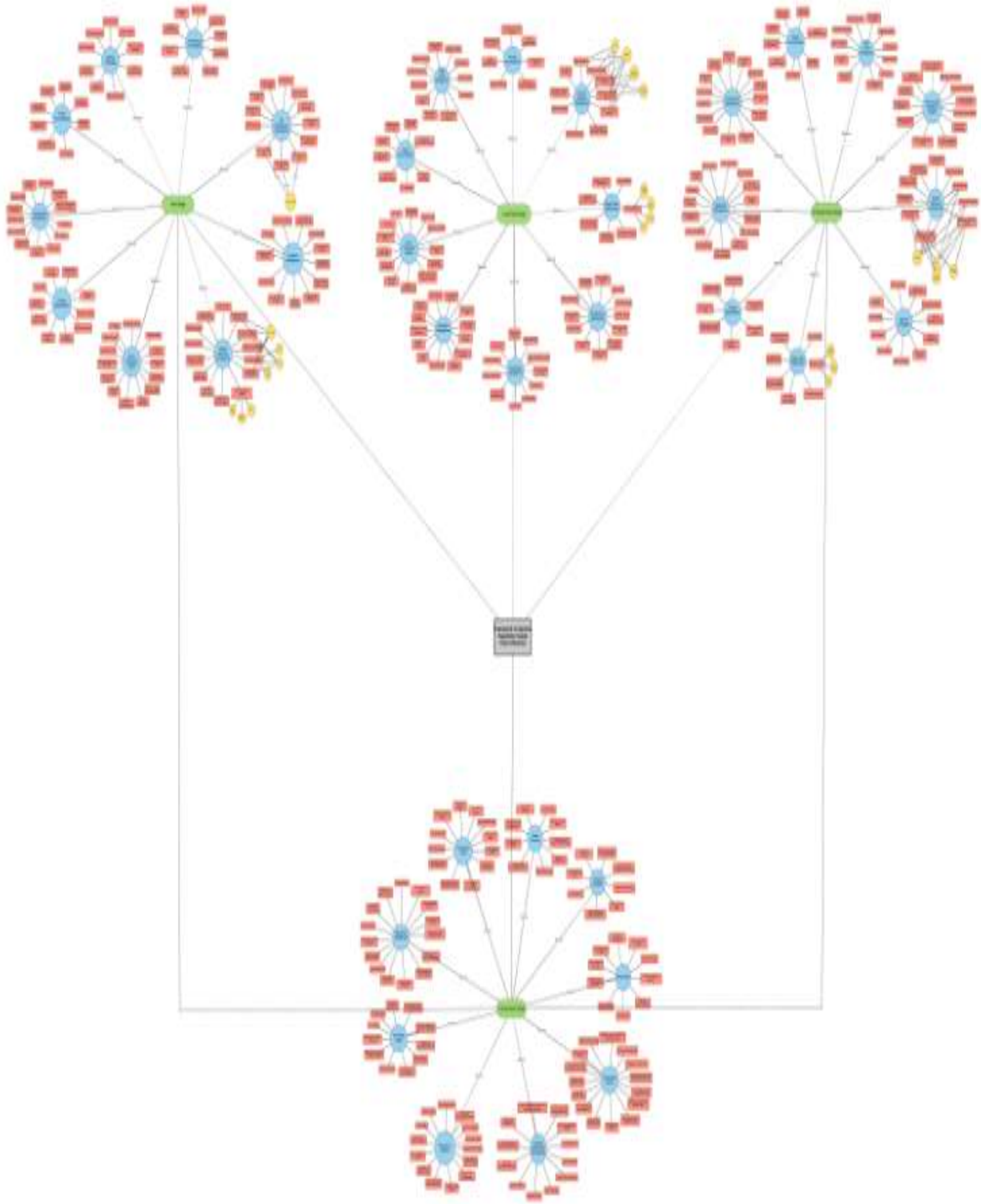


**Figure 6.2: Framework to Improve Supply Chain Efficiency of Vegetables with reference to Tomato**

### 6.1. Interpretation of the Framework

The framework illustrates the measures, which need to be taken at different stages of F&V sector in India to improve the supply chain efficiency.

It is evident that Infrastructural development, human resource development, proper operations management, availability of resources, proper planning, supply chain integration, temperature management, pest control management, process mechanization, proper communication among the partner in the supply chain, and Government/Institutional support are the key measures, which needs to be taken at different stages of F&V supply chain starting from the point of origin i.e. farm stage to other intermediate stages (local commission stage, wholesale mandi stage).

Transportation stage is one of the most important element in the supply chain as it connects all the stages and moves the produce from the point of origin to the point of consumption. In this stage, the focus should be on Freight economy, transport facilitation, temperature control, usage of technology, operations management, economy of distance, and transportation infrastructure development. The government support is also remarkably required to develop the transportation infrastructure system in India for the efficient supply chain.

In the suggested framework, it can be seen that development of infrastructure is the absolute requirement in the F&V supply chain. Development of cold chain, processing units, food parks, packing houses, sorting-grading facilities, development of agri clusters, multi storage cold chain network, covered roof and dock area at major mandis, ripening chambers, farm-road connectivity in hilly areas and micro cold solutions are some of the essential measures,, which will play a significant role in improving the quality of fresh produce in the supply chain.

Human Resource development would help in reducing the cost and time overrun in the supply chain and it leads to increase in shelf life of the produce by better handling and proper sorting and grading activities. Training and development programs, awareness campaigns, development of local labour and its sourcing to get the operations done, capacity building programs, regular field visit by the officials and time to time dissemination of information materials to the man powers would play a significant role in developing the skilled human resources.

Availability of resources like picking platforms, harvesting devices and tools, financial assistance, human resources availability, and availability of packaging materials are some of the relevant measures that needs to be considered to reduce the cost and lead time in the supply chain.

As proper planning is the key to success in every business, the F&V sector also requires the same strategy for effective operations. The activities should be adequately planned so the supply chain can run smoothly. There should be an appropriate planning, which should consider harvesting time, the tools required, check on available resources, frequency of harvesting operations in a particular season, the maturity stage, demand of the market, supply of produce, place to supply and distance, incoming quantity from the supplier, requirement of manpower and packaging materials. These actions will help the stakeholders to perform the operations in a timely manner ensuring quality that to at a minimum cost.

Operational issues are the major problems in the supply chain of F&V. Hence, proper operations and its management are one of the key points to improve the supply chain efficiency of F&V sector. The essential measures, which may be considered for effective operations management are: Proper time frame for the activities, adoption of cross-docking operations, elimination of non-value added activities in the supply chain, time-bound operations, strict supervision and monitoring of activities, avoid overstocking, adoption of responsive strategy, right scheduling of incoming goods, day-to-day inventory controlling, and appropriate packaging of items.

In competitive era, companies are focusing on the high level of integration and collaboration with the trade partners in the supply chain, which helps them to grow and coordinate among the partners. In F&V supply chain also, there is a need of collaboration between the farmer and other firms like food processing units, hotel industry and fresh retailers. Contract farming, horizontal integration for sharing of resources, collaborative decision making to cater the demand, collaboration with the organised market, and collaboration with supply chain solution providers are some of the key measures, which may be considered for supply chain collaboration. The collaboration will lead to the growth of all the stakeholders involved in the supply chain.

As F&V are highly perishable, proper temperature management is must across the supply chain. Some of the measures, which may be considered across the stages to maintain the temperature for extending shelf life of the products are as follows: usage of cooling chambers, micro cold chain solutions, avoid excess amount of heat during the operations, usage of electronic management system and controller for temperature management, containers with ventilation slots, cooling fans in the storage area, proper air circulation, night ventilation technique to store the goods, and usage of reefer trucks for transportation.

It has been revealed that pest control management is crucial in the supply chain, especially in food sector, which would help to prevent the product from contamination. Therefore, there is a need for proper pest control management in different stages of the supply chain. Some of the measures to control the pest are hot water treatment, insect and pest free dock areas, vehicle free from hitchhiking pest, covered vehicle during transit, insect proof packaging boxes, chemical substance free area, usage of food irradiation technology, usage of palletization, proper aisle areas, and routing cleaning of the storage and operational areas.

To reduce the high operational cost and high lead time, there is a need to shift towards mechanized processes in the supply chain. Sorting and grading machinery, technology parks, tech intensive processing units, mobile truck loader and unloader, forklifts, and conveyor belt system are some of the essential steps, which may be considered towards the mechanized system.

Effective communication among the partner in the supply chain is required. Hence, there should be continuous and clear communication between all the stakeholders to pass on the real-time information regarding market demand. Transparent communication, high level of trust among the partners, continuous information from Agro Produce Marketing Committee (APMC), and Horticulture information system are the measures for effective communication in the supply chain.

One of the primary objectives of logistics is to minimise the freight charges. Therefore, the focus in transportation should be on freight economy. Some of the key measures to achieve freight economy are the adoption of consolidation practice, responsive strategy, collaboration with transport providers, use of multi-modal transportation, proper route planning, and selection of the shortest route.

It is also essential to highlight the Government intervention in order to improve the supply chain, which is required in F&V sector starting from the farm gate to the wholesale level. For improving efficiency at every stage of the supply chain, there should be constant support from the government to the stakeholders, i.e., the farmers, local traders, wholesalers. It is also vital to encourage entrepreneurship in the area of agriculture by providing subsidies and less interest rate. There should be a sound and effective policy environment, which promotes investment and formation of alliances/commodity-based clusters to overcome the constraints of a limited number of facilities. Private player should be encouraged for the development of cold chain, processing units, food parks and other facilities nearby the major production areas and major markets. Moreover, the government should make the action plan for the infrastructure development of F&V wholesale markets. Government support is necessary at each and every step while going forward towards the development of efficient supply chain. The support may include regulation of rental charges, free entry of private players, assistance in the purchase of machinery, subsidy on electricity cost, promoting cooperative societies, controlling and monitoring of hoardings, and development of ropeways system in the hilly areas to connect the point of source to the main roads. The government will play a crucial role in the development of infrastructure pertaining to agriculture, transportation, and dock areas, as they are one of the key stakeholders in the chain.

National Centre for Cold Chain Development (NCCD), National and State Horticulture Board (NHB), National Skill Development Council (NSDC), National Bank for Agriculture and Rural Development (NABARD), Asian Development Bank (ADB), Ministry of Food Processing Industries (MoFPI), Ministry of Agriculture & Farmers' Welfare (MoAFW), Ministry of Micro, Small and Medium Enterprises (MSME), and Agri supporting institutions/university are some of the key organisations, which will play a vital role in developing the supply chain more efficient through various initiatives. Among other initiatives the development of cold chain, micro cold chain units, food processing units, sorting grading facilities, and food parks; development of smart mandi systems (proper dock area, cooling and ripening chambers, micro cold chain solutions); development of man power through training programs; awareness campaigns; development of transportation infrastructure in terms of road penetration, farm connectivity, ropeway systems, and expansion of Horti trains should also be emphasised upon.

**Concluding Remarks**

This chapter concludes the framework developed for improving supply chain efficiency of F&V sector based upon the measures suggested by the experts through interview method of qualitative research. Next chapter describes the conclusion of the study, recommendation by the researcher, limitation and future scope of the study & finally, highlights the contribution of this study to the present literature.

# 7. CONCLUSION AND RECOMMENDATION

*This chapter presents the conclusion of the study, revealing the importance of framework developed for improving supply chain efficiency of F&V sector with specific reference to mango and tomato in India. It also discusses the limitation of this study and future research direction, thereby followed by recommendations based on the findings. The ultimate aim of any study is to spell out the final significant contribution to knowledge; hence, this chapter briefly presents the factors leading to inefficiency at various stages of mango & tomato and further presents the contribution of this study to present literature.*

## 7.1. Conclusion

The F&V sector is an emerging and fast-growing business sector in India. F&V sector in the case of agriculture and allied sector in India accounts for a significant share in the world production. The literature review reflects that the entire supply chain is suffering from maximum inefficiencies, which are resulting in the massive amount of losses and wastages and become one of the key impediments in the agricultural economy. The literature further revealed that various studies are available on the supply chain of agri and other products, but hardly any study could be found on suggesting a framework for improving supply chain efficiency at various stages of F&V sector. This research gap has been addressed in this study.

Sorting, Grading & Packaging and Tying, Plucking & Collection, Handling, Loading & Stacking of goods, Unloading of Crates/Cartons/Wooden Box from Trucks at Mandi Level, Storing & Ripening, and Transportation (During transit) from Farm to Wholesale Mandi are some of the activities, which are found as the weak link and contributing to supply chain inefficiency in Fruits sector with specific reference to mango.

In tomato supply chain, Carriage of crates to the Collection Area/Collection Centre, Unloading of tomato and loading to the buyer's crate, Storing of fresh produce at Mandi area, and Transportation (During transit) of tomatoes from farm to Wholesale Mandi are some of the activities, which are found as the weak links and contributing to supply chain inefficiency.

This study reveals that Resources, Operational Charges, Infrastructure, Labour’ s Knowledge, Operational issues, Imprudence, Labour Availability, Quality Control System, Standardisation, Connectivity, Labour, Ambience, Preservation, Labour Charges, Information, Techniques, Market Uncertainty, Rates & Charges, Transit Ease, Verification & Frisking, Geography, Technical Resources and Resources/Transport Facilities are the factors leading to supply chain inefficiency in different stages of F&V supply chain with specific reference to mango and tomato.

The measures, which need to be taken for an important reason/major reasons under each factor leading to supply chain inefficiency were identified and used to develop a framework. The study found that government support is hugely required at each stage to develop the efficient supply chain of F&V sector, which will help to improve the scenario of the agricultural sector and will give better returns to the farmers and also help to enhance and improve the food economy of India.

The study reveals that Infrastructural development, Human Resource development, Operations management, Availability of resources, Use of technology, Accurate planning, Supply chain integration, Temperature control, Pest control management, Process mechanization, Effective communication among the partners in the supply chain, and Government/Institutional support are some of the critical elements in the framework, which will improve the supply chain efficiency.

The current research represents one of the first efforts to develop a framework to improve supply chain efficiency of F&V sector in India. The framework will benefit the stakeholders involved in the process of decision making like Farmers, Local Traders, State Government, Department of food processing industries, Policymakers, Transportation and logistics companies, Cold Chain Solution Providers, Private agri-business companies, APMC, Wholesalers in planning and executing their operations accordingly.

As Indian economy is based on agriculture, and there is enormous potential to serve markets through various value addition, development of efficient supply chain will play a crucial role in reducing the losses and wastages, increase in farmer income, develop the avenues of exports, generate employment opportunities for the local people, and improve the livelihood of the farmers and various other stakeholders, which will leads to growth economy and help India to emerge as a global leader in Food Sector.

### 7.2. Limitations

The study has been limited to the supply chain of F&V with specific reference to mango and tomato from farm stage to wholesale stage. With the change in geography, the specific factors may change such as the infrastructure, resources availability, and farmer's knowledge. This study is limited to the traditional model of F&V supply chain, and the results are thus limited to only those players who are involved in the traditional model.

The measures given in this study are limited to only the most important variable under each identified factors for inefficiency in the supply chain of mango and tomato with respect to cost, time, and quality.

Further, the language barrier to collect data from illiterate & less educated farmers was one of the challenge in this study.

### 7.3. Directions for Future Research

The study conducted has opened up promising vistas for future research. As the measures given in this study are limited to only the most important variable under each identified factors for inefficiency, the measures for other reasons may also be looked out in a future study. Moreover, a similar study can be carried out in other geographic regions or compared with the supply chain of developed countries. Also, the study included the traditional players of the F&V supply chain in India from farm to the wholesale stage; the factors can also be identified for retail stage.

A similar empirical study may further be carried out for the supply chain of the related sector like food processing unit, beverages industry, pharmaceutical cold chain and other fresh produce such as apple, litchi, potato, and onion. Finally, an attempt can also be made to develop a similar framework for the organised/modern food supply chain.

## 7.4. Recommendations

As this study has focused on different stages of F&V Supply Chain, the recommendations for each stage in F&V are as follows:

***Farm Stage***

- Private players, as well as cooperative societies/associations, should be encouraged to establish processing units and cold storages nearby significant production areas where the farmers can avail the facility of mechanized sorting and grading activities. The access charges should be fixed and regulated by the government, which should be reasonable so that the farmers can afford the cost of operations. The development institutions can play an essential role in setting up of these kinds of facilities at the major production areas.
- As lack of skilled labour was found one of the major issues, the workforce should be trained and made aware about the different techniques to sort, grade and handle the perishable produce, which would help in maintaining the quality and quick operations during the peak season time. As F&V are highly perishable in nature, proper handling and care is a must for them. These initiatives can be taken through awareness campaigns and a direct field visit to horticulture officer. They should create awareness on proper sorting and grading practices, handling system management in loading/unloading of the vehicle and of produce from crates. Development and dissemination of information manuals to the workers and stakeholders for their better understanding of the techniques would also be a great idea to go further for a better change. The agriculture supporting institutions such as Uttarakhand Horticulture Board, Uttar Pradesh Horticulture Board, NABARD, NIFTEM, Krishi Vigyan Kendra, and Agriculture universities should focus on skill development of the workers so they can adopt the best logistics practices and perform their functions effectively and efficiently.

- Supply chain collaboration between the farmer and private players like fresh retailers, hotel industry, and food processing units will also play a crucial role to reduce the burden of farmers. Logistics hub may be developed nearby the major production areas to create a point between the farmers and the company. This practice will help both the farmers and the stakeholders. They can directly purchase the healthy and quality graded produce directly from the farm gate, which in return, also save the transportation cost and other operating costs of the farmer. This initiative can be a good step towards making the F&V supply chain more organised.
- Well established information system for better coordination among different stakeholders from farmers to consumers is the need of the hour. There should be a continuous communication between all the stakeholders to identify the exact requirements of the market as harvest time approaches, and also to let the buyers know about the best time of harvest and expected quality. Continuous information can also be provided through FM radios, eNAM (National Agriculture Market), Kisan Vigyan Kendra, and Kisan Channels.
- In hilly regions, the concentration should be on the development of infrastructure to connect the farm to the road areas. As the fresh produce grown in the hilly region has its importance to fulfill the demand gap during the peak season, an extensive ropeway system should be developed, which will be the best solution to reduce the cost and time overrun in the supply chain. Horticulture Mission for North East and Himalayan States (HMNEH), Ministry of Transportation, MoFPI, MSME and Ministry of Agriculture and Farmers Welfare (MoAFW) should set up a coordination cell for the development and betterment of transportation network system in hilly regions.

***Local Commission Stage***

- For prolonged shelf life of the produce and value addition in the supply chain, semi-processing units should be developed nearby the major production areas. These processing facilities must be well-equipped with the necessary facilities for primary processing.
- The operations related to loading and unloading of crates for further sale should be done under a covered area to safeguard the fresh produce from

direct sunlight. The supplier and buyer can establish the temporary shed around the operation area to provide adequate shade to the produce during unloading and loading of crates.

- Packaging is also vital to maintain the quality of fresh produce. The containers shall meet the quality, hygiene, ventilation and resistance characteristics to ensure proper handling, shipping, and preserving the fresh produce. Indian Institute of Packaging may play an active role.
- The packages should be stacked and arranged in such a manner that there is proper air circulation. Storage site structure should be protected from excessive humidity, excessive heat, and direct sunrays.

***Wholesale Mandi Stage***

- Micro cold chain solutions and pre-cooling facilities should be developed at Mandi level, so there can be a proper cold chain network through, which the product may move on to the market without affecting the quality.
- Rather than using private cold storage facilities, the wholesalers can come up with their cooperatives. The establishment of co-operatives has done much in certain countries. Government support is required to develop such infrastructure at wholesale mandi. National Centre for Cold Chain Development (NCCD), Agro Produce Marketing Committee (APMC) may play a significant role in this initiative.
- There is a need of process mechanization at the wholesale level, as large amount of fresh produce is arriving and handled in a single day. Mobile loader and unloader, Mini forklifts, and palletization should be adopted at this level to handle larger quantity of goods. National Small Industries Corporation (NSIC), SIDBI, Regional Rural Banks (RRBs), and Cooperative banks may support in hire and purchase of Material Handling Equipments (MHEs).
- The poor dock area at wholesale mandi has been found as one of the reasons for the high lead time in operations and poor quality. The mandi needs to be smart to conduct proper operations, which will ensure the safe and timely completion of loading and unloading operations. Smart mandi can be developed like smart cities, which would consist of well-planned and

equipped infrastructure for handling and storage of F&V. The NCCD, NHB and MoAFW should prepare an action plan for this purpose and estimate requirements of funds for creating more dock space at Mandi.

***Mashakhor-Local Trader Stage***

- The MoFPI should establish the mini food parks nearby the wholesale Mandi region. These food parks will help the traders to keep their items fresh at low rental cost.
- The trader can look for the forward integration with different agencies like hotel industry, fresh retailers to sell the product. This integration will reduce the inventory carrying cost and timely delivery of produce to the customers.
- The National Informatics Centre, Horticulture Information Centre, GoI and MoAFW should focus on the establishment of National/Regional information networking system through which the information regarding the market can be disseminated to all the stakeholders in the supply chain.

***Transportation Stage***

- As a massive problem of traffic congestion occurs especially during peak season, dedicated rail service can be set up during these periods from June to August for the movement of fresh produce covering major production areas to Azadpur Mandi, Delhi. Transportation through dedicated rail service would save the cost of the stakeholders and reduce the dependency on road mode of transportation. Ministry of Railways and Ministry of Transport may prepare an action plan to improve the road congestion situation.
- For cost-efficient transportation, consolidation practice should be adopted by the stakeholders to share the cost. Fresh produce for the same destination can be transported through one vehicle, which will reduce per unit cost of transportation.
- For transportation of agri produce especially perishable items, the transporter should focus on covering the distance between two points through the shortest route taking into consideration various factors like traffic jams, congested route, and improper road conditions. With the help of proper analysis of the available routes, the best route can be easily determined, which would save the time and cost of the transporter.

- In 2012, several Government agencies made a combined effort (Indian Railways, the Container Corporation of India and the National Horticulture Board of the department of agriculture) and started the concept of Horti-trains for transportation of horticultural produce to connect major fruit and vegetable-producing centers with the consuming ones. Now, there is a need to extend the transportation network of the Horti- trains to the major horticulture production areas covering major markets. This will maintain the quality of the product as well as reduce the cost and lead time in the food supply chain.

## 7.5. Contribution to present Goldratt's "Theory of Constraints" Thinking Processes

While the TOC was developed for manufacturing, through Goldratt's Thinking Process, the Thinking Process system has been used in many cases, to improve performance and resolve problems in many business processes.

The ultimate aim of any study such as this is to spell out the final significant contribution to knowledge. Most organisational scholars do not generate theory from scratch but generally, work to contribute to what already exists, and this is undoubtedly the case here.

This research will contribute to knowledge in the following manner:

This research presents the answers to the following question (Shown in Figure 7.1) of Goldratt's "Theory of Constraints" Thinking Process concerning the Supply Chain of F&V sector in the Indian scenario. The Figure 7.1 shows how the approach of "TOC Thinking process" has been used in this study.

The finding of this research has contributed to the literature on Goldratt's Theory of Constraints Thinking Process for the supply chain of F&V sector in the Indian scenario. The present research has identified the core constraints responsible for inefficient supply chain in F&V sector and developed a framework to improve the current situation and minimise the current losses, which would be beneficial to the grower, traders, consumers and ultimately the Indian economy.

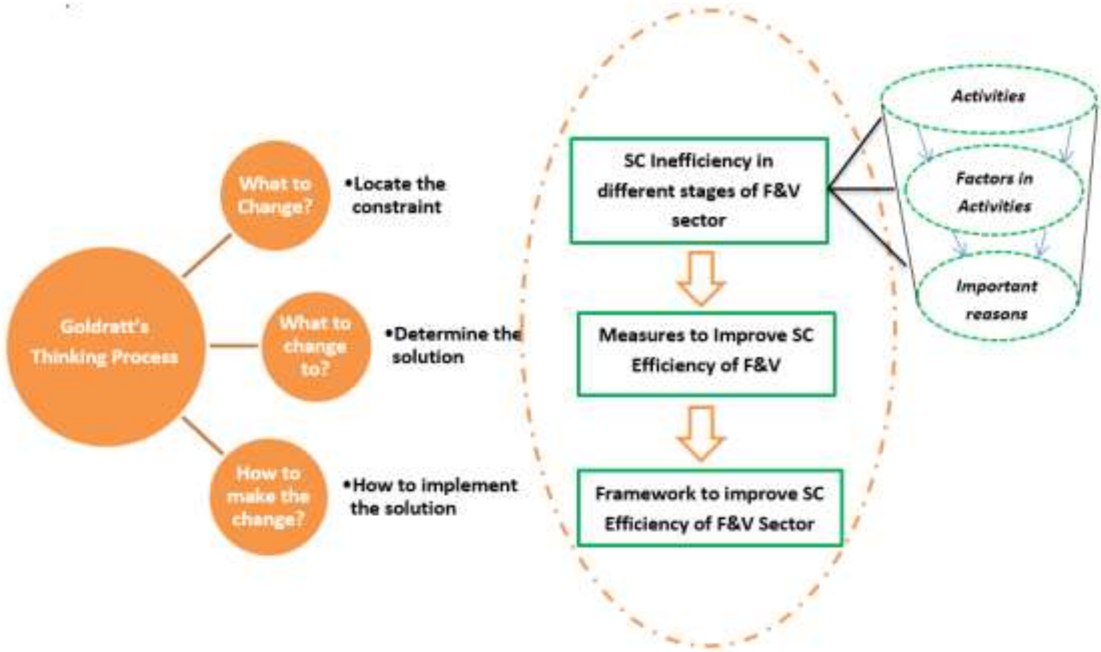



**Figure 7.1: Contribution to present Goldratt's "Theory of Constraints" Thinking Processes**

As most of the prior literature on TOC Thinking Process is focused on the manufacturing and service sector for improving the business performance, there is a lack of literature specifically on F&V supply chain in Indian context. This study used the approach of TOC Thinking process to improve the supply chain efficiency of F&V sector in India, thus filling the gap in the literature of "Theory of Constraints Thinking Process".

This framework will help various stakeholders involved in the chain, i.e., Farmers, Local Commission Agents, Local Traders, Wholesalers, Agribusiness organisation, National Horticulture Board, and State Horticulture Board to reduce the losses and wastages in F&V supply chain.

# REFRENCES


1. Adeoye, I., Odeleye, O., Babalola, S., & Afolayan, S. (2009). Economic Analysis of Tomato Losses in Ibadan Metropolis, Oyo State, Nigeria. African Journal of Basic & Applied Sciences, 1(5-6), 87-92.
2. Ajagbe, B. O., Oyediran, W. O., Omoare, A. M. and Sofowora, O. O. (2014). Assessment of Post-harvest Practices among Tomato (Solanum lycopersicum) farmers/processors in Abeokuta North Local Government Area of Ogun State, Nigeria. International Journal of Education and Research Vol. 2 No. 3 March 2014.
3. Alam, G. and Verma, D. 2007. Connecting small-scale farmers with dynamic markets: A case study of a successful supply chain in Uttarakhand, India. Centre for Sustainable Development, Dehradun, India.
4. Alber, K. L. & Walker, T. W. (1997). Supply Chain Management: A Practitioner's Approach. The Educational Society for Resource Management, 203-210.
5. Ali J., Singh S.P. and Ekanem E. (2009) Efficiency and productivity changes in the Indian food processing industry: Determinants and policy implications. International Food and Agribusiness Management Review 12: 43–66.
6. Amonge, Augustine O., 2015, "Application of Goldratt's thinking Process to Constraints within an Emergency Department—A Case Study". Masters Thesis & Specialist Projects. Paper 1551. http://digitalcommons.wku.edu/theses/1551
7. Anon. (1982). Results of the Nagpur mandrin-oranges trade development project, 1982-Experimentation. Nagpur unit: GOI.
8. Anon. (1985). Marketing of Fruits and Vegetables, Agricultural Marketing series, DMI, Ministry of Food and Agriculture,. New Delhi: Government of India.
9. Aradya, S., Habibunnisa, R., Thiagu, B., Aravinda Prasad, M. S., na, K. V., Rodriguez, R., et al. (1990). Evaluation in handling losses in tomatoes during commercial transportation. National Workshop on Post-harvest Management of Fruits and Vegetables; 14-16 March. Nagpur.
10. Aramyan, L.H., Lansink, A., van der Vorst, J. and van Kooten, O. (2007), "Performance measurement in agri-food supply chains: a case study", Supply Chain Management: An International Journal, Vol. 12 No. 4, pp. 304-15.
11. Arrindell, W. A., & van der Ende. J. (1985). An empirical test of the utility of the observations-to-variables ratio in factor and components analysis. Applied Psychological Measurement, 9, 165 - 178.
12. Artiuch, P., & Kornstein, S. (2012). Sustainable Approaches to Reducing Food Waste in India. MIT Independent Activities Period Research Project. MIT. Massachusetts. Retrieved from http://news.mit.edu/2012/sustainable-approaches-to-reducing-food-waste-in-india.
13. Arumugam, N., F.M. Arshad., E.F.C. Chiewand M. Zainalabidin, 2010. Supply chain analysis of fresh fruits and vegetables (FFV): prospects of contract farming. Agricultural Economics, 56 (9): 435-442.
14. Arunachalam, R. (2003). The Trading Agent Competition Supply Chain Management Game. Carnegie Mellon University, School of Computer Science, Institute for Software Research International.
15. ASSOCHAM. (2013). Horticulture Sector in India- State level experience. New Delhi: The Associated Chamber of Commerce and Industry of India.
16. Atibudhi, H. (1987). An estimation of post-harvest loss of onion and its management in Nawapada district of Orissa. Indian Journal of Agricultural Marketing, 11(1 & 2), 26-30.
17. Ayers, J. (2001). Handbook of Supply Chain Management. Boca Raton Fl: Saint Lucie press.

18. Ayub, G. and Siraj, M. (2008). Mango Commodity Chain Study: Knowledge Gap and use of ICTs in the Chain in India. CABI South Asia, Rawalpindi, Pakistan, 18 pp.
19. Babalola, D. A., T., O. B., Oyekanmi, M. O., & O, M. Y. (2010). Determinants of post harvest losses in tomato production: a case study of Imeko – Afon local government area of Ogun state. acta SATECH-Journal of Life and Physical Sciences, 3(2), 14-18.
20. Babalola, D., Megbope, T. A., & Agbola, O. P. (2008). Post Harvest Losses in Pineapple Production: A Case Study Of Ado-Odo Otta Local Government Area Of Ogun State. Bowen Journal of Agriculture, 5(1 & 2), 55-62.
21. Bahinipati, B.K. (2014), “The procurement perspectives of fruits and vegetables supply chain planning”, International Journal of Supply Chain Management, Vol. 3 No. 2, pp. 111-131.
22. Balaji, M. and Arshinder, K. Modeling the causes of food wastage in Indian perishable food supply chain. Resour. Conserv. Recycl. 2016, 114, 153–167.
23. Ballou, R. H. (2004). Business logistics/Supply chain management : planning, organizing, and controlling the Supply chain. Upper Saddle River, N.J.: Pearson Prentice Hall.
24. Banerjee, A., & Mukhopadhyay, S.K. (2016). A contemporary TOC innovative thinking process in the backdrop of leagile supply chain. Journal of Enterprise Information Management, 29(3), 400-431. https://doi.org/10.1108/JEIM-08-2014-0086
25. Bartlett, J.E., Kotrlik, J.W., and Higgins, C.C. (2001). “Organizational Research: Determining Appropriate sample Size in Survey Research”. Information Technology, Learning, and Performance Journal, 19(1), pp 43-50 (Spring).
26. Battour, M., M., K. (2011) The impact of Islamic attributes of destination on tourists' motivation, satisfaction and destination loyalty / Mohamed Mohamed Kamal Battour. PhD thesis, University of Malaya. http://studentsrepo.um.edu.my/3216/
27. Beamon, B. M. (1999). Measuring Supply chain performance. International Journal of Operations & Production Management, 19(3), 275-292.
28. Bernard, H. R. (2002). Research Methods in Anthropology: Qualitative and Quantitative Methods (3rd ed.). Walnut Creek, CA: Alta Mira Press.
29. Berry, D., Towill, D., & Wadsley, N. (1994). Supply Chain Management in the Electronics Products Industry. International Journal of Physical Distribution and Logistics Management, 24 (10), 20-32.
30. Bhardwaj, R. K., Sikka, B. K., Sharma, M. L., Singh, A., & Singh, N. K. (2011). Sustainable Agriculture for Increasing Efficiency of Tomato - Value Chain in Uttarakhand (India). International Conference on Technology and Business Management (pp. 15-26). Szabist: AIMS International.
31. Bhardwaj, S., & Palaparthy, I. (2008). Factors Influencing Indian Supply Chains of Fruits and Vegetables: A Literature Review. The Icfai University Journal of Supply Chain Management, 5(3), 59-68.
32. Bhardwaj, S., & Palaparthy, I. (2008). Factors Influencing Indian Supply Chains of of Fruits and Vegetables: A Literature Review. The Icfai University Journal of Supply Chain Management , V (3), 59-68.
33. Bhushan, N. (2013). Post-Harvest Profile of Mango. Nagpur Office: Directorate of Marketing & Inspection, Ministry of Agriculture, Government of India.
34. Bigliardi, B. and Bottani E., (2010), "performance measurement in the food supply chain: a balanced scorecard approach", Facilities, 28 (5/6), p. 249-260
35. Bishara, R. H. (2006). Cold chain management – an essential component of the global pharmaceutical supply chain. Retrieved from American Pharmaceutical Review: www.americanpharmaceuticalreview.com/life_science/Bishara_APR.pdf
36. Blackburn, J., & Scudder, G. (2009). Supply chain strategies for perishable products: the case of fresh produce. Production and Operations Management , 18 (2), 129-137.
37. Blandon, S. Henson and J. Cranfield, “Small-Scale Farmer Participation in New Agri-Food Supply Chains: Case of the Supermarket Supply Chain for Fruit and Vegetables in

Honduras," Journal of International Development, Vol. 21, No. 7, 2009, pp. 971-984. doi:10.1002/jid.1490
38. Boer, K. D., & Pandey, A. (1997). India's sleeping giant: food. Mckinsey Quarterly.
39. Borgstrom, B., 2005, "Exploring efficiency and effectiveness in the supply chain: a conceptual analysis". In: Proceedings from the twenty-first IMP conference, Rotterdam, Netherlands; 2005.
40. Bosona, T., and Gebresenbet, G. (2013), "Food traceability as an integral part of logistics management in food and agricultural supply chain", Food Control, Vol. 33 No. 1, pp. 32-48.
41. Bowersox, D. J., & Closs, D. J. (1996). Logistical Management – The Integrated Supply Chain Process. New York.: McGraw-Hill Companies Inc.
42. Bowersox, D. J., Closs, D. J., & Stank, T. P. (2000). Ten mega-trends that will revolutionise Supply chain logistics. Journal of Business Logistics, 21(2), 1-16.
43. Broekmeulen, R., 1998. Operations management of distribution centers for vegetables and fruits. International Transactions in Operational Research 5 (6), 501–508.
44. Brown, S. (2010). Likert Scale Examples for Surveys. Iowa State University Extension. Retrieved from http://www.extension.iastate.edu/ag/staff/info/likertscaleexamples.pdf
45. Bryant, F. B., & Yarnold, P. R. (1995). Principal components analysis and exploratory and confirmatory factor analysis. In L. G. Grimm & R R. Yarnold (Eds.), Reading and understanding multivariate statistics (pp. 99-136). Washington, DC: American Psychological Association.
46. Bryman, A. & Bell, E. (2007). Planning a research project and formulating research questions. In: Business Research Methods. New York. Oxford University Press. P. 75-92.
47. Brzozowska, A., Kabus, J., & Nowakowska-Grunt, J. (2016). Theory of Constraints in Designing the Logistics Information System in Agribusiness. Scientific Journal of Silesian University of Technology. Series Transport, 365-374.
48. Bubny, P. (2000), ``Keeping cool with RFIDS'', Supermarket Business, Vol. 55, No. 5, p. 95.
49. Bukeviciute, L., Dierx, A., Ilzkovitz, F. and Roty, G. (2009), "Price transmission along the food supply chain in the European Union", In 112th seminar of the European Association of Agricultural Economists, pp. 3-6.
50. Burt, D.N., Dobler, D.W. and Starling, S.L. (2003), World Class Supply Management: The Key to Supply Chain Management, 7th Edition, McGraw-Hill Irwin, New York.
51. Buyukbay, E., Uzunoz, M., & Bal, H. (2011). Post-harvest losses in tomato and fresh bean production in Tokat province of Turkey, Scientific Research and Essays, 6(7), 1656-1666.
52. Cadilhon, J., Fearne, A., Tam, P., Moustier, P., and Poole, N. (2005) 'Collaborative commerce or just common sense? Insights from vegetable supply chains in Ho Chi Minh City.'Supply Chain Management: an International Journal, 10 (3). pp. 147-149.
53. Cadilhon, J.J., Fearne, A.P., Moustier, P. & Poole, N.D. (2003). Modeling vegetable marketing systems in South East Asia: phenomenological insights from Vietnam. Supply Chain Management: An International Journal, 8 (5), 227-241.
54. Callanan, G., 2006, "Improving Supply Chain Efficiency in the Retail Sector", Supply Chain Europe; 15, 2; ABI/INFORM Complete, pg. 22
55. Canfora, I. (2016), "Is the Short Food Supply Chain an Efficient Solution for Sustainability in Food Market?", Agriculture and Agricultural Science Procedia, Vol. 8 No. 1, pp. 402- 407.
56. Cavana, R. Y., Delahaye, B. L., & Sekaran, U. (2008). Applied business research: qualitative and quantitative methods: New York: John Wiley
57. CEAGESP. (2002). Diganao ao desperdicio. Disponivelem. Retrieved July 28, 2013, from http://www.ceagesp.com.br>
58. Chadha, K.L. & Pareek, O.P. (Eds) (1993). Advances in Horticulture Volume 3 – Fruit Crops, Malhotra Publishing House, New Delhi

59. Chandrashekar, H. (2009) Supply Chain Management of Fruits and Vegetables in Karnataka—A Study of Safal Market, Bangalore, Karnataka, India. Interdisciplinary Journal of Contemporary Research in Business, 1, 43.
60. Chang, M. and Chiu, Y., 2010. Supply Chain Efficiency Analysis: A Theoretical Approach. The Journal of Applied Business Research, 26 (6), pp. 4129-444.
61. Chen J. (1997). Achieving maximum Supply chain efficiency. IIE Solutions, Vol. 29, pp. 30-35.
62. Chopra, S., Meindl, P. and Kalra, D.V. (2010). Supply chain management: Strategy, planning and operation. Pearson Prentice Hall, Noida.
63. Choudhary, S., K. 2013. Contribution of National Horticulture Mission in agricultural development, International Journal of Advanced Research in Management and Social Sciences, 2(6): 52-64.
64. Christopher, M. (1998). Logistics and Supply Chain Management: Strategies for Reducing Costs and Improving Services. London: Pitman.
65. Churchill, G., & Peter, P. J. (1984). Research design effects on the reliability of rating scales: a meta-analysis. Journal of Marketing Research(21), 360-375.
66. CII. (1997). The Fruit and Vegetable Opportunity:Food and Agriculture Integrated Development (FAID) Action Report. Mckinsey Report.
67. CIPHET (Central Institute of Post-Harvest Engineering and Technology). 2010. Estimation of Quantitative Harvest and Post-harvest Losses of Major Agricultural Produce in India All India Coordinated Research Project on Post-harvest Technology, CIPHET (ICAR), Ludhiana, 2010.
68. Clements, M.D., Lazo, R.M., Martin, S.K., 2008. Relationship connectors in NZ fresh produce supply chains. British Food Journal 110 (4/5), 346–360.
69. Collin, J. (2003). Selecting the right Supply Chain for a Customer in project business. Helsingfors: Diss. Tekniska högskolan Helsingfors.
70. Cooper, M. C., & Ellram, L. M. (1993). Characteristics of Supply Chain Management and the implications for purchasing and logistics strategy. The International Journal of Logistics Management, 4 (2), 13-24.
71. Cooper, M. C., Ellram, L. M., Gardner, J. T., & Hanks, A. M. (1997b). Meshing multiple alliances. Journal of Business Logistics , 18 (1), 67-89.
72. Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997a). Supply Chain Management: More than a New Name for Logistics. The International Journal of Logistics Management, 8 (1), 1-14.
73. Cooper, M. J., and Loe, T., W. 2000. Using the theory of constraints' thinking processes to improve problem-solving skills in marketing. Journal of Marketing Education 22 (August): 137-46.
74. Creswell, J. W. (1994). Research Design: Qualitative and Quantitative Approaches. Thousand Oaks. CA: Sage.
75. Creswell, J.W. and Plano Clark, V.L. (2011) Designing and Conducting Mixed Methods Research. 2nd Edition, Sage Publications, Los Angeles.
76. Croom, S., Romano, P., & Giannakis, M. (2000 ). Supply chain management: an analytical framework for critical literature review. European Journal of Purchasing & Supply Management, 6, 67-83.
77. Dagar, S. S. (2007, May 20). Agriculture's Second Wind. Business Today.
78. Danese, P., Romano, P., 2011. Supply chain integration and efficiency performance: a study on the interactions between customer and supplier integration. Supply Chain Management: An International Journal 16 (4), 220–230.
79. Dastagiri M.B and Immanuelraj T.K (2012) Supermarket Supply Chains in Horticulture in India: The Novel Marketing Models, Effects and Policies. Agrotechnology 1:107, doi10417/2168-9881

80. De Meyer, A., Nakane, J., & Miller, J. G. (1989). Flexibility: the next competitive battle the manufacturing futures survey. Strategic Management Journal, 10, 135-144.
81. DeCoster, J. (1998). Overview of factor analysis. Retrieved May 08, 2014 from http://www.stat-help.com/notes.html
82. Degun, G. (2014, January 27). Supply chain inefficiency to blame for majority of wasted food. Retrieved February 19, 2018, from CIPS-Supply Management: https://www.cips.org/supply-management/news/2014/january/supply-chain-inefficiency-to-blame-for-majority-of-wasted-food/
83. De-la-Fuente, M.V., Ros, L., 2010. Cold Supply Chain Processes in a Fruit-and-Vegetable Collaborative Network, in "Balanced Automation Systems for Future Manufacturing Networks" Ortiz, Darío, Gómez, Eds. Springer, Germany, p. 3.
84. Denzin, N.K., & Lincoln, Y.S. (2005). The Sage Book of Qualitative research (3rd ed.). Thousand Oaks, CA: Sage.
85. Dey, S. (2012). Rythu Bazaar: A Study of the Supply Chain of the Farmers' Markets of Andhra Pradesh. The IUP Journal of Operations Management, Vol. XI, No. 3, pp. 43-66.
86. Dharni, K., & Sharma, S. (2008). Food Processing in India: Opportunities and Constraints. The Icfai University Journal of Agricultural Economics , V (3), 30-38.
87. Dharni, K., & Sharma, S. (2008). Food Processing in India: Opportunities and Constraints. The Icfai University Journal of Agricultural Economics, V(3), 30-38.
88. Dokuzoguz M (1997). Developments on Storage of Horticultural Products in Turkey. First Symposium of Storage andMarketing in Horticultural Products, 21-24 October, Yalova, p. 9, (in Turkish).
89. Dornier, P. P. (1998). Global operations and logistics : text and cases. New York: Wiley.
90. Ehie, I. and Sheu, C. (2005), "Integrating Six Sigma and theory of constraints for continuous improvement: a case study", Journal of Manufacturing Technology Management, Vol. 16 No. 5, pp. 542-53.
91. Eichhorn, B. R., 2014, Common method variance techniques, Working paper, Cleveland State University.
92. Ellram, L. R. (1991). Supply Chain Management: The Industrial Organization Perspective. International Journal of Physical Distribution and Logistics Management, 21, 13-22.
93. Ellram, L., & Krause, D. (1994). Supplier partnerships in Manufacturing versus Non-Manufacturing Firms. The International Journal of Logistics Management, 5(1), 43-53.
94. El-Sakty, K., & Beheiry, M. E. (2014). Global Supply Chain Growth Opportunities Using Thinking Process. The International Maritime Transport & Logistics Conference. Arab: The International Maritime Transport & Logistics Conference.
95. European Commission (2015): You are part of the food chain. Key facts and figures on the food supply chain in the European Union. Text available from the following site: http://ec.europa.eu/agriculture/markets-andprices/market-briefs/pdf/04_en.pdf (access on 18th June 2017).
96. Everitt, S. (1975). Multivariate analysis: The need for data, and other problems. British Journal of Psychiatry. 126, 2S7-240.
97. Fairchild, A. (2005), "Intelligent matching: integrating efficiencies in the financial supply chain", Supply Chain Management: An International Journal, Vol. 10 Nos 3/4, pp. 244-248.
98. Fearne, A. and Hughes, D. (2000), "Success factors in the fresh produce supply chain: insights from the UK", British Food Journal, Vol. 102, No.10, pp. 760-776.
99. Fearne, A., Barrow, S. and Schulenberg, D. (2006), "Implanting the benefits of buyer-supplier collaboration in the soft fruit sector", Supply Chain Management: An International Journal, Vol. 11 No. 1, pp. 3-5.

100. FICCI. (2010). Bottlenecks in Indian Food Processing Industry. Retrieved January 22, 2014, from FICCI Website: http://www.ficci.com/SEDocument/20073/Food-Processing-Bottlenecks-study.pdf
101. FICCI. (2010). Bottlenecks in Indian Food Processing Industry. Retrieved January 22, 2017, from FICCI Website: http://www.ficci.com/SEDocument/20073/Food-Processing-Bottlenecks-study.pdf
102. Field, A (2009) Discovering Statistics Using SPSS. Sage Publications Ltd., London.
103. Fisher, M., L. “What Is the Right Supply Chain for Your Product” Harvard Business Review, Vol. 75, No. 2, 1997, pp. 105-116.
104. Folkerts, H. & Koehorst, H. (1997). Challenges in international food supply chains: vertical co-ordination in the European agribusiness and food industries. Supply Chain Management: An International Journal, 2 (1), 11-14.
105. Food and Agriculture Organization of the United Nations. 2013. Food wastage footprint. Impacts on natural resources. Summary report. Rome: FAO. Available from http://www.fao.org/docrep/018/i3347e/i3347e.pdf. Accessed on 6 November 2016.
106. Fredendall, L.D. and Hill E. (2001), Basics of Supply Chain Management, St Lucie Press, New York.
107. Gajanana, T. M., Murthy, D. S., Sudha, M., & Dakshinamoorthy. (2006). Marketing and estimation of post-harvest losses of tomato crop in Karnataka. Indian Journal of Agricultural Marketing, 20(1), 1-7.
108. Gajanana, T., Sreenivasa Murthy, D., & Sudha, M. (2002). Marketing practices and post-harvest loss assessment of banana var .Poovan in Tamil Nadu. Agricultural Economics Research Review, 15(1), 56-65.
109. Gangrade, K., D. 2006, Methods of Data Collection: Questionnaire and Schedule, in Verma S.K. and Wani,M.Afzal,. (eds.), “Legal Research Methodology” ,Indian Law Institute, Delhi, 2006( Reprint) ,p.355
110. Garson, D. G. (2008). Factor Analysis: Statnotes. Retrieved March 22, 2008, from North Carolina State University Public Administration Program, http://www2.chass.ncsu.edu/garson/pa765/factor.htm.
111. Gauraha, A. (1997). Economic assessment of post-harvest lossess in vegetable crops. Indian Journal of Agricultural Marketing, 11(1 & 2), 38-339.
112. Gauraha, A., & Thakur, B. (2008). Comparative economic analysis of post-harvest losses in vegetables and foodgrains crops in Chhattisgarh. Indian Journal of Agricultural Economics, 63(3), 376.
113. George, D., & Mallery, P. (2003). SPSS for Windows step by step: A simple guide and reference (11.0 update (4th ed.) ed.). Boston: Allyn & Bacon.
114. Giunipero, L., C. and Brand, R., R. (1996) "Purchasing's Role in Supply Chain Management", The International Journal of Logistics Management, Vol. 7 Issue: 1, pp.29-38, https://doi.org/10.1108/09574099610805412
115. GOI. (2012). National Food Processing policy. Retrieved 11 24, 2012, from Confederation of Women Entrepreneurs: http://co-we.com/wp-content/uploads/national-food-processing-policy.pdf
116. GoI. (2016a). Economic Survey 2015-16: Percentage Share of Horticulture Output in Agriculture is more than 33 Per Cent. Retrieved August 18, 2017, from Press Information Bureau, Government of India, Ministry of Food Processing Industries: http://pib.nic.in/newsite/PrintRelease.aspx?relid=136852
117. GoI. (2016b, August 9). Wastage of Agricultural Produce . Retrieved August 18, 2017, from Press Information Bureau, Government of India, Ministry of Food Processing Industries: http://pib.nic.in/newsite/PrintRelease.aspx?relid=148566
118. GoI. (2017). Annual Report 2016-17 (Dept. of Agriculture, Cooperation & farmers Welfare). New Delhi: Ministry of Agriculture & Farmers Welfare, Govt. of India.

119. Goldratt, E. M. (1992). 'An Introduction to Theory of Constraints: THE GOAL APPROACH,' Avraham Y. Goldratt Institute.
120. Goonatilake, L. (1990). Inventory management in the manufacturing sector in developing countries. Engineering Costs and Production Economics, 19(1), 19-24.
121. Gorsuch, R. L. (1983). Factor analysis (2nd ed.). Hillsdale, NJ: Erlbaum.
122. Govil, R. (2012). Why don't Indian farmers grow more fruits and vegetables? Retrieved August 10, 2014, from IFMR Trust: http://www.ifmr.co.in/blog/2013/01/30/why-dont-indian-farmers-grow-more-fruits-and-vegetables/
123. Griffin, M., Sobal, J., & Lyson, T. A. (2008). An analysis of a community food waste stream. Agriculture and Human Values, 26(1-2), 67-81.
124. Grimsdell, K. (1996) "The supply chain for fresh vegetables: what it takes to make it work", Supply Chain Management: An International Journal, Vol. 1 Issue: 1, pp.11-14.
125. Gunasekaran, A. & Kobu, B. (2007). Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications. International Journal of Production Research, 45 (12), 2819-2840.
126. Gunduz M (1997). Market Structure, Storage, Marketing Systems and Foreign Trade Relations in Horticulture Products. First Symposium of Storage and Marketing in Horticultural Products, 21-24 October, Yalova, (in Turkish), pp. 9-14.
127. Guritno, A.D., Fujianti, R. & Kusumasari, D. (2015). Assessment of the supply chain factors and classification of inventory management in suppliers' level of fresh vegetables. Agriculture and Agricultural Science Procedia, 3, 51-55.
128. Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). Global food losses and food waste. Food and Agriculture Organization of the United Nations, Rom.
129. Hair, J. F., Anderson, E., & Ronald, L. T. (1991). Multivariate data analysis (5th ed.). Upper Saddle River, NJ: Prentice Hall.
130. Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Ronald, T. L. (2008). Multivariate Data Analysis (6 ed.). New Delhi: Pearson Education.
131. Hair, J. F., Money, A. H., Samouel, P., & Page, M. (2007). Research Methods for Business. The UK: John Wiley & Son Ltd.
132. Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2010). Multivariate Data Analysis. Seventh Edition. Prentice Hall, Upper Saddle River, New Jersey.
133. Halder, P., & Pati, S. (2011). A Need For Paradigm Shift to Improve Supply Chain Management of Fruits & Vegetables in India. Asian Journal of Agriculture and Rural Development , 1 (1), 1-20.
134. Halder, P., & Pati, S. (2011). A Need For Paradigm Shift to Improve Supply Chain Management of Fruits & Vegetables in India. Asian Journal of Agriculture and Rural Development , 1 (1), 1-20.
135. Hamalainen, E., and Tapaninen, U. (2011) Accuracy of forecasting in a Nordic paper mill's supply chain: A case study. Norsk Geografisk Tidsskrift–Norwegian Journal of Geography, 65:2, pp. 104– 113.
136. Handfield, R., B. and Nichols, E., L., 1999. Introduction to Supply Chain Management. Prentice-Hall, Upper Saddle River, NJ.
137. Harland, C. (1994). Perceptions of Requirements and Performance in European Automotive Aftermarket Supply Chains. PhD thesis, Warwick.
138. Harman, H. H. (1960) Modern factor analysis. Chicago, IL. University of Chicago Press
139. Harman, H.H. (1976). Modern factor analysis (3rd ed. revised). Chicago, IL: University of Chicago Press.
140. Harrington, L. (1996, July 15). Untapped savings abound. Industry Week, 53 58.
141. Hatcher, L. (1994). A Step-by-Step Approach to Using the SAS[R] System for Factor Analysis and Structural Equation Modeling. Cary: SAS Institute.

142. Haug, P. (1985). A multiple-period, mixed-integer-programming model for multinational facility location. Journal of Management, 11(3), 83-96.
143. Hazarika, C. (2006). Post-harvest loss and food security — A study on fruits and vegetables in Assam. Indian Journal of Agricultural Economics, 61(3), 418-419.
144. Hazarika, C. (2008) Extent of post-harvest losses of ginger in Assam – A micro level analysis. Indian Journal of Agricultural Economics, 63(3): 370-371.
145. Hewitt, F. (1994) "Supply Chain Redesign", The International Journal of Logistics Management, Vol. 5 Issue: 2, pp.1-10, https://doi.org/10.1108/09574099410805162
146. Higginson, J. K. & Alam, A. (1997). Supply Chain Management Techniques in Medium-to-Small Manufacturing Firms. International Journal of Logistics Management, 8 (2), 19-32.
147. Hingley, M., Sodano, V. and Lindgreen, A. (2008), "Differentiation strategies in vertical channels: a case study from the market for fresh produce", British Food Journal, Vol. 110 No. 1, pp. 42-61.
148. Hinkin, T. R. (1995). A review of scale development in the study of behavior in organizations. Journal of Management, 21,967-988.
149. HMNEH (2010). Horticulture Mission for North East and Himalayan States-Operational Guidelines. Krishi Bhawan, New Delhi: GOI, Ministry of Agriculture.
150. Hoover Jr. W.E., Eloranta, E., Holmstrom, J. and Huttunen, K. (2001), Managing the Demand-Supply Chain: Value Innovations for Customer Satisfaction, Wiley, New York.
151. Hoover, W. E., Eloranta, E., Holmstrom, J., & Huttuen, K. (2001). Managing the Demand-Supply Chain- Value Innovations for Customer Satisfaction. New York: Wiley.
152. Horscroft, P. and Braithwaite, A. (1990) "Enhancing Supply Chain Efficiency - The Strategic Lead Time Approach", The International Journal of Logistics Management, Vol. 1 Issue: 2, pp.47-53, https://doi.org/10.1108/09574099010804590
153. Hsiao, J.-M. M. (October 2006). The Impact of Retailer-Supplier Cooperation and Decision-Making Uncertainty on Supply Chain Performance. Institute of Transport and Logistics Studies, Faculty of Economics and Business, The University of Sydney.
154. Hughes, D. (1996) "Reversing market trends: the challenge for the UK fresh fruit sector", British Food Journal, Vol. 98 Issue: 9, pp.19-25, https://doi.org/10.1108/00070709610151076.
155. Hutcheson, G. and Sofroniou, N. (1999) The Multivariate Social Scientist: Introductory Statistics Using Generalized Linear Models. Sage Publication, Thousand Oaks, CA. https://doi.org/10.4135/9780857028075
156. IBEF. (2018, January). Agriculture and Allied Industries. Retrieved from India Brand Equity Foundation: https://www.ibef.org/download/Agriculture-and-Allied-Industries-January-2018.pdf
157. Iliopoulos, C., Theodorakopoulou, I. and Lazaridis, P. (2012) "Innovation implementation strategies for consumer driven fruit supply chains", British Food Journal, Vol. 114 Issue: 6, pp.798-815, https://doi.org/10.1108/00070701211234336
158. International Center for Competitive Excellence, 1994, University of North Florida, Dr. Douglas M. Lambert, Director. Available at http://www.tlog.lth.se/fileadmin/tlog/Utbildning/Kurser/Logistik_i_foersoerjningskedjor/Lectures/Scm_Processes.pdf
159. International Trade Administration (2016). Retrieved March 30, 2017, from 2016 Top Markets Report Cold Chain: http://trade.gov/topmarkets/pdf/Cold_Chain_Executive_Summary.pdf
160. Ip, W. H., Chan, S. L. & Lam, C. Y. (2011). Modeling supply chain performance and Stability. Industrial Management and Data systems, Vol.111No. 8 pp1332 – 1354
161. Jain, N. (2007). International Conference on Agribusiness and Food Industry in Developing Countries : Opportunities and Challenges. Retrieved February 19, 2013, from IIM Lucknow: http://www.iiml.ac.in/events/Program.html

162. Jain, N. (2007). International Conference on Agribusiness and Food Industry in Developing Countries: Opportunities and Challenges. Retrieved February 19, 2013, from IIM Lucknow: http://www.iiml.ac.in/events/Program.html
163. Jain, N. (2007, 8 10-12). International Conference on Agribusiness and Food Industry in Developing Countries :Opportunities and Challenges. Retrieved 1 22, 2014, from IIM lucknow: http://www.iiml.ac.in/events/P1_02_Neeraj_Jain.pdf
164. Janvier-James Assey Mbang (2013). "Supply Chain Efficiency Evaluation: A contemporary Theoretical Model". World Academic Journal of Business & Applied Sciences-Journal of Supply Chain Management Vol.1, No 1 (2013)-Germany (Article publié en Allemagne)
165. Jha, A. (2007). International Conference on Agribusiness and Food Industry in Developing Countries : Opportunities and Challenges. Retrieved February 19, 2013, from IIM Lucknow: http://www.iiml.ac.in/events/Program.html
166. Jha, S., N, Vishwakarma, R., K., Ahmad, T., Rai, A. and Dixit, A., K. (2015). Report on assessment of quantitative harvest and post-harvest losses of major crops and commodities in India. ICAR-All India Coordinated Research Project on Post-Harvest Technology, ICAR-CIPHET, P.O.-PAU, Ludhiana-141004.
167. Jones, T and Rilley, D, W. (1985), "Using Inventory for Competitive Advantage through Supply Chain Management," International Journal of Physical Distribution and Materials Management, Vol. 15, No. 5, pp. 16-26.
168. Joshi, R., Banwet, D.K. and Shankar, R. (2009), "Indian cold chain: modeling the inhibitors", British Food Journal, Vol. 111 No. 11, pp. 1260-83.
169. Jraisat, L.E. and Sawalha, I.H., 2013. Quality control and supply chain management: a contextual perspective and a case study. Supply Chain Management: An International Journal 18 (2), 194-207.
170. Kachru, R. (2002). Agro-Processing Industries in India—Growth, Status and Prospects. Retrieved January 26, 2014, from Department of Agriculture and Cooperation: http://agricoop.nic.in/farm%20mech.%20pdf/05024-06.pdf
171. Kader, A. (2005). Increasing food availability by reducing postharvest losses of fresh produce. V International Post-harvest Symposium, International Society for Horticulutral Science. Italy: Verona.
172. Kader, A., & Rolle, R. (2004) In the role of post-harvest management in assuring the quality and safety of horticultural produce, FAO Food and Agricultural Organizations of the United Nations, Rome.
173. Kaiser, H. F. (1974). An index of factorial simplicity. Psychometrika, 39,31-36
174. Kallega, H. K., Kar, A., & Mathur, V. C. (2015). Temporal and Spatial Performance of Horticultural Crops in India. Economic Affairs, 60(3), 367-373.
175. Kantor, L., Lipton, K., Manchester, A., & Oliveira, V. (1997). Estimating and addressing America's food losses. Food Review, 20(1), 2.
176. Kapoor, P. (2009, July 28). Doctoc-International Summit on Food Processing and Agribusiness. Retrieved January 22, 2014, from Docstoc.com: http://www.docstoc.com/docs/127265667/ENTREPRENEURIAL-OPPORTUNITIES-IN-THE-AGRI-BUSINESS
177. Kapoor, P. (2009, July 28). Doctoc-International Summit on Food Processing and Agribusiness. Retrieved January 22, 2016, from Docstoc.com: http://www.docstoc.com/docs/127265667/Entrepreneurial-Opportunities-in-the-Agri-Business
178. Karabulut OA, Kuruoglu G, Ilhan K, Arslan U (2005). Using of Heat Treatments against Postharvest Diseases, J. Ondokuz Mayıs Univ. Facul. Agric., 20(1): 94-101, (in Turkish).
179. Karabulut OA, Kuruoglu G, Ilhan K, Arslan U (2005). Using of Heat Treatments against Postharvest Diseases, J. Ondokuz Mayıs Univ. Facul. Agric., 20(1): 94-101, (in Turkish).

180. Karkkainen, M. (2003), ‘Increasing efficiency in the supply chain for short shelf life goods using RFID tagging’, International Journal of Retail & Distribution Management, Vol. 31, No. 10., pp529- 536
181. Kaynas K, Celikel FG, Türkes N, Surmeli N. (1988). Studies on Maturity Physiology of Storage Facilities and of Some TomatoVarieties Grown in Yalova and Iznik Regions. Vegetable Breeding in Open Research Project Report, Ataturk Horticulture Research Institute, (in Turkish). pp. 415-423.
182. Kerlinger, F.N. (1986) Foundations of Behavioral Research. 3rd Edition, Holt, Rinehart and Winston, New York.
183. Khan, A. (2005, September 5). The domestic food market: is India ready for food processing? Retrieved January 26, 2014, from India Development Foundation: http://www.idfresearch.org/pdf/dommarket.pdf
184. Kim, I., and Min, H. (2011) ‘Measuring supply chain efficiency from a green perspective’, Management Research Review, Vol. 34, No. 11, pp.1169–1189.
185. Kim, J.-O., & Mueller, C. W. (1978). Introduction to Factor Analysis: What It Is and How To Do It. Beverly Hills, California, USA: Sage Publications.
186. Kim, S., Mabin, V.J. and Davies, J. (2008), “The theory of constraints thinking processes: retrospect and prospect”, International Journal of Operations & Production Management, Vol. 28 No. 2, pp. 156-84.
187. Kinnear, T.C. and Taylor, J.R. (1996), Marketing Research: An Applied Approach, 5th ed., McGraw-Hill, New York, NY.
188. Klein, J. D and Lurie, S. (1991). Postharvest Heat Treatment and Fruit Quality, Postharvest News Inf., 2:15-19.
189. Kline, P. (1994). An easy guide to factor analysis. New York, NY: Routledge.
190. Koch, C. (2002), “The ABCs of supply chain management”, Supply Chain Management Resource Center, accessed on 16, January, 2017, available at: http://www.fijihosting.com/dload/abc_of_supply_chain_management.pdf
191. KPMG, & ASSOCHAM. (2009). Food processing and Agri business. Retrieved January 22, 2014, from Smallb.in A SIDBI Initiative: http://smallb.in/sites/default/files/knowledge_base/reports/FoodProcessingandAgribusinessAssocham_opt.pdf
192. Kull, T.J., Boyer, K., & Calantone, R. (2007) Last-Mile supply chain efficiency: an analysis of learning curves in online ordering. International Journal of Operations & Production Management, 27 (4): 409 –434.
193. Kumar S, Pal S, Joshi PK (2004). Vegetable Sector in India: An Overview, Impact of Vegetable Research in India, National Centre for Agrıcultural Economics and Policy Research, ICAR, New Delhi, pp. 9-33
194. Kumar, D., Basavaraja, H. and Mahajanshetti, S. B. 2006. An economic analysis of postharvest losses in vegetables in Karnataka. Indian Journal of Agricultural Economics; 61(1):134-146.
195. Kusumastuti, R.D., van Donk, D.P. and Teunter, R. (2016), “Crop-related harvesting and processing planning: a review”, International Journal of Production Economics, Vol. 174 No.1, pp. 76-92.
196. Labs, W. (2010). Supply Chain Efficiency Starts at the Top. Retrieved August 14 , 2017, from Food Engineering: http://www.foodengineeringmag.com/articles/88161-supply-chain-efficiency-starts-at-the-top
197. Lacerda, D.P, Cassel, R, A. and Rodrigues, L, H. (2010). Service process analysis using process engineering and the theory of constraints thinking process. Business Process Management Journal, 16: 264-281.
198. Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply Chain Management Implementation Issues and Research Opportunities. The International Journal of Logistics Management, 11 (1), 1-17.

199. Lau, K., H. (2012) "Demand management in downstream wholesale and retail distribution: a case study", Supply Chain Management: An International Journal, Vol. 17 Issue: 6, pp.638-654, https://doi.org/10.1108/13598541211269247
200. Lawande KE (2004). ”Status of Onion and Garlic Research in India, Impact of Vegetable Research in India, National Centre for Agrıcultural Economics and Polıcy Research, ICAR, New Delhi, pp. 59-64.
201. Lee, H. L., & N G, S. M. (1997). Introduction to the Special Issue on Global Supply Chain Management. Productions and Operation Management, 6, 191-2.
202. Li, D. and O'Brien, C. (1999), "Integrated decision modelling of supply chain efficiency", International Journal of Production Economics, Vol. 59 Nos 1-3, pp. 147-57
203. Liang, L.F., Yang, F., Cook, W.D., Zhu, J., 2006. DEA models for supply chain efficiency evaluation. Annals of Operations Research 145 (1), 35–49.
204. Librelato, T. P., Lacerda, D. P., Rodrigues, L. H., & Veit, D. R. (2014). Mapping and the theory of constraints thinking process. Business Process Management Journal, 20, 922-949. doi: 10.1108/BPMJ-07-2013-0098
205. Lin P. C. and Wu L. S. (2011), How supermarket chains in Taiwan select suppliers of fresh fruit and vegetables via direct purchasing, The Service Industries Journal, Vol. 31, No. 8, pp. 1237-1255
206. Mabin, V.J. (1999), "Goldratt's 'Theory of Constraints' thinking processes: a systems methodology linking soft with hard, systems thinking for the next millennium", Proceedings of the 17th International System Dynamics Conference and 5th Australian and New Zealand Systems Conference, Wellington, New Zealand, July 20-23.
207. Mabin, V.J. and Balderstone, S.J. (2003), "The performance of the theory of constraints methodology: analysis and discussion of successful TOC applications", The International Journal of Operations & Production Management, Vol. 23 No. 6, pp. 568-95.
208. MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong S. (1999). Sample size in factor analysis. Psychological Methods, 4, 84-99.
209. Macharia, J., Collins, R. and Sun, T. (2013), "Value-based consumer segmentation: the key to sustainable agri-food chains", British Food Journal, Vol. 115 No. 9, pp. 1313-1328.
210. Madan, M., & Ullasa, B. A. (1993). Post-harvest losses in fruits. In K. C. Pareek, Advances in Horticultur e – Fruit Crops, Part 4. New Delhi: Malhothra Publishing House.
211. Maheshwar, C., & Chanakwa, T. S. (2006). Postharvest Losses Due to Gaps in Cold Chain in India-A Solution, Ishs Acta Horticulturae 712: IV International Conference on Managing Quality in Chains - The Integrated View on Fruits and Vegetables Quality. Retrieved January 26, 2016, from Acta Horticulturae: http://www.actahort.org/books/712/712_100.htm
212. Malhotra, N. K. (2007). Marketing research: An applied orientation. Upper Saddle River, NJ: Pearson/Prentice Hall.
213. Malhotra, N. and Birks, D. (2007) Marketing Research: an applied approach: 3rd European Edition, Harlow, UK, Pearson Education, 835pp.
214. Mallapur, C. (2015). For First Time, A Seminal Change In India's Agriculture. Retrieved January 18, 2017, from India Spend: http://www.indiaspend.com/cover-story/for-first-time-a-seminal-change-in-indias-agriculture-75893
215. Martı´nez-de-Albe´niz, V., D. Simchi-Levi. 2007. Improving supply chain efficiency through wholesale price renegotiation. Working paper, University of Navarra, Spain
216. Mathi, K. M. (2007, August 10-12). International Conference on Agribusiness and Food Industry in Developing Countries: Opportunities and Challenges. Retrieved January 22, 2014, from IIM Lucknow Websites: http://www.iiml.ac.in/events/C9_01_K_Malar_Mathi.pdf
217. Matopoulos, A., Vlachopoulou, M., Manthou, V. and Manos, B. (2007), "A conceptual framework for supply chain collaboration: empirical evidence from the agri-food

industry”, Supply Chain Management: An International Journal, Vol. 12 No. 3, pp. 177-86.

218. Mena, C., Adenso-Diaz, B., & Yurt, O. (2011). Thecauses of food waste in the supplier-retailer interface: Evidences from the UK and Spain. Resources, Conservation and Recycling, 55(6), 648-658.

219. Mentzer, J. T., & Konrad, B. P. (1991). An efficiency/effectiveness approach to logistics performance analysis. Journal of Business Logistics, 12(1), 33-62.

220. Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis: An expanded sourcebook (2nd ed.). Thousand Oaks, CA: Sage Publications.

221. Mishra, P. K., & Sinha, A.. (2010). Supply Chain Management of Agricultural Commodities through Electronic Spot Exchanges. Retrieved from http://ssrn.com/abstract=1728686

222. Mishra, R.K (2012) Measuring supply chain efficiency: a DEA approach. Journal of Operations and Supply Chain Management 5(1):45–68

223. Mittal, S. (2007). Can Horticulture be a success story for India? Working Paper. Retrieved March 21, 2013, from http://www.eaber.org/: http://www.eaber.org/sites/default/files/documents/ICRIER_Mittal_2007_02.pdf

224. Modi, P., Mishra, D., Gulati, H., & Murugesan, K. (2009). UTTARAKHAND STATE COOPERATIVE FEDERATION: CAN IT HELP THE HORTICULTURE FARMERS? VISION—The Journal of Business Perspective , 13 (2), 53-61.

225. Modi, P., Mishra, D., Gulati, H., & Murugesan, K. (2009, April-June). Uttarakhand State Cooperative Federation: Can it Help the Horticulture Farmers? VISION—The Journal of Business Perspective, 13(2), 53-61.

226. Moloney, C. (2016, August 11). India’s farm-produce losses at Rs 92,000 cr, thrice the agriculture budget. Financial Express.

227. Monczka, R., Trent, R., and Handfield, R. (2002), Purchasing and Supply Chain Management, 2nd Edition, South Western, Cicinnati.

228. MOSPI. (2012). Horticulture-Ministry of Statistics and Programme Implementation. Retrieved August 18, 2013, from Ministry of Statistics and Programme Implementation: http://mospi.nic.in/Mospi_New/upload/SYB2013/CH-9-HORTICULTURE/horticulture.pdf

229. MOSPI. (2013). State Domestic Product and other aggregates. Retrieved April 29, 2014, from Ministry of Statistics and Programme Implementation: http://mospi.nic.in/Mospi_New/site/inner.aspx?status=3&menu_id=82

230. Mowat, A. and Collins, R. (2000) "Consumer behaviour and fruit quality: supply chain management in an emerging industry", Supply Chain Management: An International Journal, Vol. 5 Issue: 1, pp.45-54, https://doi.org/10.1108/13598540010312963

231. Murthy, D. S., Gajanana, T. M., & Sudha, M. (2002). Marketing practices and post-harvest loss estimation in mango var. Baganapalli at different stages of marketing — A methodological perspective. Agricultural Economics Research Review, 15(2), 188-200.

232. Murthy, D. S., Gajanana, T. M., & Sudha, M. (2003). Estimation of post- harvest loss and marketing efficiency in banana var yelakki in Karnataka. Bihar Journal of Agricultural Economics, 10(3), 221-230.

233. Murthy, D. S., Gajanana, T. M., Sudha, M., & Dakshinamoorthy, V. (2009). Marketing and Post harvest losses in fruits: Its implications on Availability and economy. Indian Journal of Agricultural economics , 64 (2), 259-275.

234. Murthy, D. S., Gajanana, T., Sudha, M., & Dakshinamoorthy, V. (2007). Marketing Losses and Their Impact on Marketing Margins: A Case Study of Banana in Karnataka. Agricultural Economics Research Review, 20, 47-60.

235. Myers, M. D. (2009). Qualitative research in business& management. London: SAGE publication Ltd.

236. Naidu, S. (2007, August 10-12). International Conference on Agribusiness and Food Industry in Developing Countries: Opportunities and Challenges. Retrieved January 22, 2014, from IIM Lucknow Website: http://www.iiml.ac.in/events/ICABFI.htm
237. Narula, S. A. (2011). Reinventing cold chain industry in India: need of the hour. Interview with Mr Sanjay Aggarwal. Journal of Agribusiness in Developing and Emerging Economies, 1 (2).
238. NationalAcademyofSources. (1978). Postharvest Food Losses in Developing Countries. Washington D.C.: National Academy of Sciences.
239. NCCD. (2015*a*). Overview on Cold-chain Development (2015). Retrieved July 4, 2017, from National Center for Cold Chain Development: http://www.nccd.gov.in/PDF/Report_on_Cold-chain_Development_2015.pdf
240. NCCD. (2015*b*). All India distribution of Cold Stores as of 31.07.2015. Retrieved from nccd.giv.in: https://nccd.gov.in/PDF/ColdStoragedistribution2015.pdf
241. Negi, S., & Anand, N. (2014, December). Supply Chain Efficiency: An Insight from Fruits and Vegetables Sector in India. Journal of Operations and Supply Chain Management, 7(2), 154-167.
242. Negi, S., & Anand, N. (2015). Cold Chain: A Weak Link in the Fruits and Vegetables Supply Chain in India. The IUP Journal of Supply Chain Management, 48-62.
243. Negi, S., & Anand, N. (2015). Issues and Challenges in the Supply Chain of Fruits & Vegetables Sector in India: A Review. International Journal of Managing Value and Supply Chains, 6(2), 47-62.
244. Negi, S., & Anand, N. (2016). An Overview of Fruits and Vegetables' Retail Supply Chain Models in India. In N. Kamath, & S. Saurav, Handbook of Research on Strategic Supply Chain Management in the Retail Industry (pp. 170-187). United States of America: Business Science Reference (an imprint of IGI Global).
245. Negi, S., & Anand, N. (2017). Factors that impact Quality during the Transportation of Tomatoes: Evidence from India. International Journal of Applied Logistics, 7(1), 49-63.
246. Negi, S., & Anand, N. (2018a) (in press.) Wholesalers Perspectives on Mango Supply Chain Efficiency in India. Journal of Agribusiness in Developing and Emerging Economies, Published by Emerald. ISSN: 2044-0839.
247. Negi, S., & Anand, N. (2018b) (in press.) Factors Leading to Supply Chain Inefficiency in Agribusiness: Evidence from Asia's Largest Wholesale Market. International Journal of Value Chain Management, Published by Inderscience. ISSN: 1741-5365.
248. New, S. J. (1996). A framework for Analyzing Supply Chain Improvement. International Journal of Operations and Production Management, 16 (4), 19-34.
249. NHB. (2013). Area and Production Statistics. Retrieved February 4, 2014, from National Horticulture Board: http://nhb.gov.in/area%20_production.html
250. NHB. (2015). Area and Production Status- Final Area & Production Estimates for Horticulture Crops for 2013-2014. Retrieved January 26, 2015, from National Horticulture Board: http://nhb.gov.in/area%20_production.html
251. NHB. (2015). Indian Horticulture Database 2014. Gurgaon: Ministry of Agriculture, Government of India.
252. NHB. (2017). Horticulture Statistics At a Glance 2017. Retrieved January 24, 2018, from National Horticulture Board: http://nhb.gov.in/statistics/Publication/Horticulture%20At%20a%20Glance%202017%20for%20net%20uplod%20(2).pdf
253. Norusis M.J. (1993). SPSS for Windows Advanced Statistics, Release 6.0. SPSS Inc., Chicago.
254. Nowakowska-Grunt, J., & Moroz, E. (2013). Theory of constraints as an effective tool for supply chain management. Advanced Logistic Systems, 17(1), 71–78.

255. Oglethorpe, D. and Heron, G. (2013). Testing the theory of constraints in UK local food supply chains. International Journal of Operations &Production Management, 33(10), 1346-136.
256. Ojo, M. O. (1991). Food Policy and Economic Development in Nigeria for Central Bank of Nigeria. Page Publishers Services Limited, 1-9.
257. Oliver, R. K., & Webber, M. D. (1992). Supply Chain Management: Logistics Catches up with Strategy. Outlook Cit. Christopher, Logistics Catches up with Strategy. Outlook Cit. Christopher, London.
258. ONICRA. (2012). Indian Cold Chain Industry. Retrieved January 25, 2017, from ONICRA:http://www.onicra.com/images/pdf/publications/coldchainindustryreportjune2014.pdf
259. Ozcan M, Balkaya A (1995). Causes of Harvest and Post-Harvest Losses on Fruits and Vegetables Product Grown in Amasya Province, J. Ondokuz Mayıs Univ. Facul Agric., 10(1): 51-61, (in Turkish).
260. Ozcan M, Balkaya A, Ceyhan V (1997). Analysis of Vegetable Marketing Activities in the Black Sea region, First Symposium of Storage and Marketing in Horticultural Products, 21-24 October, Yalova. pp. 229-234s, (in Turkish)
261. Ozcan, M. (2007). Affects on Quality and Durability of Harvest and Post-Harvest Practices in Horticultural Products. Retrieved September 18, 2013, from http://www.carsambaziraatodasi.com/ab1_1.asp.
262. Pallant, J. (2005) SPSS Survival Guide: A Step by Step Guide to Data Analysis Using SPSS for Windows. 3rd Edition, Open University Press, New York.
263. Pandey, M., Sikka, B., K. & Panthari, S. (2009), "ICT System for Increasing Efficiency of Apple- Value Chain," paper presented at the National Seminar 2009 on ICT for Agriculture & Rural Development, Arunachal Pradesh. http://gbpuat.academia.edu/MukeshPandey/Papers/126481/ICT_System_for_Increasing_Efficiency_of_Apple-Value_Chain
264. Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. Philosophical Transactions of the Royal Society B-Biological Sciences, 365(1554), 3065-3081.
265. Park, T., A. and King, R., P., 2007, "Evaluating Food Retailing Efficiency: The Role of Information Technology," Journal of Productivity Analysis, Vol. 27, No. 2, pp. 101-113. doi: 10.1007/s11123-006-0030-6
266. Parkan, C., & Dubey, R. (2009). Recent developments in the practice of supply chain management and logistics in India. Portuguese journal of management studies, 14(1), 71–87.
267. Parwez, S. (2014), "Food supply chain management in Indian Agriculture: Issues, opportunities and further research", African Journal of Business Management, Vol. 8 No. 14, pp. 572- 581.
268. Patel, V. K. (2012). Study the Supply Chain of Fruits and Vegetables of Reliance Fresh. Gujarat: Dhirubhai Ambani Institute of Information and Communication Technology.
269. Patton, M. Q. (2002). Qualitative Research & Evaluation Methods. 3rd edition. Sage Publications, Inc.
270. Pauline V. Young. (1968). Scientific Social Surveys and Research (Prentice-Hall of India Pvt. Ltd., New Delhi).
271. Pegels, C. C., & Watrous, C. (2005), Application of the theory of constraints to a bottleneck operation in a manufacturing plant, Journal of Manufacturing Technology Management, 16(3), 302-311.
272. Perdana, T. and Kusnandar (2012), "The Triple Helix Model for fruits and vegetables supply chain management development involving small farmers in order to fulfill the global market demand: a case study in "Value Chain Center (VCC) Universitas Padjadjaran"", Procedia - Social and Behavioral Sciences, Vol. 52, pp. 80-89.

273. Peter, J. (1979). Reliability: A review of psychometric basics and recent marketing practices. Journal of Marketing Research, 16, 6-17.
274. Pettersson, A. (2008). Measurements of efficiency in a Supply chain. Retrieved August 10, 2014, from Lulea University of Technology: http://pure.ltu.se/portal/files/2331159/ltu-lic-0851-se. pdf
275. Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879-903.
276. Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2012). Sources of Method Bias in Social Science
277. POLICY, N. F. (n.d.). Retrieved 11 24, 2012, from http://co-we.com/wp-content/uploads/national-food-processing-policy.pdf
278. Polito, T., Watson, K. and Vokurka, R.J. (2006), "Using the theory of constraints to improve competitiveness: an airline case study", Competitiveness Review, Vol. 16 No. 1, pp. 44-50.
279. Polito, T., Watson, K., & Vokurka, R. J. (2006), Using the theory of constraints to improve competitiveness: An airline case study, Competitiveness Review, 16(1), 44-50.
280. Prasad, S. and Sounderpandian, J. (2003) 'Factors influencing global supply chain efficiency: implications for information systems', Supply Chain Management: An International Journal, Vol. 8, No. 3, pp.241–250.
281. Prigojin, I. Fallik, E., Qat, Y., Ajalin, I, Allam, H., Ezzat, M., Almasri, M. and Bader, M. 2005. Middle East regional agricultural program - survey on postharvest losses of tomato fruit (Lycopersicon esculentum) and table grapes (Vitis vinifera), Acta Hort. 682:1049-1056
282. Raak, N., Symmank, C., Zahn, S., Aschemann-Witzel, J. and Rohm, H., 2017. Processing and product-related causes for food waste and implications for the food supply chain. Waste Management, 61, pp.461–472.
283. Rahman, S. (1998), "Theory of constraints: a review of the philosophy and its applications", International Journal of Operations & Production Management, Vol. 18 No. 4, pp. 336-56.
284. Rahman, S. (2002), "The theory of constraints' thinking process approach to developing strategies in supply chains", International Journal of Physical Distribution & Logistics Management, Vol. 32 No. 10, pp. 809-28.
285. Rais, M. and Sheoran, A. (2015) Scope of Supply Chain Management in Fruits and Vegetables in India. Journal of Food Processing Technology 6: 427. doi:10.4172/2157-7110.1000427
286. Rajkumar, P. (2010), "Food mileage: an indicator of evolution of agricultural outsourcing", Journal of Technology Management & Innovation, Vol. 5 No. 2, pp. 37-46.
287. Raman, A., N. DeHoratius, Z. Ton. 2001. Execution: The missing link in retail operations. California Management Rev. 43 136–152.
288. Ramanathan, A. and Parthasarathy, R. (2014) Fruit wastages from farm gate to retail outlets in Tamil Nadu, India-with specific focus on fruit processing units. Middle-East Journal of Scientific Research 21 (11): 1994-2003
289. Ramesh, S. (2009, July 28). Food Processing Sector in India-Challenges and Oppurtunities-KPMG. Retrieved January 22, 2014, from Scribd.com: http://www.scribd.com/doc/39050239/Food-Process-Sing-Opportunities-in-India-Ppt
290. Rao Narsinga, B.S. (2013). Fruits, vegetables, milk and animal foods balanced Indian diets-a critical appraisal, NFI Bulletin, 34(1), 1-8
291. Rastoin, J.-L., Ayadi, N., & Montigaud, J.-C. (2006, June-July 29-2). Regional Benchmarking of the fruit and vegetable supply chains in the context of the Euro-Mediterranean free trade area. Retrieved 7 19, 2017, from AgEconsearch: https://ageconsearch.umn.edu/bitstream/10072/1/sp06ra09.pdf

292. Rathore, J., Sharma, A., & Saxena, K. (2010). Cold Chain Infrastructure for Frozen Food: A Weak Link in Indian Retail Sector. The IUP Journal of Supply Chain Management, VII (1 & 2), 90-103.
293. Reddy, G., Murthy, M., Meena, P., 2010. Value chains and retailing of fresh vegetables and fruits, Andhra Pradesh. Agricultural Economics Research Review 23, 435-460.
294. Reddy, P. P (2004). "Vegetable Research in India-An IIHR Perspective, Impact of Vegetable Research in India, National Centre for Agrıcultural Economics and Polıcy Research, ICAR, New Delhi, pp. 45-58.
295. Rehman, M. u., Khan, N., & Jan, I. (2007). POST HARVEST LOSSES IN TOMATO CROP (A Case of Peshawar Valley). Sarhad Journal of Agriculture, 1279-1284.
296. Reid, R., A. 2007. Applying the TOC five-step focusing process in the service sector. Managing Service Quality, 17 (2), 209–234.
297. Reid, R.A. and Cormier, J.A. (2003), "Applying the TOC TP: a case study in the service sector", Managing Service Quality, Vol. 13 No. 5, pp. 349-69.
298. Reiner, G., and Hofmann, P. (2006). Efficiency analysis of supply chain processes. International Journal of Production Research, 44(23), 5065–5087.
299. Research and Recommendations on How to Control It. Annual Review of Psychology, 63, 539-569.
300. Roekel, V. J., Willems, S., Dave M. Boselie (2002). To stimulate cross-border trade in developing countries and emerging economies, World Bank Paper Cross-Border Agri Supply Chain Management, 's-Hertogenbosch, 19 August 2002.
301. Ross, D. F. (1998), Competing through Supply Chain Management: Creating Market Winning Strategies Through Supply Chain Partnership, Kluwer Academic Publishers, Boston.
302. Rummel, R.J. (1970). Applied factor analysis. Evanston, IL: Northwestern University Press.
303. Ruslan, N. A., Man, N., Nawi, N. M., & Ding, P. (2013). Factors That Influence the Implementation of Postharvest Handling Practices Among Fresh Vegetable Producers in Selected States in Malaysia. Journal of International Food & Agribusiness Marketing, 25(1), 87-97.
304. Ruteri, J.M. and Xu, Q. (2009) 'Supply chain management and challenges facing the food industry sector in Tanzania', International of Journal of Business and Management, Vol. 4, No. 12, pp.70–80.
305. Rytila, J, S. and Spens, K, M., 2006, "Using simulation to increase efficiency in blood supply chains", Management Research News, Vol. 29 Issue: 12, pp.801-819, https://doi.org/10.1108/01409170610717826
306. Salin, V. (1998). Information technology in agri-food supply chains. International Food and Agribusiness Management Review , 1 (3), 329-34.
307. Salin, V. and Nayga, R.M. Jr (2003), "A cold chain network for food exports to developing countries", International Journal of Physical Distribution & Logistics Management, Vol. 33 No. 10, pp. 918-33.
308. Sapra, R., & Joshi, S. (2011, Nov-Dec). Cold Chain Logistics Sector Analysis Nov-Dec. Retrieved February 4, 2014, from Business Design: http://www.businessdesign.co.in/webfiles/Project/312313092332Cold%20Chain%20Logistics_Jan.2011.pdf
309. Sarode, A. D. (2010). Effect of logistical operation relationship on the performance of supply chain management. Retrieved June 4, 2016, from Shodhganga : a reservoir of Indian theses @ INFLIBNET: http://shodhganga.inflibnet.ac.in/handle/10603/5397
310. Satyanarayana, A., Math, R. G., Jyothirmayi, T., & Rao, D. G. (2007, August 10-12). International Conference on Agribusiness and Food Industry in Developing Countries: Opportunities and Challenges. Retrieved January 22, 2014, from IIM Lucknow website: http://www.iiml.ac.in/events/C5_03_A_Satyanarayana.pdf

311. Saurav, S., & Potti, R. (2016). Cold Chain Logistics in India: A Study. In A. Dwivedi, Innovative Solutions for Implementing Global Supply Chains in Emerging Markets (pp. 159-172). IGI Global.
312. Schwab, D. P. (1980). Construct validity in organization behavior. In B. M. Staw & L. L. Cummings (Eds.), Research in organizational behavior (Vol. 2, pp. 3-43). Greenwich, CT: JAI.
313. Sharma, G., & Singh, S. (2011). Economic Analysis of Post-Harvest Losses in Marketing of Vegetables in Uttarakhand. Agricultural Economics Research Review, 24, 309-315.
314. Sharma, M.J., Yu, S.J., 2010, "Measuring Supply Chain Efficiency and Congestion", Engineering Letters, vol.18, pp.384-390
315. Shehrawat, P., S. 2006. Agro Processing Industries---A Challenging Entrepreneurship for Rural Development, The Intern Indigenous J. of Entrepreneurship, Advancement, Strategy and Education, 3: 1-13.
316. Shukla, A., Lalit, V., & Venkatasubramanian, V. (2011). Optimizing efficiency-robustness trade-offs in supply chain design under uncertainty due to disruptions International Journal of Physical Distribution & Logistics Management, 41 (6), 623-647 DOI: 10.1108/09600031111147844
317. Shukla, D. (2010, February 15-16). UNCTAD. Retrieved January 22, 2014, from Engaging the Trading Community Forum on WTO, Trade Facilitation and the Private Sector in Developing Countries-Trade Obstacles Faced by Indian Exporters: http://unctad.org/sections/wcmu/docs/ettcp05_en.pdf
318. Shukla, D. (2010, February 15-16). UNCTAD. Retrieved January 22, 2014, from Engaging the Trading Community Forum on WTO, Trade Facilitation and the Private Sector in Developing Countries-Trade Obstacles Faced by Indian Exporters: http://unctad.org/sections/wcmu/docs/ettcp05_en.pdf
319. Shukla, M., & Jharkharia, S. (2013). Agri-fresh produce supply chain management: a state-of-the-art literature review. International Journal of Operations and Production Management , 33 (2), 114-158.
320. Shukla, M., & Jharkharia, S. (2013). Agri-fresh produce supply chain management: a state-of-the-artliterature review. International Journal of Operations & Production Management, 33(2), 114-158.
321. Sidhu, R. S., Sidhu, M. S., and Singh, J. M. 2011, Marketing efficiency of green peas under different supply chains in Punjab. Agric. Econ. Res. Rev, 24: 267-273.
322. Sidhu, R., Kumar, S., Vatta, K., & Singh, P. (2010). Supply Chain Analysis of Onion and Cauliflower in Punjab. Agricultural Economics Research Review , 445-454.
323. Sidhu, R., Kumar, S., Vatta, K., & Singh, P. (2010). Supply Chain Analysis of Onion and Cauliflower in Punjab. Agricultural Economics Research Review , 445-454.
324. Simatupang, T.M., Wright, A.C. and Sridharan, R. (2004), "Applying the theory of constraints to supply chain collaboration", Supply Chain Management: An International Journal, Vol. 9 No. 1, pp. 57-70.
325. Simchi-Levi, D., Kaminsky, P., Simchi-Levi, E., & Shankar, R. (2008). Designing and Managing the Supply Chains – Concepts, Strategies and Case Studies. New Delhi: Tata McGraw-Hill.
326. Simchi-Levy, D., Kaminsky, P., & Simchi-Levy, E. (2000). Designing and Managing the Supply Chain. USA: McGraw-Hill.
327. Simsita, Z.T., Gunayb, N.S., Dan Vayvayc, O. 2014. Theory of Constraints: A Literature Review. Procedia - Social and Behavioral Sciences, vol. 150, 930-936.
328. Singh, B., Banerjee, M. K., Singh, K. P., Pandey, P. K., Sudhakar, P., & Rai, M. (2004). AICRP on Vegetables in India: Evolution andAchievements Impact of Vegetable Research in India. New Delhi: National Centre for Agrıcultural Economics and Polıcy Research,ICAR.

329. Singh, B.K., (2012). “A study on investors’ attitude towards mutual funds as an investment option”, International Journal of Research in Management, Vol. 2, No. 2, pp. 61-70, accessed as on 12 August, 2015, http://rspublication.com/ijrm/march%2012/6.pdf
330. Singh, K. and Misra, S. (2017), “Theory of Constraints for Sustainable Inventory Management in Downstream Supply Chain”. Journal of Management, 4(2), pp. 1– 10. http://www.iaeme.com/jom/issues.asp?JType=JOM&VType=4&IType=2
331. Singh, S. P., Sikka, B. K., & Singh, A. (2009). Supply Chain Management and Indian Fresh Produce Supply Chain: Opportunities and Challenges. International Food & Agribusiness Management Association, 19th Annual World Symposium.
332. Singh, S. P., Sikka, B. K., & Singh, A. (2009). Supply Chain Management and Indian Fresh Produce Supply Chain: Opportunities and Challenges. International Food & Agribusiness Management Association, 19th Annual World Symposium.
333. Singh. R, Singh., H.P, Badal. P.S, Singh. O.P, Kushwaha. & S, Sen.C (2008) “Problems and Prospects of Food-Retailing in the State of Uttar Pradesh (India)” Journal of Services Research, Vol. 8, No. 2, pp-91-99.
334. Sinha, N. (2011, January 14). 33% of total produce go wasted: Survey. Retrieved Aug 13, 2017, from Times of India:http://timesofindia.indiatimes.com/city/patna/33-of-total-produce-go-wasted Survey/articleshow/7279690.cms
335. Sinha, P. K., & Thomas, S. (2012). Organized Retailing of Horticultural Commodities. Ahmedabad: IIM Ahmedabad.
336. Souza, F. B., & Pires, S.R.I. (2010). Theory of constraints contributions to outbound Logistics. Management Research Review, 33 (7), 683-700.
337. Spradley, J. (1979) The Ethnographic Interview. Holt Rinehart & Winston, New York.
338. Srinivas, R., Venkatesha Reddy, T., Ravi, P. C., Lalith, A., & Reddy, B. (1997). Post-harvest loss assessment in totapuri and alphanso mangoes. Journal of Food Science and T echnologies, 34(1), 70-71.
339. Stephens S. (2001), “Supply Chain Operations Reference Model Version 5.0: a New Tool to Improve Supply Chain Efficiency and Achieve Best Practice”, Information Systems Frontiers, Vol. 3 No. 4, pp. 471-476
340. Stern, L, W., El-Ansary, A., I., Coughlan, A., T., et al. (2001). Marketing Channels. (6th ed. ed.). New Jersey., Upper Saddle River: Prentice Hall.
341. Stevens, G., C. (1989) "Integrating the Supply Chain", International Journal of Physical Distribution & Materials Management, Vol. 19 Issue: 8, pp.3-8, https://doi.org/10.1108/EUM0000000000329
342. Subrahmanyam, K. (1986). Post-harvest losses in horticultural crops: An appprisal. Agricultural Situation India, 41, 339-43.
343. Sudha, M., Gajanana, T. M., Sreenivasa Murthy, D., & Dakshinamoorthy, V. (2002). Marketing practices and post-harvest loss assessment of pineapple in Kerala. Indian Journal of Agricultural Marketing, 16(1), 56-65.
344. Sudharshan, G.M., Anand, M.B., Sudulaimuttu, D., 2013. Marketing and post-harvest losses in fruits: its implications on availability and economy –a study on pomegranate in Karnataka. Int. J. Manage. Soc. Res. 2 (7), 34–43
345. Tabachnick, B.G. and Fidell, L.S. (2007) Multivariate Analysis of Variance and Covariance. Using Multivariate Statistics. Allyn and Bacon, Boston, 243-310.
346. Tan, D., 2012, "Developing Agricultural Products Logistics in China from the Perspective of Green Supply Chain," International Journal of Business and Management, 7(21), 106-112.
347. Tatlidil, F., Kiral, T., Gunes, A., Demir, K., Erdemir, G., Fidan, H., et al. (2003). Economic Analysis of Crop losses during Pre-Harvest and Harvest Periods in Tomato Production in the Ayaşand Nallıhan Districts of Ankara Province. Ankara.

348. Taylor III, L. J., & Asthana, R. (2016). Applying Theory of Constraints Principles and Goldratt's Thinking Process to the Problems Associated with Inventory Control. Franklin Business & Law Journal, 2016(4), 83-104.
349. Taylor III, L. J., & Churchwell, L. (2004). Goldratt's Thinking Process Applied to the Budget Constraints of A Texas MHMR Facility. Journal of Health & Human Services Administration, 26(4), 415-437.
350. Taylor III, L., J., Jackson, M., J., Jackson, W., T. and Seanard, E. (2007). "Goldratt's Thinking Process: Is There a Place for it in the Total Enterprise Simulation." Developments in Business Simulation and Experiential Learning, vol. 34, 379-386. (Reprinted in The Bernie Keys Library, available at http://www.absel.org).
351. Taylor, D.H. and Fearne, A. (2006), “Towards a framework for improvement in the management of demand in agri-food supply chains”, Supply Chain Management: An International Journal, Vol. 11 No. 5, pp. 379-84.
352. Taylor, L, J. and Waggoner, J. (2008) “Goldratts’ thinking process applied to the problems associated with the glass ceiling effect,” Proceedings Culture, Communications and Conflict.
353. Taylor, L, J. III and Miller, P., E., G. (2004). Goldratt's Thinking Process Applied to Bank Mergers and Acquisitions. Problems and Perspectives in Management, 2(4)
354. Taylor, L. J., & Esan, T. O. (2012). Goldratt’s theory applied to the problems associated with the mode of transportation, storage and sale of fresh fruits & vegetables in Nigeria. Journal of African Research in Business and Technology, 2012, 1-16. doi:10.5171/2012.862202
355. Taylor, L. J., & Smith, J. (2016). Goldratt's Thinking Process Applied to the Digital Rights Management. Franklin Business & Law Journal, 2016(4), 8-32.
356. Taylor, L. J., III, & Sheffield, D. (2002). Goldratt’s thinking process applied to medical claims processing. Hospital Topics: Research and Perspectives on Healthcare, 80(4), 13–21.
357. Taylor, L. J., III, & Thomas, E. E. (2008). Applying Goldratt’s thinking process and the theory of constraints to the invoicing system of an oil and gas engineering consulting firm. Performance Improvement, 47(9), 26–34.
358. Taylor, L. J., Murphy, B. and Price, W. 2006. Goldratt’s thinking process applied to employee retention. Business Process Management Journal 12(5): 646–670.
359. Taylor, L., J. and Ortega, R. (2003) “The Application Goldratt’s Thinking Process To Problem Solving,” Academy of Strategic Management. Vol: 2 No: 2 (9-14).
360. Taylor, L.J., III and Poyner, I. (2008) ‘Goldratt’s thinking process applied to the problems associated with trained employee retention in a highly competitive labor market’, Journal of European Industrial Training, Vol. 32, No. 7, pp.594–608.
361. Thron, T., Nagy, G.B. and Wassan, N. (2007), “Evaluating alternative supply chain structures for perishable products”, International Journal of Logistics Management, Vol. 18 No. 3, pp. 364-84.
362. Tippayawong KY, Patitad P, Sopadang A, Enkawa T, 2010 Factors Affecting Efficient Supply Chain Operational Performance of High and Low Technology Companies in Thailand, Management Science & Engineering, 4(3):24-33.
363. Tiwari, S. (2012, April). Lean manufacturing practics of indian firms. Retrieved August 6, 2017, from Shodhganga: a reservoir of Indian theses @ INFLIBNET: http://shodhganga.inflibnet.ac.in/handle/10603/38771
364. Toyryla, I. 1999.Realising the Potential of Traceability - A case study research on usage and impacts of product traceability, Finnish Academy of Technology, Espoo.
365. Troger K, Hensel O, Burkert A (2007). Conservation of Onion and Tomato in Niger - Assessment of Post-Harvest Losses and Drying Methods. Conference on International Agricultural Research for Development, University of Kassel-Witzenhausen and University of Gottingen, October 9-11.

366. Troger K, Hensel O, Burkert A (2007). Conservation of Onion and Tomato in Niger - Assessment of Post-Harvest Losses and Drying Methods. Conference on International Agricultural Research for Development, University of Kassel-Witzenhausen and University of Gottingen, October 9-11.
367. Tsolakis, N.K., Keramydas, C.A., Toka, A.K., Aidonis, D.A. and Iakovou, E.T. (2014), “Agrifood supply chain management: A comprehensive hierarchical decision-making framework and a critical taxonomy”, Biosystems Engineering, Vol. 120 No. 1, pp. 47-64.
368. Turan (2008) Post-harvest Practices on Fruits. 12: 3, July- August, (in Turkish).
369. Vagias, Wade M. (2006). Likert-type scale response anchors. Clemson International Institute for Tourism & Research Development, Department of Parks, Recreation and Tourism Management. Clemson University.
370. Vasileiou K, Morris J., 2006. The sustainability of the supply chain for fresh potatoes in Britain. Supply Chain Management: An International Journal;11(4): 317–27.
371. Veena, Babu, K. N., & Venkatesha, H. R. (2011). Supply Chain: A Differentiator in Marketing Fresh Produce. The IUP Journal of Supply Chain Management, VIII (I), 23-36.
372. Veena, Babu, K. N., & Venkatesha, H. R. (2011). Supply Chain: A Differentiator in Marketing Fresh Produce. The IUP Journal of Supply Chain Management, VIII (I), 23-36.
373. Verma, A., & Singh, K. (2004). An economic analysis of Post-harvest losses in Fresh Vegetables. Indian Journal of Agricultural Marketing, 18(1), 134-139.
374. Vimal, S. (1972), Research Designs and Strategies (The Agricultural Development Council, New York)
375. Viswanadham, N. (2007). CAN INDIA BE THE FOOD BASKET FOR THE WORLD? Working Paper Series Indian School of Business. Retrieved January 22, 2014, from CCC India: http://www.cccindia.co/corecentre/Database/Docs/DocFiles/Can_India_be.pdf
376. Vogt, W. Paul (1999). Dictionary of statistics and methodology. Sage: Thousand Oaks, California.
377. Vorst, J. V., & Beulens, A. (2002). Identifying sources of uncertainty to generate supply chain redesign strategies. International Journal of Physical Distribution&Logistics Management, 32 (6), 409-30.
378. Waheed, A., Iqbal, M. J., & Shah, F. H. (1986). Post-harvest losses in vegetables, Pakistan Journal of Scientific and Industrial Research, 29(4), 268-73.
379. Walker II, E. D. and Cox III, J. F. 2006. Addressing ill-structured problems using Goldratt’s thinking processes: A white collar example. Man. Decis. 44, 1, 137–154.
380. Walters, D. (2006) "Effectiveness and efficiency: the role of demand chain management", The International Journal of Logistics Management, Vol. 17 Issue: 1, pp.75-94
381. Widodo, K. H., Nagasawa, H., Morizawa, K., & Ota, M. (2006). A periodical flowering-harvesting model for delivering agricultural fresh products. European Journal of Operational Research, 170(1), 24-43
382. Wilson, N. (1996a) "Supply chain management: a case study of a dedicated supply chain for bananas in the UK grocery market", Supply Chain Management: An International Journal, Vol. 1 Issue: 2, pp.28-35, https://doi.org/10.1108/13598549610155279.
383. Wilson, N. (1996b) "The supply chains of perishable products in northern Europe", British Food Journal, Vol. 98 Issue: 6, pp.9-15, https://doi.org/10.1108/00070709610131320
384. Winser, J. D. (2003). A structural equation model of supply chain management strategies and firm performance. Journal of Business Logistics, 24 (1), 1-26.
385. Wolniak, R., Skotnicka-Zasadzien, B., & Zasadzien, M. (2017). Application of the Theory of Constraints for Continuous Improvement of a Production Process-Case Study. International Conference on Social, Education and Management Engineering (SEME 2017), (pp. 169-173).
386. Wong, W.P., and Wong, K.W (2007) "Supply chain performance measurement system using DEA modeling", Industrial Management & Data Systems, Vol. 107 Issue: 3, pp.361-381, https://doi.org/10.1108/02635570710734271

387. World Economic Forum, 2016. Part 1 - Global Risks 2016. Retrieved January 2, 2018, from World Economic Forum: http://reports.weforum.org/global-risks-2016/part-1-title-tba/
388. Xiao, Y. and Chen, J. (2012). Supply chain management of fresh products with producer transportation. Decision Sciences, 43(5):785–815.
389. Yared Lemma, D.K. and Gatew, G. (2014), “Loss in Perishable Food Supply Chain: An Optimization Approach Literature Review”, International Journal of Scientific and Engineering Research, Vol. 5 No. 5, pp. 302-311.
390. Yin, R. K. (2003). Case study research: Design and methods. Thousand Oaks, Calif: Sage Publications.
391. Yong, A. G., & Pearce, S. (2013). A beginner’s guide to factor analysis: Focusing on exploratory factor analysis. Tutorials in quantitative methods for psychology, 9(2), 79-94
392. Zaldivar, C. (1991). Post-harvest losses: significance, assessment and control. In: Memorias Simposio Nacional Fisiologia y Technologia Postcosecha de Productos Horticolas enMaxica, E.M. Yahia, and I.H. Higuera C. (eds.). Mexico: Noriega Editores.
393. Zelbst, P., J., Green, Jr., KW, VE Sower, Reyes P. 2012. Impact of RFID utilization on manufacturing effectiveness and efficiency. Int J Oper Prod Manage,32(3):329–350.
394. Zheng H, Lu L. A Research on Agricultural Products Supply Chain and Food Safety. International Symposium, ISAEBD 2011. Dalian (China) 2011; 331-6.
395. Zivaljevic, A., 2015, “Theory of constraints – application in land transportation systems.” Management of Environmental Quality: An International Journal. v. 26, n. 4, p. 505–517.
396. Zokaei, K. and Hines, P. (2007), “Achieving consumer focus in supply chains”, International Journal of Physical Distribution & Logistics Management, Vol. 37 No. 3, pp. 223-47.

# APPENDICES

# APPENDIX I

## QUESTIONNAIRE-RO1

***Project Topic:*** Developing a Framework to Improve Supply Chain Efficiency of Fruits and Vegetables Sector

I am Saurav Negi, Doctoral Research Fellow at University of Petroleum and Energy Studies, Dehradun, is pursuing PhD, titled, "Developing a Framework to improve Supply Chain Efficiency of Fruits and Vegetables Sector".

***Objective of the study:*** RO1-To identify the most significant activities contributing to supply chain inefficiency in different stages of fruits and vegetables supply chain with specific reference to mango and tomato

***Scope of the Study:*** The identified activity will help in developing a framework to improve supply chain efficiency in Fruits and Vegetable sector.

***Nature of the Study:*** The entire project is based on Primary research having sample size more than 200, which includes Farmers, Traders/ Agents, Commission Agents, Wholesaler, and Transporter.

***Confidentiality:*** The data provided would be used for academic purpose only. For any queries, you may kindly contact Mr. Saurav Negi at +91-9634714440 or snegi@ddn.upes.ac.in

Kindly provide your personal details as follows:

Name: ……………………………………………………………………………

Location……………………………………………………………………………

Occupation: ………………………………………………………………………………

Age: 20-35 ☐ 36-50 ☐ 51-above ☐

Educational Qualification: No education ☐ Primary ☐ Secondary ☐ Tertiary ☐

Experience in the area: 0-5 Yrs ☐ 5-10 Yrs ☐ 10-15 Yrs ☐ 15-20 Yrs ☐ 20< ☐ above

Email: ………………………………………………………………………………

Contact Number: …………………………………………………………………….

***Supply Chain Efficiency*** *in general, describes the extent to which* **time, effort or cost is well** used *for the intended task or purpose. It is often used with the specific purpose of relaying the capability of a specific application of effort to produce a specific outcome effectively with a* **minimum amount or quantity of waste, expense, or unnecessary effort.** *It is the measure of getting the right quality product to the right place at the right time at the least cost.*

## FARMER (FARM STAGE ACTIVITIES)

**Objective**: *To identify the **most significant activity** contributing to supply chain inefficiency with respect to cost, time and quality in different stages of fruits supply chain with specific reference to mango*

| STAGE I (Farmer/Grower Level) | Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to: | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost | | | | | Time | | | | | Quality | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| ***ACTIVITY*** | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| Plucking & Collection of Mangoes in Crates/Baskets | | | | | | | | | | | | | | | |
| Carriage of Crates/Baskets to the Collection Area | | | | | | | | | | | | | | | |
| Unloading of fully loaded Crates/baskets at Collection/ Assembling area | | | | | | | | | | | | | | | |
| Cleaning/Washing of Mangoes | | | | | | | | | | | | | | | |
| Sorting, Grading & Packaging in Carton Box/ Wooden Box/Crates/Gunny Bags as per the grade & Taping and Tying | | | | | | | | | | | | | | | |
| Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/Mini Trucks | | | | | | | | | | | | | | | |
| Handling, Loading & Stacking of Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks | | | | | | | | | | | | | | | |
| Tying the Load in Tractor/Bullock cart/Truck/Mini Trucks | | | | | | | | | | | | | | | |
| In Transit (To Local Market/Main Road) | | | | | | | | | | | | | | | |

## LOCAL TRADER/MIDDLEMEN STAGE ACTIVITIES

**Objective**: *To identify the **most significant activity** contributing to supply chain inefficiency with respect to cost, time and quality in different stages of fruits supply chain with specific reference to mango*

| STAGE II (Local Trader/ Middlemen) | **Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to:** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cost** | | | | | **Time** | | | | | **Quality** | | | | |
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| ***ACTIVITY*** | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| Unloading of Box/Carton/Crates/ Bags from Tractor/Bullock cart/Truck/Mini Trucks to the area of Local Agents/ local market | | | | | | | | | | | | | | | |
| Storing of Fresh Produce at Local Agents area/Local market | | | | | | | | | | | | | | | |
| Auctioning/Selling of Fresh Produce | | | | | | | | | | | | | | | |
| Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | | | | | | | | | | | | | | | |
| Unloading of mango from seller's crates (at Local Market) and loading to the buyer's crate (Local trader) | | | | | | | | | | | | | | | |
| Sorting, Grading & Repackaging of Mango as per the Grades in another Crates by the buyer (Local trader) for further selling | | | | | | | | | | | | | | | |
| Handling, Loading & Stacking of Box/Carton/Crates in Trucks | | | | | | | | | | | | | | | |
| Tying the Load in Trucks | | | | | | | | | | | | | | | |
| In Transit (To Mandi) | | | | | | | | | | | | | | | |

## WHOLESALE/MANDI STAGE ACTIVITIES

**Objective**: *To identify the **most significant activity** contributing to supply chain inefficiency with respect to cost, time and quality in different stages of fruits supply chain with specific reference to mango*

| STAGE III (Wholesale/ Mandi level) | Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to: | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost | | | | | Time | | | | | Quality | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| ***ACTIVITY*** | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | | | | | | | | | | | | | | | |
| Storing of Crates/ Cartons /Wooden Box at Mandi | | | | | | | | | | | | | | | |
| Auctioning/Selling of Mangoes | | | | | | | | | | | | | | | |
| Quality Inspection by the buyers (Random Sampling) | | | | | | | | | | | | | | | |
| Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | | | | | | | | | | | | | | | |
| Tying the Load in Trucks Mini Vans/ Rikshaw/Bullock Cart | | | | | | | | | | | | | | | |
| In Transit (To local trade/Maashakhors area) | | | | | | | | | | | | | | | |

## LOCAL TRADER/MASHAKHOR STAGE ACTIVITIES

**Objective**: *To identify the* ***most significant activity*** *contributing to supply chain inefficiency with respect to cost, time and quality in different stages of fruits supply chain with specific reference to mango*

| LEVEL IV (Local Trader at Azadpur Mandi) | Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to: | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost | | | | | Time | | | | | Quality | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| ***ACTIVITY*** | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's/Maashakhor's area at Azadpur mandi | | | | | | | | | | | | | | | |
| Storing of Goods | | | | | | | | | | | | | | | |
| Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading | | | | | | | | | | | | | | | |
| Cleaning of Mangoes | | | | | | | | | | | | | | | |
| Sorting, Grading & Repackaging of Mangoes by the Local traders/Maashakhors at Azadpur Mandi for further sale | | | | | | | | | | | | | | | |
| Storing & Ripening | | | | | | | | | | | | | | | |
| Selling of Mangoes to customers | | | | | | | | | | | | | | | |

## TRANSPORTER (TRANSPORTATION ACTIVITY)

**Objective**: *To identify the* ***most significant activity*** *contributing to supply chain inefficiency with respect to cost, time and quality in different stages of fruits supply chain with specific reference to mango*

| STAGE V (Transportation Stage) | Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to: | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost | | | | | Time | | | | | Quality | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| **LEVEL I (Farmer/Grower Level)** | | | | | | | | | | | | | | | |
| In Transit (From Farm To Local Market/Main Road) | | | | | | | | | | | | | | | |
| **LEVEL II (Local Commission Agent/ Local Trader Level)** | | | | | | | | | | | | | | | |
| In Transit (From Local Market To Mandi) | | | | | | | | | | | | | | | |
| **LEVEL III (Wholesale/ Mandi level)** | | | | | | | | | | | | | | | |
| In transit (From Mandi To local trade area) | | | | | | | | | | | | | | | |

## FARMER (FARM STAGE ACTIVITIES)

**Objective**: *To identify the* ***most significant activity*** *contributing to supply chain inefficiency with respect to cost, time and quality in different stages of vegetables supply chain with specific reference to tomato*

| **STAGE I (Farmer/Grower Level)** | **Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to:** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cost** | | | | | **Time** | | | | | **Quality** | | | | |
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| ***ACTIVITY*** | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| Plucking & Collecting Tomato in Bucket/ Basket | | | | | | | | | | | | | | | |
| Picking from Bucket/ Basket and Putting in Crates | | | | | | | | | | | | | | | |
| Carriage of Crates to the Collection Area/Collection Centre | | | | | | | | | | | | | | | |
| Storing of goods | | | | | | | | | | | | | | | |
| Unloading of fully loaded Crates at Collection Area/ Centre | | | | | | | | | | | | | | | |
| Cleaning of Tomatoes | | | | | | | | | | | | | | | |
| Sorting & Grading of Tomatoes and Packing in Crates as per the grade | | | | | | | | | | | | | | | |
| Consolidation of Goods | | | | | | | | | | | | | | | |
| Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | | | | | | | | | | | | | | | |
| Tying the Load in Mini Vehicles or Trucks | | | | | | | | | | | | | | | |
| In Transit (To Local Market/Main Road) | | | | | | | | | | | | | | | |

## LOCAL MANDI STAGE ACTIVITIES

**Objective**: *To identify the **most significant activity** contributing to supply chain inefficiency with respect to cost, time and quality in different stages of vegetables supply chain with specific reference to tomato*

| **STAGE II (Local Trader/ Middlemen)** | **Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to:** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cost** | | | | | **Time** | | | | | **Quality** | | | | |
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| ***ACTIVITY*** | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| Unloading of Crates from Mini Vehicles/Truck to the Local Mandi | | | | | | | | | | | | | | | |
| Storing of Fresh Produce at Local Mandi | | | | | | | | | | | | | | | |
| Sorting & Grading of Tomatoes | | | | | | | | | | | | | | | |
| Auctioning/Selling of Fresh Produce | | | | | | | | | | | | | | | |
| Inspection /Quality Check (Random Sampling) by the buyer (Local trader) | | | | | | | | | | | | | | | |
| Unloading of Tomato from seller's crates and Loading to the buyer's crates | | | | | | | | | | | | | | | |
| Handling, Loading & Stacking of Crates in Trucks | | | | | | | | | | | | | | | |
| Tying the load in Truck | | | | | | | | | | | | | | | |
| In Transit (To Mandi) | | | | | | | | | | | | | | | |

## WHOLESALE/MANDI STAGE ACTIVITIES

**Objective**: *To identify the **most significant activity** contributing to supply chain inefficiency with respect to cost, time and quality in different stages of vegetables supply chain with specific reference to tomato*

| STAGE III (Wholesale/ Mandi level) | **Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to:** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cost** | | | | | **Time** | | | | | **Quality** | | | | |
| | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** |
| ***ACTIVITY*** | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| Unloading of Crates from Trucks at Mandi Level | | | | | | | | | | | | | | | |
| Storing & Handling of Crates at Mandi | | | | | | | | | | | | | | | |
| Sorting & Grading of Tomatoes | | | | | | | | | | | | | | | |
| Auctioning/Selling of Tomatoes | | | | | | | | | | | | | | | |
| Quality Inspection by the buyers (Random Sampling) | | | | | | | | | | | | | | | |
| Unloading of Tomato and Loading to the buyer's Crate | | | | | | | | | | | | | | | |
| Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | | | | | | | | | | | | | | | |
| Tying the load | | | | | | | | | | | | | | | |
| Dispatch of Goods | | | | | | | | | | | | | | | |

## TRANSPORTER (TRANSPORTATION ACTIVITY)

**Objective**: *To identify the* ***most significant activity*** *contributing to supply chain inefficiency with respect to cost, time and quality in different stages of vegetables supply chain with specific reference to tomato*

| **STAGE V (Transportation Stage)** | **Rank the following activity on the basis of their significance in terms of their contribution to SC inefficiency with respect to:** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cost** | | | | | **Time** | | | | | **Quality** | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant | Not Significant | Less Significant | Neutral | Significant | Highly Significant |
| **LEVEL I (Farmer/Grower Level)** | | | | | | | | | | | | | | | |
| In Transit (From Farm/Collection Centre To Local Trader Mandi) | | | | | | | | | | | | | | | |
| **LEVEL II (Local Trader/Mandi Level)** | | | | | | | | | | | | | | | |
| In Transit (From Local Mandi To Azadpur Mandi) | | | | | | | | | | | | | | | |

# APPENDIX II

## Variables identified through Literature Review for RO2

### Table-List of variables for high cost in fruits supply chain

| Stage | S. No. | Variables | Activity |
|---|---|---|---|
| Stage I-Farm Stage | 1 | Ignorance of Farmers to new methods of cultivation | Plucking & Collection of Mangoes in Crates/Baskets |
| | 2 | High manual labour charges-Plucking | |
| | 3 | Poor connectivity between plucking area and assembly area | |
| | 4 | Large number of Labour required for plucking & Collection | |
| | 5 | Lack of Labour's knowledge pertaining to sorting & grading techniques and processes | Sorting, Grading & Packaging, and Tying |
| | 6 | Lack of mechanical sorting, grading and packaging facility | |
| | 7 | Timely Non-availability of packaging materials | |
| | 8 | High Packaging Material charges | |
| | 9 | Price differential of packing material at different places | |
| | 10 | Requirement of expertise for grading and packaging | |
| | 11 | Excess usage of Material for layering and tapping the cartons/boxes | |
| | 12 | Non-usage of Sorting & Grading Technology | |
| | 13 | Non adoption of advanced packaging materials | |
| | 14 | Lack of Government packing houses/grading facilities | |
| | 15 | Poor farm connectivity by road | Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/Mini Trucks |
| | 16 | High Labour charges for carriage | |
| | 17 | High Labour cost due to long distance between packing and loading area | |
| | 18 | Large number of Labour required for carriage activity | |
| Stage II- Local Trader/Middlemen Stage | 1 | Lack of knowledge pertaining to sorting & grading techniques and processes | Sorting, Grading & Repackaging of Mango (as per the Grades) in another Crates by the buyer (Local trader) for further selling |
| | 2 | Lack of mechanical sorting, grading and packaging facility | |
| | 3 | Expensive Packaging material | |
| | 4 | Requirement of expertise for grading and packaging | |
| | 5 | Repeated handling and grading & repackaging at every stage | |
| | 6 | Lack of Government packing houses/grading facilities | |
| | 7 | Non-availability of advanced packaging material | |
| | 8 | Non-usage of Sorting & Grading Technology | |
| | 9 | Excess usage of Material for layering and tapping the cartons/boxes | |
| | 10 | High Manual Labour Charges | Handling, Loading & Stacking of Box/Carton/Crates in Trucks |
| | 11 | Large number of Labour required for Handling and Loading | |
| | 12 | Manual operations in HLS | |
| | 13 | Pre loading labour charges | |
| | 14 | Non-availability of tools and equipments for handling & loading | |
| | 15 | High Manual Labour Charges-Unloading | Unloading of Box/Carton/Crates/ Bags from Tractor/Bullock cart/Truck/Mini Trucks to the area of Local Agents/ local market |
| | 16 | Damage to crates/boxes while unloading | |
| | 17 | Large number of Labour required for Unloading | |
| | 18 | Manual operations in Unloading | |
| | 19 | Pre unloading labour charges | |
| | 20 | Non-availability of tools and equipments for unloading the load | |
| Stage III-Wholesale/Mandi Stage | 1 | High Labour Charges-Unloading | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level |
| | 2 | Damage to crates/boxes while unloading | |
| | 3 | Large number of Labour required for Unloading | |
| | 4 | Manual operations for Unloading | |
| | 5 | Pre unloading labour charges | |
| | 6 | Non-availability of tools and equipments for unloading the load | |
| | 7 | High Labour Charges in HLS | Handling, Loading & Stacking of goods in Mini |
| | 8 | Manual operations for HLS | |
| | 9 | Pre loading labour charges | |

| | | | |
|---|---|---|---|
| | **10** | Non-availability of tools and equipments for handling & loading | Vans/Trucks/ Rikshaw/Bullock Carts |
| | **11** | Expensive packaging materials | Storing of Crates/ Cartons /Wooden Box at Mandi |
| | **12** | High electricity charges | |
| | **13** | High charges of cold storage | |
| | **14** | Damage to boxes/crates due to rough manual handling while storage | |
| | **15** | Labour charges for maintenance and security | |
| **Stage IV- Local Trader/Mashakhor Stage** | **1** | Lack of knowledge pertaining to sorting & grading techniques and processes | Sorting, Grading & Repackaging of Mangoes by the Local traders at Adarshnagar, Azadpur for further sale |
| | **2** | Lack of mechanical sorting, grading and packaging facility | |
| | **3** | Timely Non-availability of packaging materials | |
| | **4** | Expensive Packaging material | |
| | **5** | Price differential of Packaging Materials at different places | |
| | **6** | High Labour charges arising out of expertise required for grading and packaging | |
| | **7** | Excess usage of Material for layering and tapping the cartons/boxes | |
| | **8** | Non-usage of Sorting & Grading Technology | |
| | **9** | Non-usage of Advanced Packaging Materials | |
| | **10** | Lack of Government packing houses/grading facilities | |
| | **11** | High Labour Charges for Unloading | Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's area at Adarshnagar, Azadpur mandi |
| | **12** | Damage to crates/boxes while unloading | |
| | **13** | Manual operations in Unloading | |
| | **14** | Non-availability of tools and equipments for unloading the load | |
| | **15** | High charges of ripening chamber | Storing & Ripening of Mangoes |
| | **16** | Damage to boxes/crates due to rough handling while storage | |
| | **17** | Expenditure on chemicals used for ripening | |
| | **18** | High electricity charges | |
| | **19** | High charges of cold storage facilities | |
| | **20** | Cost of labour for maintenance and security | |
| **Stage V-Transportation Stage** | **1** | Poor road connectivity | Transport from Farm to Wholesale Mandi |
| | **2** | Inappropriate Vehicle Routing | |
| | **3** | High charges of Taxes | |
| | **4** | Long distance between Farm and Wholesale Market | |
| | **5** | High Traffic Jams | |
| | **6** | Crossing and Toll Booth Charges | |
| | **7** | Convenience Charges by Policeman | |
| | **8** | High Fuel Prices | |
| | **9** | Timely Non-availability of transport facilities | |
| | **10** | High Freight Charges | |

**Table-List of variables for high lead time in fruits supply chain**

| **Stage** | **S. No.** | **Variables** | **Activity** |
|---|---|---|---|
| **Stage I-Farm Stage** | **1** | Manual sorting, grading & packaging | Sorting, Grading & Packaging and Tying |
| | **2** | Lack of knowledge pertaining to sorting & grading techniques and processes | |
| | **3** | Lack of sorting & grading technology | |
| | **4** | Non-availability of skilled labour for sorting, grading & packaging | |
| | **5** | Lack of mechanical sorting, grading and packaging facility | |
| | **6** | Labour's Ignorance for time allocated to sorting, grading and packaging | |
| | **7** | Timely Non-availability of packaging materials | |
| | **8** | Lack of Training and Knowledge about sorting, grading & packaging | |

| | | | |
|---|---|---|---|
| | 9 | Harvesting by hand picking | Plucking & Collection of Mangoes in Crates/Baskets |
| | 10 | Assembly points are not properly identified-Plucking | |
| | 11 | Lack of appropriate harvesting tools and equipments | |
| | 12 | Lack of Skilled labour for plucking and collection | |
| | 13 | Lack of proper planning for harvesting | |
| | 14 | Lack of farmer's awareness and knowledge regarding technology | |
| | 15 | Labour's Ignorance for time allocated to plucking and collection | |
| | 16 | Excess harvesting due to lack of information regarding market demand | |
| | 17 | Long distance between plucking area and assembly area | Carriage of Crates/Baskets to the Collection Area |
| | 18 | Poor road connectivity | |
| | 19 | Manual carriage by the means of head-load | |
| | 20 | Handling excess load by labour at the time of carriage | |
| | 21 | Employment of incapable labour (women and children) for carriage | |
| | 22 | Poor condition of path used for carriage | |
| **Stage II-Local Trader/Middlemen Stage** | 1 | Manual sorting, grading & packaging | Sorting, Grading & Repackaging of Mango (as per the Grades) in another Crates by the buyer (Local trader) for further selling |
| | 2 | Lack of knowledge pertaining to sorting & grading techniques and processes | |
| | 3 | Lack of sorting & grading technology | |
| | 4 | Non-availability of skilled labour for sorting, grading & packaging | |
| | 5 | Lack of mechanical sorting, grading and packaging facility | |
| | 6 | Time Ignorance during sorting, grading and packaging | |
| | 7 | Timely Non-availability of packaging materials | |
| | 8 | Lack of Training and Knowledge about sorting, grading & packaging | |
| | 9 | Manual unloading | Unloading of mango from seller's crates (at Local Market) and loading to the buyer's crate (Local trader) |
| | 10 | Employment of inadequate labour for unloading operations | |
| | 11 | Non-availability of skilled labour for unloading the crates | |
| | 12 | Inadequate space for unloading operations | |
| | 13 | Non-availability of equipments for unloading the crate | |
| | 14 | Handling and Loading by the means of head load | Handling, Loading & Stacking of Box/Carton/Crates in Trucks |
| | 15 | Single manual handling while loading | |
| | 16 | Bulk handling at the time of loading operations | |
| | 17 | Non-availability of skilled labour | |
| | 18 | Non-availability of tools and equipments for handling & loading | |
| **Stage III-Wholesale/Mandi Stage** | 1 | Manual unloading | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level |
| | 2 | Improper and High stacking of crates | |
| | 3 | Employment of inadequate labour for unloading operations | |
| | 4 | Non-usage of skilled labour for unloading the crates | |
| | 5 | Inadequate space for unloading operations | |
| | 6 | Non-availability of equipments for unloading | |
| | 7 | Arrival of Larger Quantity of goods | |
| | 8 | Improper planning for scheduling of Incoming Goods | |
| | 9 | Delay in auctioning of mangoes | Storing of Crates/ Cartons /Wooden Box at Mandi |
| | 10 | Inadequate and non-availability of timely demand information | |
| | 11 | High Stock/Volume of unsold mangoes at Mandi | |
| | 12 | Holding of goods in anticipation of high prices | |
| | 13 | Handling and Loading by the means of head load | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts |
| | 14 | Single manual handling while loading | |
| | 15 | Bulk handling of the crates/packages | |
| | 16 | Non-usage of skilled labour | |
| | 17 | Non-availability of tools and equipments for handling & loading | |
| **Stage IV-Local Trader/Mashakhor Stage** | 1 | Lack of demand in the market | Storing & Ripening of Mangoes |
| | 2 | Poor information regarding market demand | |
| | 3 | Holding of goods in anticipation of high prices | |
| | 4 | Lack of proper and uniform grading which hinder to achieve uniform ripening | |
| | 5 | Inadequate equipment for ripening | |
| | 6 | Manual sorting, grading & packaging | Sorting, Grading & Repackaging of Mangoes by the Local traders at |
| | 7 | Lack of knowledge pertaining to sorting & grading techniques and processes | |
| | 8 | Lack of sorting & grading technology | |

| | | | |
|---|---|---|---|
| | **9** | Non-availability of skilled labour for sorting, grading & packaging | Adarshnagar, Azadpur for further sale |
| | **10** | Lack of mechanical sorting, grading and packaging facility | |
| | **11** | Ignorance of time allocated to sorting, grading and packaging | |
| | **12** | Timely Non-availability of packaging materials | |
| | **13** | Lack of Training and Knowledge about sorting, grading & packaging | |
| | **14** | Manual unloading | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading |
| | **15** | Employment of inadequate labour for unloading operations | |
| | **16** | Non-availability of skilled labour for unloading the crates | |
| | **17** | Inadequate space for unloading operations | |
| | **18** | Non-availability of equipments for unloading the crate | |
| **Stage V-Transportation Stage** | **1** | Poor road connectivity | Transport from Farm to Wholesale Mandi |
| | **2** | Poor road conditions | |
| | **3** | Inappropriate Vehicle Routing | |
| | **4** | Irresponsible and Careless driving | |
| | **5** | Long distance between Farm and Wholesale Market | |
| | **6** | Timely Non-availability of transportation vehicle | |
| | **7** | Non Adherence to Time Schedule Allocated for Transportation | |
| | **8** | Police Verification and Frisking | |
| | **9** | Frequent Crossings and Toll Booths | |
| | **10** | Traffic Jams in Azadpur Mandi | |
| | **11** | Congestion and Traffic Jams | |

**Table-List of variables for poor quality in fruits supply chain**

| Stage | S. No. | Variables | Activity |
|---|---|---|---|
| **Stage I-Farm Stage** | **1** | Lack of proper grading and quality control system | Sorting, Grading & Packaging and Tying |
| | **2** | Carelessness in sorting, grading & packaging | |
| | **3** | Non-availability of skilled labour for sorting, grading & packaging | |
| | **4** | Lack of Training and Knowledge about packaging | |
| | **5** | Usage of inappropriate cushioning material for packaging | |
| | **6** | Non-usage of padding material for packaging | |
| | **7** | Loose packing of fruits inside packaging | |
| | **8** | Poor quality of packaging material | |
| | **9** | Non-availability of cooling shed in the collection area | |
| | **10** | Open Air area for sorting, grading and packaging operations | |
| | **11** | Non differentiation of produce on the level of ripening during sorting, grading and packaging | |
| | **12** | Brushing due to sharp edges of the packaging material | |
| | **13** | Inappropriate or poorly sealed packaging | |
| | **14** | Non treatment of produce before sorting, grading and packaging | |
| | **15** | Improper handling of fruits during sorting, grading & packaging | |
| | **16** | Overloading of fruits while packaging | |
| | **17** | Ignorance of time to be allocated to sorting, grading and packaging | |
| | **18** | Timely non-availability of packaging material | |
| | **19** | No scientific standard for determination of maturity | Plucking & Collection of Mangoes in Crates/Baskets |
| | **20** | Harvesting before maturity for getting higher price early in the season | |
| | **21** | Lack of trained manpower-Plucking | |
| | **22** | Brushing and Crushing of fruits because of accidental falling | |
| | **23** | Spreading the produce on the floor in the orchard's yard | |
| | **24** | Mechanical injury during operations | |
| | **25** | Mishandling and carelessness while plucking and collection | |
| | **26** | Exposure to high temperature during collection | |
| | **27** | Lack of appropriate harvesting tools | |
| | **28** | Lack of farmer's awareness and knowledge regarding technology | |
| | **29** | Excess Plucking due to Lack of information regarding market demand | |
| | **30** | Delayed or late harvesting | |
| | **31** | Harvesting during warmest part of the day | |
| | **32** | Non-availability of skilled labour | Handling, Loading |

| | | | |
|---|---|---|---|
| | 33 | Non-availability of support equipments for handling & loading | & Stacking of Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks |
| | 34 | Rough handling at the time of loading & stacking | |
| | 35 | Improper and high stacking | |
| | 36 | Dumping of Crates in the vehicle | |
| | 37 | Bulk handling of fresh produce | |
| | 38 | Single manual handling while loading & stacking | |
| | 39 | No proper arrangement of packages/crates for air circulation while stacking in vehicle | |
| | 40 | Open dock area which expose to direct sunlight/heat | |
| **Stage II-Local Trader/Middlemen Stage** | 1 | Insufficient storage and temperature controlled facilities | Storing of Fresh Produce |
| | 2 | Rough handling while storing | |
| | 3 | Improper and high stacking while storing | |
| | 4 | Inappropriate storing practices leading to compression | |
| | 5 | Inadequate ventilation at the place of storage | |
| | 6 | High temperature at storage area | |
| | 7 | Damage to the Mangoes caused by pest and fungal infection during storage | |
| | 8 | Non-availability of cooling shed at the place of storage | |
| | 9 | Delays in moving the produce to the wholesale market | |
| | 10 | Holding of goods in anticipation of high prices | |
| | 11 | Overstock due to Inadequate and non-availability of timely demand information | |
| | 12 | Non-usage of skilled labour for unloading the crates | Unloading of mango from seller's crates (at Local Market) and loading to the buyer's crate (Local trader) |
| | 13 | Rough handling while unloading | |
| | 14 | Inadequate space for unloading operations | |
| | 15 | Unloading the crates in an open area which expose to direct sunlight/heat | |
| | 16 | Unloading the crates in an inappropriate manner | |
| | 17 | Non-usage of skilled labour for Handling Loading & Stacking | Handling, Loading & Stacking of Box/Carton/Crates in Trucks |
| | 18 | Non-usage of supporting equipments for handling & loading | |
| | 19 | Rough handling at the time of loading & stacking | |
| | 20 | Improper and high stacking | |
| | 21 | Dumping of Crates into the vehicle | |
| | 22 | Bulk handling of fresh produce | |
| | 23 | Single manual handling while loading & stacking | |
| | 24 | No proper arrangement of packages/crates for air circulation while stacking in vehicle | |
| | 25 | Open dock area which expose to direct sunlight/heat | |
| **Stage III-Wholesale/Mandi Stage** | 1 | Insufficient storage and temperature controlled facilities | Storing of Crates/ Cartons /Wooden Box at Mandi |
| | 2 | Lack of cold storage facility | |
| | 3 | Rough handling while storing | |
| | 4 | Improper and high stacking while storing | |
| | 5 | Compression of mangoes due to heavy load in storing | |
| | 6 | Inadequate ventilation at the place of storage | |
| | 7 | High temperature at storage area | |
| | 8 | Damage to the mangoes caused by pest and fungal infection during storage | |
| | 9 | Non-availability of cooling shed at the place of storage | |
| | 10 | Holding of goods in anticipation of high prices | |
| | 11 | Overstock due to Inadequate and non-availability of timely demand information | |
| | 12 | Non-availability of skilled labour for unloading the crates | Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level |
| | 13 | Rough handling while unloading | |
| | 14 | Inadequate space for unloading operations | |
| | 15 | Expose to direct sunlight/heat while unloading | |
| | 16 | Open dock area which expose to direct sunlight/heat | |
| | 17 | Unloading in an inappropriate manner | |
| | 18 | Non-availability of skilled labour | Handling, Loading & Stacking of goods in Mini Vans/Trucks/ |
| | 19 | Non-availability of equipments for handling & loading | |
| | 20 | Rough handling at the time of loading & stacking | |
| | 21 | Improper and high stacking | |

| | | | |
|---|---|---|---|
| | **22** | Dumping of Crates into the vehicle | Rikshaw/Bullock Carts |
| | **23** | Bulk Handling at the time of Loading and Stacking | |
| | **24** | Single manual handling while loading & stacking | |
| | **25** | No proper arrangement of packages/crates for air circulation while stacking | |
| | **26** | Open dock area which expose to direct sunlight/heat | |
| **Stage IV-Local Trader/Mashakhor Stage** | **1** | Insufficient storage and ripening chamber facilities | Storing & Ripening of Mangoes |
| | **2** | Rough handling while storing | |
| | **3** | Improper and high stacking while storing | |
| | **4** | Compression of mangoes due to heavy load in storing | |
| | **5** | Inadequate ventilation at the place of storage | |
| | **6** | High temperature at storage and ripening area | |
| | **7** | Damage to the mangoes caused by pest and fungal infection during storage | |
| | **8** | Usage of calcium carbide for ripening process | |
| | **9** | Holding of goods in anticipation of high prices | |
| | **10** | Inadequate and non-availability of timely demand information | |
| | **11** | Improper placing of fruits during ripening | |
| | **12** | Inadequate equipment and ripening method | |
| | **13** | Lack of Proper Monitoring in Ripening Process | |
| | **14** | Lack of proper and uniform grading which hinder to achieve uniform ripening | |
| | **15** | Insufficient storage and temperature controlled facilities | Storing of Mangoes |
| | **16** | Lack of usage of cold storage facility | |
| | **17** | Rough handling while storing | |
| | **18** | Improper and high stacking while storing | |
| | **19** | Compression of mangoes due to heavy load in storing | |
| | **20** | Inadequate ventilation at the place of storage | |
| | **21** | High temperature at storage area | |
| | **22** | Damage to the mangoes caused by pest and fungal infection during storage | |
| | **23** | Non-availability of cooling shed at the place of storage | |
| | **24** | Holding of goods in anticipation of high prices | |
| | **25** | Lack of Information regarding market conditions | |
| | **26** | Non-availability of skilled labour for unloading the crates | Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading |
| | **27** | Rough handling while unloading | |
| | **28** | Inadequate space for unloading operations | |
| | **29** | Unloading the crates in an open area which expose to direct sunlight/heat | |
| | **30** | Unloading the crates in an inappropriate manner | |
| **Stage V-Transportation Stage** | **1** | Non-usage of Temperature controlled Transportation system | Transport from Farm to Wholesale Mandi |
| | **2** | No control on Temperature/ Humidity during transit | |
| | **3** | Packaging boxes of different weight, size, commodity in the same carrier | |
| | **4** | Jerks in Transit, by which pack structure get loose | |
| | **5** | Poor road conditions | |
| | **6** | Overburden and Overloading | |
| | **7** | Fungal infection during transit | |
| | **8** | Compression of goods due to putting weight on the load | |
| | **9** | Hitchhiking pests during transit | |
| | **10** | Improper stacking during transportation | |

**Table-List of variables for high cost in vegetables supply chain**

| Stage | S. No. | Variables | Activity |
|---|---|---|---|
| Stage I-Farm Stage | 1 | Hilly terrain | Carriage of Crates to the Collection Area/Collection Centre |
| | 2 | Poor farm connectivity by road | |
| | 3 | High Labour charges for carriage | |
| | 4 | Large number of Labour required for carriage activity | |
| | 5 | High Labour Charges | Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks |
| | 6 | Large number of Labour required for Handling and Loading | |
| | 7 | Manual operations for HLS | |
| | 8 | Pre loading labour charges | |
| | 9 | Non-availability of tools and equipments for handling & loading | |
| | 10 | Lack of knowledge pertaining to sorting & grading techniques and processes | Sorting & Grading of Tomatoes and Packing in Crates as per the grade |
| | 11 | Lack of mechanical sorting, grading and packaging facility | |
| | 12 | Timely Non-availability of packaging materials | |
| | 13 | High Packaging material charges | |
| | 14 | Price differential of Packaging materials at different places | |
| | 15 | High Labour charges arising out of expertise required for grading and packaging | |
| | 16 | Excess usage of packaging material for layering and tapping the cartons/boxes | |
| | 17 | Non-usage of Sorting & Grading Technology | |
| | 18 | Non-availability of advanced packaging materials | |
| | 19 | Lack of Government packing houses/grading facilities | |
| Stage II-Local Mandi Stage | 1 | Manually unloading operation | Unloading of Tomato and Loading to the buyer's Crate |
| | 2 | Non-availability of equipments for unloading the crate | |
| | 3 | High Labour charges for operations | |
| | 4 | High cost due to non-availability of government facilities for operations | |
| | 5 | Expensive packaging materials | |
| | 6 | High Labour Charges | Handling, Loading & Stacking of Box/Carton/Crates in Trucks |
| | 7 | Large number of Labour required for Handling and Loading | |
| | 8 | Manual operations for HLS | |
| | 9 | Pre loading labour charges | |
| | 10 | Non-availability of tools and equipments for handling & loading | |
| | 11 | High Labour Charges | Unloading of Box/Crates from Truck/Mini Trucks to the area of Local Agents/ local market |
| | 12 | Damage to crates/boxes while unloading | |
| | 13 | Large number of Labour required for Unloading the load from Truck | |
| | 14 | Manual operations for Unloading | |
| | 15 | Pre unloading labour charges | |
| | 16 | Non-availability of tools and equipments for unloading the load | |
| Stage III-Wholesale/Mandi Stage | 1 | Manual unloading | Unloading of Tomato from seller's crates and Loading to the buyer's crates |
| | 2 | Non-availability of equipments for unloading the crate | |
| | 3 | High Labour charges for operations | |
| | 4 | Non-availability of government facilities for operations | |
| | 5 | Large Requirement of Packaging Material | |
| | 6 | High Labour Charges | Unloading of Tomato Crates from Trucks at Mandi Level |
| | 7 | Damage to crates/boxes while unloading | |
| | 8 | Pre unloading labour charges | |
| | 9 | Non-availability of tools and equipments for unloading the load | |
| | 10 | Large number of Labour required for Unloading | |
| | 11 | Manual operations for unloading the load | |
| | 12 | High Labour Charges for Loading | Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart |
| | 13 | Manual operations for HLS | |
| | 14 | Pre loading labour charges | |
| | 15 | Non-availability of tools and equipments for handling & loading | |
| Stage IV-Transportation Stage | 1 | Poor road connectivity | Transport (Farm to Wholesale Mandi) |
| | 2 | Inappropriate Vehicle Routing | |
| | 3 | High charges of Taxes | |

| | | | |
|---|---|---|---|
| | 4 | Long distance between Farm and Wholesale Market | |
| | 5 | High Traffic Jams | |
| | 6 | Crossing and Toll Booth Charges | |
| | 7 | Convenience Charges by Policeman | |
| | 8 | High Fuel prices | |
| | 9 | Timely Non-availability of transport facilities | |
| | 10 | High Freight Charges | |

**Table-List of variables for high lead time in vegetables supply chain**

| Stage | S. No. | Variables | Activity |
|---|---|---|---|
| Stage I-Farm Stage | 1 | Assembly points are not properly identified | Carriage of Crates to the Collection Area/Collection Centre |
| | 2 | Long distance between plucking area and assembly area | |
| | 3 | Poor road connectivity | |
| | 4 | Manual carriage by the means of head-load | |
| | 5 | Handling excess load by labour at the time of carriage | |
| | 6 | Employment of incapable labour (women and children) for carriage | |
| | 7 | Poor condition of path used for carriage | |
| | 8 | Hilly Terrain | |
| | 9 | Manual sorting, grading & packaging | Sorting & Grading of Tomatoes and Packing in Crates |
| | 10 | Lack of knowledge pertaining to sorting & grading techniques and processes | |
| | 11 | Lack of sorting & grading technology | |
| | 12 | Non-availability of skilled labour for sorting, grading & packaging | |
| | 13 | Lack of mechanical sorting, grading and packaging facility | |
| | 14 | Ignorance of time allocated to sorting, grading and packaging | |
| | 15 | Timely Non-availability of packaging materials | |
| | 16 | Lack of Training and Knowledge about sorting, grading & packaging | |
| | 17 | Harvesting by hand picking | Plucking & Collecting Tomato in Bucket/ Basket |
| | 18 | Excess harvesting due to lack of information regarding market demand | |
| | 19 | Lack of appropriate harvesting tools and equipments | |
| | 20 | Lack of Skilled labour for plucking and collection | |
| | 21 | Lack of proper planning for harvesting | |
| | 22 | Lack of farmer's awareness and knowledge regarding technology | |
| | 23 | Ignorance of time allocated to plucking and collection | |
| Stage II-Local Mandi Stage | 1 | Manual unloading | Unloading of Tomato and Loading to the buyer's Crate |
| | 2 | Employment of inadequate labour for unloading operations | |
| | 3 | Non-availability of skilled labour for unloading the crates | |
| | 4 | Inadequate space for unloading and loading operations | |
| | 5 | Non-availability of equipments for unloading the crate | |
| | 6 | Manual unloading | Unloading of Crates from Truck/Mini Vehicles to the Local Mandi |
| | 7 | Improper and High stacking of crates | |
| | 8 | Employment of inadequate labour for unloading operations | |
| | 9 | Non-availability of skilled labour for unloading the crates | |
| | 10 | Inadequate space for unloading operations | |
| | 11 | Non-availability of equipments for unloading | |
| | 12 | Inadequate Resources for dealing with unexpected bulk arrival | |
| | 13 | Improper planning for scheduling of Incoming Goods | |
| | 14 | Handling and Loading by the means of head load | Handling, Loading & Stacking of Box/Carton/Crates in Trucks |
| | 15 | Single manual handling while loading | |
| | 16 | Bulk handling of crates/packages | |
| | 17 | Non-availability of skilled labour | |
| | 18 | Non-availability of tools and equipments for handling & loading | |
| Stage III-Wholesale Stage | 1 | Manual unloading and loading operations | Unloading of Tomato from seller's crates and Loading to the buyer's crates |
| | 2 | Employment of inadequate labour for operations | |
| | 3 | Non-availability of skilled labour for unloading and loading the crates | |
| | 4 | Inadequate space for unloading and loading operations | |

| | | | |
|---|---|---|---|
| | 5 | Non-availability of equipments for loading and unloading the crate | |
| | 6 | Manual unloading | Unloading of Tomato Crates from Trucks at Mandi Level |
| | 7 | Improper and High stacking of crates | |
| | 8 | Employment of inadequate labour for unloading operations | |
| | 9 | Non-availability of skilled labour for unloading the crates | |
| | 10 | Inadequate space for unloading operations | |
| | 11 | Non-availability of equipments for unloading | |
| | 12 | Inadequate Resources for dealing with unexpected bulk arrival | |
| | 13 | Improper planning for scheduling of Incoming Goods | |
| | 14 | Handling and Loading by the means of head load | Handling, Loading & Stacking of Tomato Crates in Trucks |
| | 15 | Manual handling while loading | |
| | 16 | Bulk handling of crates/packages | |
| | 17 | Non-availability of skilled labour for HLS | |
| | 18 | Non-availability of tools and equipments for handling & loading | |
| Stage IV-Transportation Stage | 1 | Poor road connectivity | Transport (Farm to Wholesale Mandi) |
| | 2 | Poor road conditions in hilly areas | |
| | 3 | Hilly Terrain | |
| | 4 | Inappropriate Vehicle Routing | |
| | 5 | Irresponsible and Careless driving | |
| | 6 | Long distance between Farm and Wholesale Market | |
| | 7 | Timely Non-availability of transportation vehicle | |
| | 8 | Non Adherence to Time Schedule Allocated for Transportation | |
| | 9 | Police Verification and Frisking | |
| | 10 | Frequent Crossings and Toll Booths | |
| | 11 | Traffic Jams in Azadpur Mandi | |
| | 12 | Congestion and Traffic Jams | |

**Table-List of variables for poor quality in vegetables supply chain**

| Stage | S. No. | Variables | Activity |
|---|---|---|---|
| Stage I-Farm Stage | 1 | Insufficient storage and temperature controlled facilities | Storing of Goods |
| | 2 | Lack of availability of temperature controlled storage area | |
| | 3 | Rough handling while storing | |
| | 4 | Improper and high stacking while storing | |
| | 5 | Compression of Tomatoes due to heavy load in storing | |
| | 6 | High temperature at storage area | |
| | 7 | Damage to the Tomatoes caused by pest and fungal infection during storage | |
| | 8 | Non-availability of cooling shed at the place of storage | |
| | 9 | Holding of goods in anticipation of high prices | |
| | 10 | Inadequate ventilation at the place of storage | |
| | 11 | Overstock due to Inadequate and non-availability of timely demand information | |
| | 12 | Falling of Tomatoes from crates/baskets during carriage | Carriage of Crates to the Collection Area/Collection Centre |
| | 13 | High temperature during carriage | |
| | 14 | Jerks during carriage which impact the quality | |
| | 15 | Mishandling and Careless during carriage | |
| | 16 | Handling excess load by labour at the time of carriage | |
| | 17 | Non-usage of skilled labour | Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks |
| | 18 | Non-availability of Mechanical handling & loading facility | |
| | 19 | Rough handling at the time of loading & stacking | |
| | 20 | Improper stacking | |
| | 21 | Dumping of Crates | |
| | 22 | Bulk handling of fresh produce | |
| | 23 | Single manual handling while loading & stacking | |
| | 24 | No proper arrangement of packages/crates for air circulation while stacking | |
| | 25 | Open Air Loading operations which expose to direct sunlight/heat | |

| | | | |
|---|---|---|---|
| Stage II-Local Mandi Stage | **1** | Insufficient storage and temperature controlled facilities | Storing of Fresh Produce |
| | **2** | Rough handling while storing | |
| | **3** | Improper and high stacking while storing | |
| | **4** | Inappropriate storing practices leading to compression of tomatoes | |
| | **5** | Inadequate ventilation at the place of storage | |
| | **6** | High temperature at storage area | |
| | **7** | Damage to the Tomatoes caused by pest and fungal infection during storage | |
| | **8** | Non-availability of cooling shed at the place of storage | |
| | **9** | Delays in moving the produce to the wholesale market | |
| | **10** | Holding of goods in anticipation of high prices | |
| | **11** | Overstock due to Inadequate and non-availability of timely demand information | |
| | **12** | Non-availability of skilled labour for unloading the crates | Unloading of Tomato from seller's crates (at Local Market) and loading to the buyer's crate (Local trader) |
| | **13** | Rough handling while unloading | |
| | **14** | Inadequate space for unloading operations | |
| | **15** | Unloading the crates in an open area which expose to direct sunlight/heat | |
| | **16** | Unloading the crates in an inappropriate manner | |
| | **17** | Non-availability of skilled labour for unloading the crates | Unloading of Crates from Truck/Mini Vehicles to the Local Mandi |
| | **18** | Rough handling while unloading | |
| | **19** | Inadequate space for unloading operations | |
| | **20** | Expose to direct sunlight/heat while unloading | |
| | **21** | Open Dock Area which expose to direct sunlight | |
| | **22** | Unloading in an inappropriate manner | |
| Stage III-Wholesale/Mandi Stage | **1** | Insufficient storage and temperature controlled facilities | Storing of Fresh Produce at Local Mandi |
| | **2** | Non-availability of cold storage facility | |
| | **3** | Rough handling while storing | |
| | **4** | Improper and High stacking while storing | |
| | **5** | Inappropriate storing practices leading to compression of Tomatoes | |
| | **6** | Inadequate ventilation at the place of storage | |
| | **7** | High temperature at storage area | |
| | **8** | Damage to the Tomatoes caused by pest and fungal infection during storage | |
| | **9** | Non-availability of cooling shed at the place of storage | |
| | **10** | Holding of goods in anticipation of high prices | |
| | **11** | Inadequate and non-availability of timely demand information | |
| | **12** | Non-availability of skilled labour for unloading the crates | Unloading of Tomato from seller's crates and loading to the buyer's crate |
| | **13** | Rough handling while unloading | |
| | **14** | Inadequate space for unloading operations | |
| | **15** | Unloading and loading operations in an open area | |
| | **16** | Unloading the crates in an inappropriate manner | |
| | **17** | Non-availability of skilled labour for unloading the crates | Unloading of Tomato Crates from Truck at Wholesale Mandi |
| | **18** | Rough handling while unloading | |
| | **19** | Inadequate space for unloading operations | |
| | **20** | Open Area for Unloading which expose to direct sunlight/heat | |
| | **21** | Open dock area which expose to direct sunlight/heat | |
| | **22** | Unloading in an inappropriate manner | |
| Stage IV-Transportation Stage | **1** | Non-usage of Temperature controlled Transportation system | Transport (Farm to Wholesale Mandi) |
| | **2** | No control on Temperature/ Humidity during transit | |
| | **3** | Packaging boxes of different weight, size, commodity in the same carrier | |
| | **4** | Jerks in Transit, by which pack structure get loose | |
| | **5** | Poor road conditions | |
| | **6** | Overburden and Overloading | |
| | **7** | Fungal infection during transit | |
| | **8** | Compression of goods due to putting weight on the load | |
| | **9** | Hitchhiking pests during transit | |
| | **10** | Improper stacking during transportation | |

# APPENDIX III

## QUESTIONNAIRE-RO2

***Project Topic:*** Developing a Framework to Improve Supply Chain Efficiency of Fruits and Vegetables Sector

I am Saurav Negi, Doctoral Research Fellow at University of Petroleum and Energy Studies, Dehradun, is pursuing PhD, titled, "Developing a Framework to improve Supply Chain Efficiency of Fruits and Vegetables Sector".

***Objective of the study:*** To identify the factors leading to supply chain inefficiency in the identified activities in different stages of fruits and vegetables supply chain with specific reference to mango and tomato

***Scope of the Study:*** The identified factors will help in developing a framework to improve supply chain efficiency in Fruits and Vegetables sector.

***Nature of the Study:*** The entire project is based on Primary research having sample size more than 200, which includes Farmers, Traders/ Agents, Commission Agents, Wholesaler, and Transporter.

***Confidentiality:*** The data provided would be used for academic purpose only. For any queries, you may kindly contact Mr. Saurav Negi at +91-9634714440 or snegi@ddn.upes.ac.in

Kindly provide your personal details as follows:

Name: ……………………………………………………………………………………..

Location………………………………………………………………………………

Occupation: ……………………………………………………………………………..

Age: 20-35 ☐ 36-50 ☐ 51-above ☐

Educational Qualification: No education ☐ Primary ☐ Secondary ☐ Tertiary ☐

Experience in the area: 0-5 Yrs ☐ 5-10 Yrs ☐ 10-15 Yrs ☐ 15-20 Yrs ☐ 20< above ☐

Email: ………………………………………………………………………………

Contact Number: ………………………………………………………………………

***Supply Chain Efficiency*** *in general, describes the extent to which* **time, effort or cost is well** used *for the intended task or purpose. It is often used with the specific purpose of relaying the capability of a specific application of effort to produce a specific outcome effectively with a* **minimum amount or quantity of waste, expense, or unnecessary effort.** *It is the measure of getting the right quality product to the right place at the right time at the least cost.*

## Fruits Supply Chain

## Stage I-Farm Stage (*Respondent-Farmers*)

<table>
<tr><td colspan="8">The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost at farm stage of fruit supply chain with specific reference to mango</td></tr>
<tr><td colspan="8">Please indicate how much you agree or disagree with each of these statements:</td></tr>
<tr><td colspan="8">Reasons leading to supply chain inefficiency with respect to cost</td></tr>
<tr><td rowspan="3">Activity</td><td rowspan="3">S. No.</td><td rowspan="3">Statements</td><td colspan="5">Level of Agreement</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree or disagree</td><td>Agree</td><td>Strongly agree</td></tr>
<tr><td rowspan="4">Plucking & collection of mango in the crates</td><td>1</td><td>Ignorance of Farmers to new methods of cultivation is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>High manual labour charges in Plucking is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Poor connectivity between plucking area and assembly area is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Large number of Labour required for plucking & Collection is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="10">Sorting, Grading & Packaging and Tying</td><td>5</td><td>Lack of Labour's knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>Timely Non-availability of packaging materials is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>High Packaging Material charges is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Price differential of packing material at different places is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>Requirement of expertise for grading and packaging is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>Excess usage of Material for layering and tapping the cartons/boxes is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>Non-usage of Sorting & Grading Technology is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>13</td><td>Non adoption of advanced packaging materials is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>14</td><td>Lack of Government packing houses/grading facilities is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Carriage of Packed Crate/Box/Bags for Loading in Tractor/Bullock cart/Truck/ Mini Trucks</td><td>15</td><td>Poor farm connectivity by road is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>High Labour charges for carriage is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td>High Labour cost due to long distance between packing and loading area is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>18</td><td>Large number of Labour required for carriage activity is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time at farm stage of fruit supply chain with specific reference to mango</td></tr>
<tr><td colspan="8">Please indicate how much you agree or disagree with each of these statements:</td></tr>
<tr><td colspan="8">Reasons leading to supply chain inefficiency with respect to high lead time</td></tr>
<tr><td rowspan="3">Activity</td><td rowspan="3">S. No.</td><td rowspan="3">Statements</td><td colspan="5">Level of Agreement</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree or disagree</td><td>Agree</td><td>Strongly agree</td></tr>
<tr><td>Sorting,</td><td>1</td><td>Manual sorting, grading & packaging practice is leading to supply chain inefficiency</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Grading & Packaging and Tying | 2 | Lack of knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency | | | | | |
| | 3 | Lack of sorting & grading technology is leading to supply chain inefficiency | | | | | |
| | 4 | Non-availability of skilled labour for sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | 5 | Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency | | | | | |
| | 6 | Labour's Ignorance for time allocated to sorting, grading and packaging is leading to supply chain inefficiency | | | | | |
| | 7 | Timely Non-availability of packaging materials is leading to supply chain inefficiency | | | | | |
| | 8 | Lack of Training and Knowledge about sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| Plucking & Collection of Mangoes in Crates/Baskets | 9 | Harvesting by hand picking is leading to supply chain inefficiency | | | | | |
| | 10 | Assembly points are not properly identified which is leading to supply chain inefficiency | | | | | |
| | 11 | Lack of appropriate harvesting tools and equipments is leading to supply chain inefficiency | | | | | |
| | 12 | Lack of Skilled labour for plucking and collection is leading to supply chain inefficiency | | | | | |
| | 13 | Lack of proper planning for harvesting is leading to supply chain inefficiency | | | | | |
| | 14 | Lack of farmer's awareness and knowledge regarding technology is leading to supply chain inefficiency | | | | | |
| | 15 | Labour's Ignorance for time allocated to plucking and collection is leading to supply chain inefficiency | | | | | |
| | 16 | Excess harvesting due to lack of information regarding market demand is leading to supply chain inefficiency | | | | | |
| Carriage of Crates/Baskets to the Collection Area | 17 | Long distance between plucking area and assembly area is leading to supply chain inefficiency | | | | | |
| | 18 | Poor road connectivity is leading to supply chain inefficiency | | | | | |
| | 19 | Manual carriage by the means of head-load is leading to supply chain inefficiency | | | | | |
| | 20 | Handling excess load by labour at the time of carriage is leading to supply chain inefficiency | | | | | |
| | 21 | Employment of incapable labour (women and children) for carriage is leading to supply chain inefficiency | | | | | |
| | 22 | Poor condition of path used for carriage is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality at farm stage of fruit supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| Sorting, Grading & Packaging and Tying | 1 | Lack of proper grading and quality control system is leading to supply chain inefficiency | | | | | |
| | 2 | Carelessness in sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | 3 | Non-availability of skilled labour for sorting, grading & packaging is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **4** | Lack of Training and Knowledge about packaging is leading to supply chain inefficiency | | | | | |
| | **5** | Usage of inappropriate cushioning material for packaging is leading to supply chain inefficiency | | | | | |
| | **6** | Non-usage of padding material for packaging is leading to supply chain inefficiency | | | | | |
| | **7** | Loose packing of fruits inside packaging is leading to supply chain inefficiency | | | | | |
| | **8** | Poor quality of packaging material is leading to supply chain inefficiency | | | | | |
| | **9** | Non-availability of cooling shed in the collection area is leading to supply chain inefficiency | | | | | |
| | **10** | Open Air area for sorting, grading and packaging operations is leading to supply chain inefficiency | | | | | |
| | **11** | Non differentiation of produce on the level of ripening during sorting, grading and packaging is leading to supply chain inefficiency | | | | | |
| | **12** | Brushing due to sharp edges of the packaging material is leading to supply chain inefficiency | | | | | |
| | **13** | Inappropriate or poorly sealed packaging is leading to supply chain inefficiency | | | | | |
| | **14** | Non treatment of produce before sorting, grading and packaging is leading to supply chain inefficiency | | | | | |
| | **15** | Improper handling of fruits during sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | **16** | Overloading of fruits while packaging is leading to supply chain inefficiency | | | | | |
| | **17** | Ignorance of time to be allocated to sorting, grading and packaging is leading to supply chain inefficiency | | | | | |
| | **18** | Timely non-availability of packaging material is leading to supply chain inefficiency | | | | | |
| **Plucking & Collection of Mangoes in Crates/Baskets** | **19** | No scientific standard for determination of maturity is leading to supply chain inefficiency | | | | | |
| | **20** | Harvesting before maturity for getting higher price early in the season is leading to supply chain inefficiency | | | | | |
| | **21** | Lack of trained manpower for plucking activity is leading to supply chain inefficiency | | | | | |
| | **22** | Brushing and Crushing of fruits because of accidental falling is leading to supply chain inefficiency | | | | | |
| | **23** | Spreading the produce on the floor in the orchard's yard is leading to supply chain inefficiency | | | | | |
| | **24** | Mechanical injury during operations is leading to supply chain inefficiency | | | | | |
| | **25** | Mishandling and carelessness while plucking and collection is leading to supply chain inefficiency | | | | | |
| | **26** | Exposure to high temperature during collection is leading to supply chain inefficiency | | | | | |
| | **27** | Lack of appropriate harvesting tools is leading to supply chain inefficiency | | | | | |
| | **28** | Lack of farmer's awareness and knowledge regarding technology is leading to supply chain inefficiency | | | | | |
| | **29** | Excess Plucking due to Lack of information regarding market demand is leading to supply chain inefficiency | | | | | |
| | **30** | Delayed or late harvesting is leading to supply chain inefficiency | | | | | |
| | **31** | Harvesting during warmest part of the day is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of** | **32** | Non-availability of skilled labour for HLS is leading to supply chain inefficiency | | | | | |
| | **33** | Non-availability of support equipments for handling & loading is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Box/Carton/Crates in Tractor/Bullock cart/Truck/Mini Trucks | 34 | Rough handling at the time of loading & stacking is leading to supply chain inefficiency | | | | | |
| | 35 | Improper and high stacking is leading to supply chain inefficiency | | | | | |
| | 36 | Dumping of Crates in the vehicle is leading to supply chain inefficiency | | | | | |
| | 37 | Bulk handling of fresh produce is leading to supply chain inefficiency | | | | | |
| | 38 | Single manual handling while loading & stacking is leading to supply chain inefficiency | | | | | |
| | 39 | No proper arrangement of packages/crates for air circulation while stacking in vehicle is leading to supply chain inefficiency | | | | | |
| | 40 | Open dock area which expose to direct sunlight/heat is leading to supply chain inefficiency | | | | | |

## Stage II- Local Trader/Middlemen stage (*Respondent-Local Trader/Middlemen*)

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost at Local trader/Middlemen stage of fruit supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to increasing cost**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1<br>Strongly disagree | 2<br>Disagree | 3<br>Neither agree or disagree | 4<br>Agree | 5<br>Strongly agree |
| Sorting, Grading & Repackaging of Mango (as per the Grades) in another Crates by the buyer (Local trader) for further selling | 1 | Lack of knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency | | | | | |
| | 2 | Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency | | | | | |
| | 3 | Expensive Packaging material is leading to supply chain inefficiency | | | | | |
| | 4 | Requirement of expertise for grading and packaging is leading to supply chain inefficiency | | | | | |
| | 5 | Repeated handling and grading & repackaging at every stage is leading to supply chain inefficiency | | | | | |
| | 6 | Lack of Government packing houses/grading facilities is leading to supply chain inefficiency | | | | | |
| | 7 | Non-availability of advanced packaging material is leading to supply chain inefficiency | | | | | |
| | 8 | Non-usage of Sorting & Grading Technology is leading to supply chain inefficiency | | | | | |
| | 9 | Excess usage of Material for layering and tapping the cartons/boxes is leading to supply chain inefficiency | | | | | |
| Handling, Loading & Stacking of Box/Carton/Crates in Trucks | 10 | High Manual Labour Charges is leading to supply chain inefficiency | | | | | |
| | 11 | Large number of Labour required for Handling and Loading is leading to supply chain inefficiency | | | | | |
| | 12 | Manual operations in HLS is leading to supply chain inefficiency | | | | | |
| | 13 | Pre loading labour charges is leading to supply chain inefficiency | | | | | |
| | 14 | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |
| Unloading of Box/Carton/Crates/ Bags | 15 | High Manual Labour Charges in Unloading activity is leading to supply chain inefficiency | | | | | |
| | 16 | Damage to crates/boxes while unloading is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **from Tractor/ Bullock cart/Truck/Mini Trucks to the area of Local Agents/ local market** | **17** | Large number of Labour required for Unloading is leading to supply chain inefficiency | | | | | |
| | **18** | Manual operations in Unloading is leading to supply chain inefficiency | | | | | |
| | **19** | Pre unloading labour charges is leading to supply chain inefficiency | | | | | |
| | **20** | Non-availability of tools and equipments for unloading the load is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time at Local trader/Middlemen stage of fruit supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to high lead time**

| **Activity** | **S. No.** | **Statements** | **Level of Agreement** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Sorting, Grading & Repackaging of Mango (as per the Grades) in another Crates by the buyer (Local trader) for further selling** | **1** | Manual sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | **2** | Lack of knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency | | | | | |
| | **3** | Lack of sorting & grading technology is leading to supply chain inefficiency | | | | | |
| | **4** | Non-availability of skilled labour for sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | **5** | Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency | | | | | |
| | **6** | Time Ignorance during sorting, grading and packaging is leading to supply chain inefficiency | | | | | |
| | **7** | Timely Non-availability of packaging materials is leading to supply chain inefficiency | | | | | |
| | **8** | Lack of Training and Knowledge about sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| **Unloading of mango from seller's crates (at Local Market) and loading to the buyer's crate (Local trader)** | **9** | Manual unloading is leading to supply chain inefficiency | | | | | |
| | **10** | Employment of inadequate labour for unloading operations is leading to supply chain inefficiency | | | | | |
| | **11** | Non-availability of skilled labour for unloading the crates is leading to supply chain inefficiency | | | | | |
| | **12** | Inadequate space for unloading operations is leading to supply chain inefficiency | | | | | |
| | **13** | Non-availability of equipments for unloading the crate is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of Box/Carton/Crates in Trucks** | **14** | Handling and Loading by the means of head load is leading to supply chain inefficiency | | | | | |
| | **15** | Single manual handling while loading is leading to supply chain inefficiency | | | | | |
| | **16** | Bulk handling at the time of loading operations is leading to supply chain inefficiency | | | | | |
| | **17** | Non-availability of skilled labour is leading to supply chain inefficiency | | | | | |
| | **18** | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality at local trader/middlemen stage of fruit supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| **Activity** | **S. No.** | **Statements** | **Level of Agreement** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** |

| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
|---|---|---|---|---|---|---|---|
| **Storing of Fresh Produce** | **1** | Insufficient storage and temperature controlled facilities is leading to supply chain inefficiency | | | | | |
| | **2** | Rough handling while storing is leading to supply chain inefficiency | | | | | |
| | **3** | Improper and high stacking while storing is leading to supply chain inefficiency | | | | | |
| | **4** | Inappropriate storing practices leading to compression | | | | | |
| | **5** | Inadequate ventilation at the place of storage is leading to supply chain inefficiency | | | | | |
| | **6** | High temperature at storage area is leading to supply chain inefficiency | | | | | |
| | **7** | Damage to the Mangoes caused by pest and fungal infection during storage is leading to supply chain inefficiency | | | | | |
| | **8** | Non-availability of cooling shed at the place of storage is leading to supply chain inefficiency | | | | | |
| | **9** | Delays in moving the produce to the wholesale market is leading to supply chain inefficiency | | | | | |
| | **10** | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| | **11** | Overstock due to Inadequate and non-availability of timely demand information is leading to supply chain inefficiency | | | | | |
| **Unloading of mango from seller's crates (at Local Market) and loading to the buyer's crate (Local trader)** | **12** | Non-usage of skilled labour for unloading the crates is leading to supply chain inefficiency | | | | | |
| | **13** | Rough handling while unloading is leading to supply chain inefficiency | | | | | |
| | **14** | Inadequate space for unloading operations is leading to supply chain inefficiency | | | | | |
| | **15** | Unloading the crates in an open area which expose to direct sunlight/heat | | | | | |
| | **16** | Unloading the crates in an inappropriate manner is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of Box/Carton/Crates in Trucks** | **17** | Non-usage of skilled labour for Handling Loading & Stacking is leading to supply chain inefficiency | | | | | |
| | **18** | Non-usage of supporting equipments for handling & loading is leading to supply chain inefficiency | | | | | |
| | **19** | Rough handling at the time of loading & stacking is leading to supply chain inefficiency | | | | | |
| | **20** | Improper and high stacking is leading to supply chain inefficiency | | | | | |
| | **21** | Dumping of Crates into the vehicle is leading to supply chain inefficiency | | | | | |
| | **22** | Bulk handling of fresh produce | | | | | |
| | **23** | Single manual handling while loading & stacking is leading to supply chain inefficiency | | | | | |
| | **24** | No proper arrangement of packages/crates for air circulation while stacking in vehicle is leading to supply chain inefficiency | | | | | |
| | **25** | Open dock area which expose to direct sunlight/heat is leading to supply chain inefficiency | | | | | |

### Stage III- Wholesale/Mandi stage (*Respondent-Wholesaler/Commission Agents*)

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost at Wholesale mandi stage of fruits supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to increasing cost**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 1 | High Labour Charges in Unloading is leading to supply chain inefficiency | | | | | |
| | 2 | Damage to crates/boxes while unloading is leading to supply chain inefficiency | | | | | |
| | 3 | Large number of Labour required for Unloading is leading to supply chain inefficiency | | | | | |
| | 4 | Manual operations for Unloading is leading to supply chain inefficiency | | | | | |
| | 5 | Pre unloading labour charges is leading to supply chain inefficiency | | | | | |
| | 6 | Non-availability of tools and equipments for unloading the load is leading to supply chain inefficiency | | | | | |
| Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts | 7 | High Labour Charges in HLS is leading to supply chain inefficiency | | | | | |
| | 8 | Manual operations for HLS is leading to supply chain inefficiency | | | | | |
| | 9 | Pre loading labour charges is leading to supply chain inefficiency | | | | | |
| | 10 | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |
| Storing of Crates/ Cartons /Wooden Box at Mandi | 11 | Expensive packaging materials is leading to supply chain inefficiency | | | | | |
| | 12 | High electricity charges is leading to supply chain inefficiency | | | | | |
| | 13 | High charges of cold storage is leading to supply chain inefficiency | | | | | |
| | 14 | Damage to boxes/crates due to rough manual handling while storage is leading to supply chain inefficiency | | | | | |
| | 15 | Labour charges for maintenance and security is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time at Wholesale mandi stage of fruits supply chain of fruit supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to high lead time**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| Unloading of Crates/ Cartons /Wooden Box from Trucks at Mandi Level | 1 | Manual unloading is leading to supply chain inefficiency | | | | | |
| | 2 | Improper and High stacking of crates is leading to supply chain inefficiency | | | | | |
| | 3 | Employment of inadequate labour for unloading operations is leading to supply chain inefficiency | | | | | |
| | 4 | Non-usage of skilled labour for unloading the crates is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5 | Inadequate space for unloading operations is leading to supply chain inefficiency | | | | | |
| | 6 | Non-availability of equipments for unloading is leading to supply chain inefficiency | | | | | |
| | 7 | Arrival of Larger Quantity of goods is leading to supply chain inefficiency | | | | | |
| | 8 | Improper planning for scheduling of Incoming Goods is leading to supply chain inefficiency | | | | | |
| **Storing of Crates/ Cartons /Wooden Box at Mandi** | 9 | Delay in auctioning of mangoes is leading to supply chain inefficiency | | | | | |
| | 10 | Inadequate and non-availability of timely demand information is leading to supply chain inefficiency | | | | | |
| | 11 | High Stock/Volume of unsold mangoes at Mandi is leading to supply chain inefficiency | | | | | |
| | 12 | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts** | 13 | Handling and Loading by the means of head load is leading to supply chain inefficiency | | | | | |
| | 14 | Single manual handling while loading is leading to supply chain inefficiency | | | | | |
| | 15 | Bulk handling of the crates/packages is leading to supply chain inefficiency | | | | | |
| | 16 | Non-usage of skilled labour in HLS is leading to supply chain inefficiency | | | | | |
| | 17 | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality at Wholesale mandi stage of fruits supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1<br>Strongly disagree | 2<br>Disagree | 3<br>Neither agree or disagree | 4<br>Agree | 5<br>Strongly agree |
| **Storing of Crates/ Cartons /Wooden Box at Mandi** | 1 | Insufficient storage and temperature controlled facilities is leading to supply chain inefficiency | | | | | |
| | 2 | Lack of cold storage facility is leading to supply chain inefficiency | | | | | |
| | 3 | Rough handling while storing is leading to supply chain inefficiency | | | | | |
| | 4 | Improper and high stacking while storing is leading to supply chain inefficiency | | | | | |
| | 5 | Compression of mangoes due to heavy load in storing is leading to supply chain inefficiency | | | | | |
| | 6 | Inadequate ventilation at the place of storage is leading to supply chain inefficiency | | | | | |
| | 7 | High temperature at storage area is leading to supply chain inefficiency | | | | | |
| | 8 | Damage to the mangoes caused by pest and fungal infection during storage is leading to supply chain inefficiency | | | | | |
| | 9 | Non-availability of cooling shed at the place of storage is leading to supply chain inefficiency | | | | | |
| | 10 | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| | 11 | Overstock due to Inadequate and non-availability of timely demand information is leading to supply chain inefficiency | | | | | |
| **Unloading of Crates/ Cartons** | 12 | Non-availability of skilled labour for unloading the crates is leading to supply chain inefficiency | | | | | |
| | 13 | Rough handling while unloading is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **/Wooden Box from Trucks at Mandi Level** | **14** | Inadequate space for unloading operations is leading to supply chain inefficiency | | | | | |
| | **15** | Expose to direct sunlight/heat while unloading is leading to supply chain inefficiency | | | | | |
| | **16** | Open dock area which expose to direct sunlight/heat in UfT is leading to supply chain inefficiency | | | | | |
| | **17** | Unloading in an inappropriate manner is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of goods in Mini Vans/Trucks/ Rikshaw/Bullock Carts** | **18** | Non-availability of skilled labour in HLS is leading to supply chain inefficiency | | | | | |
| | **19** | Non-availability of equipments for handling & loading is leading to supply chain inefficiency | | | | | |
| | **20** | Rough handling at the time of loading & stacking is leading to supply chain inefficiency | | | | | |
| | **21** | Improper and high stacking is leading to supply chain inefficiency | | | | | |
| | **22** | Dumping of Crates into the vehicle is leading to supply chain inefficiency | | | | | |
| | **23** | Bulk Handling at the time of Loading and Stacking is leading to supply chain inefficiency | | | | | |
| | **24** | Single manual handling while loading & stacking is leading to supply chain inefficiency | | | | | |
| | **25** | No proper arrangement of packages/crates for air circulation while stacking is leading to supply chain inefficiency | | | | | |
| | **26** | Open dock area which expose to direct sunlight/heat in HLS is leading to supply chain inefficiency | | | | | |

## Stage IV- Local trader/Mashakhor stage (*Respondent-Local Trader/Mashakhor*)

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost at Local trader/Mashakhor stage of fruits supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to increasing cost**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Sorting, Grading & Repackaging of Mangoes by the Local traders at Adarshnagar, Azadpur for further sale** | **1** | Lack of knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency | | | | | |
| | **2** | Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency | | | | | |
| | **3** | Timely Non-availability of packaging materials is leading to supply chain inefficiency | | | | | |
| | **4** | Expensive Packaging material is leading to supply chain inefficiency | | | | | |
| | **5** | Price differential of Packaging Materials at different places is leading to supply chain inefficiency | | | | | |
| | **6** | High Labour charges arising out of expertise required for grading and packaging is leading to supply chain inefficiency | | | | | |
| | **7** | Excess usage of Material for layering and tapping the cartons/boxes is leading to supply chain inefficiency | | | | | |
| | **8** | Non-usage of Sorting & Grading Technology is leading to supply chain inefficiency | | | | | |
| | **9** | Non-usage of Advanced Packaging Materials is leading to supply chain inefficiency | | | | | |
| | **10** | Lack of Government packing houses/grading facilities is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Unloading of Crates/Cartons/Box from Mini Vans/ Rikshaw/Bullock Cart to LT's area at Adarshnagar, Azadpur mandi** | **11** | High Labour Charges for Unloading is leading to supply chain inefficiency | | | | | |
| | **12** | Damage to crates/boxes while unloading is leading to supply chain inefficiency | | | | | |
| | **13** | Manual operations in Unloading is leading to supply chain inefficiency | | | | | |
| | **14** | Non-availability of tools and equipments for unloading the load is leading to supply chain inefficiency | | | | | |
| **Storing & Ripening of Mangoes** | **15** | High charges of ripening chamber is leading to supply chain inefficiency | | | | | |
| | **16** | Damage to boxes/crates due to rough handling while storage is leading to supply chain inefficiency | | | | | |
| | **17** | Expenditure on chemicals used for ripening is leading to supply chain inefficiency | | | | | |
| | **18** | High electricity charges is leading to supply chain inefficiency | | | | | |
| | **19** | High charges of cold storage facilities is leading to supply chain inefficiency | | | | | |
| | **20** | Cost of labour for maintenance and security is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time at Local trader/Mashakhor stage of fruits supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to high lead time**

| **Activity** | **S. No.** | **Statements** | **Level of Agreement** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Storing & Ripening of Mangoes** | **1** | Lack of demand in the market is leading to supply chain inefficiency | | | | | |
| | **2** | Poor information regarding market demand is leading to supply chain inefficiency | | | | | |
| | **3** | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| | **4** | Lack of proper and uniform grading which hinder to achieve uniform ripening is leading to supply chain inefficiency | | | | | |
| | **5** | Inadequate equipment for ripening is leading to supply chain inefficiency | | | | | |
| **Sorting, Grading & Repackaging of Mangoes by the Local traders at Adarshnagar, Azadpur for further sale** | **6** | Manual sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | **7** | Lack of knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency | | | | | |
| | **8** | Lack of sorting & grading technology is leading to supply chain inefficiency | | | | | |
| | **9** | Non-availability of skilled labour for sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | **10** | Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency | | | | | |
| | **11** | Ignorance of time allocated to sorting, grading and packaging is leading to supply chain inefficiency | | | | | |
| | **12** | Timely Non-availability of packaging materials is leading to supply chain inefficiency | | | | | |
| | **13** | Lack of Training and Knowledge about sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| **Unloading of mango from Crates/Cartons/** | **14** | Manual unloading is leading to supply chain inefficiency | | | | | |
| | **15** | Employment of inadequate labour for unloading operations is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Wooden Box for the purpose of further sorting & grading** | **16** | Non-availability of skilled labour for unloading the crates is leading to supply chain inefficiency | | | | | |
| | **17** | Inadequate space for unloading operations is leading to supply chain inefficiency | | | | | |
| | **18** | Non-availability of equipments for unloading the crate is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality at Local trader/Mashakhor stage of fruits supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Storing & Ripening (S&R) of Mangoes** | **1** | Insufficient storage and ripening chamber facilities is leading to supply chain inefficiency | | | | | |
| | **2** | Rough handling while storing in S&R is leading to supply chain inefficiency | | | | | |
| | **3** | Improper and high stacking while storing in S&R is leading to supply chain inefficiency | | | | | |
| | **4** | Compression of mangoes due to heavy load in storing in S&R is leading to supply chain inefficiency | | | | | |
| | **5** | Inadequate ventilation at the place of storage in S&R is leading to supply chain inefficiency | | | | | |
| | **6** | High temperature at storage and ripening area in S&R is leading to supply chain inefficiency | | | | | |
| | **7** | Damage to the mangoes caused by pest and fungal infection during storage in S&R is leading to supply chain inefficiency | | | | | |
| | **8** | Usage of calcium carbide for ripening process is leading to supply chain inefficiency | | | | | |
| | **9** | Holding of goods in anticipation of high prices in S&R is leading to supply chain inefficiency | | | | | |
| | **10** | Inadequate and non-availability of timely demand information in S&R is leading to supply chain inefficiency | | | | | |
| | **11** | Improper placing of fruits during ripening is leading to supply chain inefficiency | | | | | |
| | **12** | Inadequate equipment and ripening method is leading to supply chain inefficiency | | | | | |
| | **13** | Lack of Proper Monitoring in Ripening Process is leading to supply chain inefficiency | | | | | |
| | **14** | Lack of proper and uniform grading which hinder to achieve uniform ripening is leading to supply chain inefficiency | | | | | |
| **Storing of Mangoes** | **15** | Insufficient storage and temperature controlled facilities is leading to supply chain inefficiency | | | | | |
| | **16** | Lack of usage of cold storage facility is leading to supply chain inefficiency | | | | | |
| | **17** | Rough handling in storing activity is leading to supply chain inefficiency | | | | | |
| | **18** | Improper and high stacking while storing is leading to supply chain inefficiency | | | | | |
| | **19** | Compression of mangoes due to heavy load in storing is leading to supply chain inefficiency | | | | | |
| | **20** | Inadequate ventilation at the place of storage is leading to supply chain inefficiency | | | | | |
| | **21** | High temperature at storage area is leading to supply chain inefficiency | | | | | |
| | **22** | Damage to the mangoes caused by pest and fungal infection during storage is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 23 | Non-availability of cooling shed at the place of storage is leading to supply chain inefficiency is leading to supply chain inefficiency | | | | | |
| | 24 | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| | 25 | Lack of Information regarding market conditions is leading to supply chain inefficiency | | | | | |
| **Unloading of mango from Crates/Cartons/ Wooden Box for the purpose of further sorting & grading** | 26 | Non-availability of skilled labour for unloading the crates is leading to supply chain inefficiency | | | | | |
| | 27 | Rough handling while unloading is leading to supply chain inefficiency | | | | | |
| | 28 | Inadequate space for unloading operations is leading to supply chain inefficiency | | | | | |
| | 29 | Unloading the crates in an open area which expose to direct sunlight/heat is leading to supply chain inefficiency | | | | | |
| | 30 | Unloading the crates in an inappropriate manner is leading to supply chain inefficiency | | | | | |

## Stage V- Transportation stage (*Respondent-Transporter*)

| **The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost in transportation stage of fruits supply chain with specific reference to mango** | | | | | | |
|---|---|---|---|---|---|---|
| ***Please indicate how much you agree or disagree with each of these statements:*** | | | | | | |
| **Reasons leading to supply chain inefficiency with respect to increasing cost in Transportation of Mangoes from Farm to Wholesale Mandi** | | | | | | |
| **S. No.** | **Statements** | **Level of Agreement** | | | | |
| | | **1** | **2** | **3** | **4** | **5** |
| | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| 1 | Poor road connectivity is leading to supply chain inefficiency | | | | | |
| 2 | Inappropriate Vehicle Routing is leading to supply chain inefficiency | | | | | |
| 3 | High charges of Taxes is leading to supply chain inefficiency | | | | | |
| 4 | Long distance between Farm and Wholesale Market is leading to supply chain inefficiency | | | | | |
| 5 | High Traffic Jams is leading to supply chain inefficiency | | | | | |
| 6 | Crossing and Toll Booth Charges is leading to supply chain inefficiency | | | | | |
| 7 | Convenience Charges by Policeman is leading to supply chain inefficiency | | | | | |
| 8 | High Fuel Prices is leading to supply chain inefficiency | | | | | |
| 9 | Timely Non-availability of transport facilities is leading to supply chain inefficiency | | | | | |
| 10 | High Freight Charges is leading to supply chain inefficiency | | | | | |
| **The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time in transportation stage of fruits supply chain with specific reference to mango** | | | | | | |
| ***Please indicate how much you agree or disagree with each of these statements:*** | | | | | | |
| **Reasons leading to supply chain inefficiency with respect to high lead time in Transportation of Mangoes from Farm to Wholesale Mandi** | | | | | | |
| **S. No.** | **Statements** | **Level of Agreement** | | | | |
| | | **1** | **2** | **3** | **4** | **5** |
| | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| 1 | Poor road connectivity is leading to supply chain inefficiency | | | | | |
| 2 | Poor road conditions is leading to supply chain inefficiency | | | | | |
| 3 | Inappropriate Vehicle Routing is leading to supply chain inefficiency | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **4** | Irresponsible and Careless driving is leading to supply chain inefficiency | | | | | |
| **5** | Long distance between Farm and Wholesale Market is leading to supply chain inefficiency | | | | | |
| **6** | Timely Non-availability of transportation vehicle is leading to supply chain inefficiency | | | | | |
| **7** | Non Adherence to Time Schedule Allocated for Transportation is leading to supply chain inefficiency | | | | | |
| **8** | Police Verification and Frisking is leading to supply chain inefficiency | | | | | |
| **9** | Frequent Crossings and Toll Booths is leading to supply chain inefficiency | | | | | |
| **10** | Traffic Jams in Azadpur Mandi is leading to supply chain inefficiency | | | | | |
| **11** | Congestion and Traffic Jams is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality in transportation stage of fruits supply chain with specific reference to mango**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality in Transportation of Mangoes from Farm to Wholesale Mandi**

| S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** |
| | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **1** | Non-usage of Temperature controlled Transportation system is leading to supply chain inefficiency | | | | | |
| **2** | No control on Temperature/ Humidity during transit is leading to supply chain inefficiency | | | | | |
| **3** | Packaging boxes of different weight, size, commodity in the same carrier is leading to supply chain inefficiency | | | | | |
| **4** | Jerks in Transit, by which pack structure get loose is leading to supply chain inefficiency | | | | | |
| **5** | Poor road conditions is leading to supply chain inefficiency | | | | | |
| **6** | Overburden and Overloading is leading to supply chain inefficiency | | | | | |
| **7** | Fungal infection during transit is leading to supply chain inefficiency | | | | | |
| **8** | Compression of goods due to putting weight on the load is leading to supply chain inefficiency | | | | | |
| **9** | Hitchhiking pests during transit is leading to supply chain inefficiency | | | | | |
| **10** | Improper stacking during transportation is leading to supply chain inefficiency | | | | | |

## Vegetables Supply Chain

## Stage I-Farm Stage (*Respondent-Farmers*)

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost at farm stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to cost**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| Carriage of Crates to the Collection Area/Collection Centre | 1 | Hilly terrain is leading to supply chain inefficiency | | | | | |
| | 2 | Poor farm connectivity by road is leading to supply chain inefficiency | | | | | |
| | 3 | High Labour charges for carriage | | | | | |
| | 4 | Large number of Labour required for carriage activity is leading to supply chain inefficiency | | | | | |
| Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks | 5 | High Labour Charges in HLS is leading to supply chain inefficiency | | | | | |
| | 6 | Large number of Labour required for Handling and Loading is leading to supply chain inefficiency | | | | | |
| | 7 | Manual operations for HLS is leading to supply chain inefficiency | | | | | |
| | 8 | Pre loading labour charges is leading to supply chain inefficiency | | | | | |
| | 9 | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |
| Sorting & Grading of Tomatoes and Packing in Crates as per the grade | 10 | Lack of knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency | | | | | |
| | 11 | Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency | | | | | |
| | 12 | Timely Non-availability of packaging materials is leading to supply chain inefficiency | | | | | |
| | 13 | High Packaging material charges is leading to supply chain inefficiency | | | | | |
| | 14 | Price differential of Packaging materials at different places is leading to supply chain inefficiency | | | | | |
| | 15 | High Labour charges arising out of expertise required for grading and packaging is leading to supply chain inefficiency | | | | | |
| | 16 | Excess usage of packaging material for layering and tapping the cartons/boxes is leading to supply chain inefficiency | | | | | |
| | 17 | Non-usage of Sorting & Grading Technology is leading to supply chain inefficiency | | | | | |
| | 18 | Non-availability of advanced packaging materials is leading to supply chain inefficiency | | | | | |
| | 19 | Lack of Government packing houses/grading facilities is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time at farm stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to high lead time**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Carriage of Crates to the Collection Area/Collection Centre** | **1** | Assembly points are not properly identified which is leading to supply chain inefficiency | | | | | |
| | **2** | Long distance between plucking area and assembly area is leading to supply chain inefficiency | | | | | |
| | **3** | Poor road connectivity is leading to supply chain inefficiency | | | | | |
| | **4** | Manual carriage by the means of head-load is leading to supply chain inefficiency | | | | | |
| | **5** | Handling excess load by labour at the time of carriage is leading to supply chain inefficiency | | | | | |
| | **6** | Employment of incapable labour (women and children) for carriage is leading to supply chain inefficiency | | | | | |
| | **7** | Poor condition of path used for carriage is leading to supply chain inefficiency | | | | | |
| | **8** | Hilly Terrain is leading to supply chain inefficiency | | | | | |
| **Sorting & Grading of Tomatoes and Packing in Crates as per the grade** | **9** | Manual sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | **10** | Lack of knowledge pertaining to sorting & grading techniques and processes is leading to supply chain inefficiency | | | | | |
| | **11** | Lack of sorting & grading technology is leading to supply chain inefficiency | | | | | |
| | **12** | Non-availability of skilled labour for sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| | **13** | Lack of mechanical sorting, grading and packaging facility is leading to supply chain inefficiency | | | | | |
| | **14** | Ignorance of time allocated to sorting, grading and packaging is leading to supply chain inefficiency | | | | | |
| | **15** | Timely Non-availability of packaging materials is leading to supply chain inefficiency | | | | | |
| | **16** | Lack of Training and Knowledge about sorting, grading & packaging is leading to supply chain inefficiency | | | | | |
| **Plucking & Collecting Tomato in Bucket/ Basket** | **17** | Harvesting by hand picking is leading to supply chain inefficiency | | | | | |
| | **18** | Excess harvesting due to lack of information regarding market demand is leading to supply chain inefficiency | | | | | |
| | **19** | Lack of appropriate harvesting tools and equipments is leading to supply chain inefficiency | | | | | |
| | **20** | Lack of Skilled labour for plucking and collection is leading to supply chain inefficiency | | | | | |
| | **21** | Lack of proper planning for harvesting is leading to supply chain inefficiency | | | | | |
| | **22** | Lack of farmer's awareness and knowledge regarding technology is leading to supply chain inefficiency | | | | | |
| | **23** | Ignorance of time allocated to plucking and collection is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality at farm stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1<br>Strongly disagree | 2<br>Disagree | 3<br>Neither agree or disagree | 4<br>Agree | 5<br>Strongly agree |
| **Storing of Goods** | **1** | Insufficient storage and temperature controlled facilities is leading to supply chain inefficiency | | | | | |
| | **2** | Lack of availability of temperature controlled storage area is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 | Rough handling while storing is leading to supply chain inefficiency | | | | | |
| | 4 | Improper and high stacking while storing is leading to supply chain inefficiency | | | | | |
| | 5 | Compression of Tomatoes due to heavy load in storing is leading to supply chain inefficiency | | | | | |
| | 6 | High temperature at storage area is leading to supply chain inefficiency | | | | | |
| | 7 | Damage to the Tomatoes caused by pest and fungal infection during storage is leading to supply chain inefficiency | | | | | |
| | 8 | Non-availability of cooling shed at the place of storage is leading to supply chain inefficiency | | | | | |
| | 9 | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| | 10 | Inadequate ventilation at the place of storage is leading to supply chain inefficiency | | | | | |
| | 11 | Overstock due to Inadequate and non-availability of timely demand information is leading to supply chain inefficiency | | | | | |
| **Carriage of Crates to the Collection Area/Collection Centre** | 12 | Falling of Tomatoes from crates/baskets during carriage is leading to supply chain inefficiency | | | | | |
| | 13 | High temperature during carriage is leading to supply chain inefficiency | | | | | |
| | 14 | Jerks during carriage which impact the quality is leading to supply chain inefficiency | | | | | |
| | 15 | Mishandling and Careless during carriage is leading to supply chain inefficiency | | | | | |
| | 16 | Handling excess load by labour at the time of carriage is leading to supply chain inefficiency | | | | | |
| **Handling, Loading and Stacking of Crates in Mini Vehicles or Trucks** | 17 | Non-usage of skilled labour for HLS is leading to supply chain inefficiency | | | | | |
| | 18 | Non-availability of Mechanical handling & loading facility is leading to supply chain inefficiency | | | | | |
| | 19 | Rough handling at the time of loading & stacking is leading to supply chain inefficiency | | | | | |
| | 20 | Improper stacking is leading to supply chain inefficiency | | | | | |
| | 21 | Dumping of Crates is leading to supply chain inefficiency | | | | | |
| | 22 | Bulk handling of fresh produce is leading to supply chain inefficiency | | | | | |
| | 23 | Single manual handling while loading & stacking is leading to supply chain inefficiency | | | | | |
| | 24 | No proper arrangement of packages/crates for air circulation while stacking is leading to supply chain inefficiency | | | | | |
| | 25 | Open Air Loading operations which expose to direct sunlight/heat is leading to supply chain inefficiency | | | | | |

## Stage II-Local Mandi Stage (*Respondent-Local Commission Agents*)

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost at Local mandi stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to cost**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Unloading of Tomato and Loading to the buyer's Crate** | **1** | Manually unloading operation for Seller's crate is leading to supply chain inefficiency | | | | | |
| | **2** | Non-availability of equipments for unloading the Seller's crate is leading to supply chain inefficiency | | | | | |
| | **3** | High Labour charges for operations is leading to supply chain inefficiency | | | | | |
| | **4** | High cost due to non-availability of government facilities for operations is leading to supply chain inefficiency | | | | | |
| | **5** | Expensive packaging materials is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of Box/Carton/Crates in Trucks** | **6** | High Labour Charges for HLS is leading to supply chain inefficiency | | | | | |
| | **7** | Large number of Labour required for Handling and Loading is leading to supply chain inefficiency | | | | | |
| | **8** | Manual operations for HLS is leading to supply chain inefficiency | | | | | |
| | **9** | Pre loading labour charges is leading to supply chain inefficiency | | | | | |
| | **10** | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |
| **Unloading of Box/Crates from Truck/Mini Trucks to the area of Local Agents/ local market** | **11** | High Labour Charges to unload the truck is leading to supply chain inefficiency | | | | | |
| | **12** | Damage to crates/boxes while unloading | | | | | |
| | **13** | Large number of Labour required to Unload the load from Truck is leading to supply chain inefficiency | | | | | |
| | **14** | Manual operations for Unloading the truck is leading to supply chain inefficiency | | | | | |
| | **15** | Pre unloading labour charges is leading to supply chain inefficiency | | | | | |
| | **16** | Non-availability of tools and equipments for unloading the load from truck is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time at Local mandi stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to high lead time**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Unloading of Tomato and Loading to the buyer's Crate (UfSC)** | **1** | Manual unloading of seller 's crate is leading to supply chain inefficiency | | | | | |
| | **2** | Employment of inadequate labour for unloading operations (UfSC) is leading to supply chain inefficiency | | | | | |
| | **3** | Non-availability of skilled labour for unloading the crates (UfSC) is leading to supply chain inefficiency | | | | | |
| | **4** | Inadequate space for unloading and loading operations (UfSC) is leading to supply chain inefficiency | | | | | |
| | **5** | Non-availability of equipments for unloading the crate (UfSC) is leading to supply chain inefficiency | | | | | |
| **Unloading of Crates from Truck/Mini** | **6** | Manual unloading (UfT) is leading to supply chain inefficiency | | | | | |
| | **7** | Improper and High stacking of crates | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Vehicles to the Local Mandi (UfT)** | **8** | Employment of inadequate labour for unloading operations (UfT) is leading to supply chain inefficiency | | | | | |
| | **9** | Non-availability of skilled labour for unloading the crates (UfT) is leading to supply chain inefficiency | | | | | |
| | **10** | Inadequate space for unloading operations (UfT) is leading to supply chain inefficiency | | | | | |
| | **11** | Non-availability of equipments for unloading (UfT) is leading to supply chain inefficiency | | | | | |
| | **12** | Inadequate Resources for dealing with unexpected bulk arrival is leading to supply chain inefficiency | | | | | |
| | **13** | Improper planning for scheduling of Incoming Goods is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of Box/Carton/ Crates in Trucks** | **14** | Handling and Loading by the means of head load is leading to supply chain inefficiency | | | | | |
| | **15** | Single manual handling while loading is leading to supply chain inefficiency | | | | | |
| | **16** | Bulk handling of crates/packages is leading to supply chain inefficiency | | | | | |
| | **17** | Non-availability of skilled labour is leading to supply chain inefficiency | | | | | |
| | **18** | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality at Local mandi stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| **Activity** | **S. No.** | **Statements** | **Level of Agreement** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Storing of Fresh Produce** | **1** | Insufficient storage and temperature controlled facilities is leading to supply chain inefficiency | | | | | |
| | **2** | Rough handling while storing is leading to supply chain inefficiency | | | | | |
| | **3** | Improper and high stacking while storing is leading to supply chain inefficiency | | | | | |
| | **4** | Inappropriate storing practices leading to compression of tomatoes is leading to supply chain inefficiency | | | | | |
| | **5** | Inadequate ventilation at the place of storage is leading to supply chain inefficiency | | | | | |
| | **6** | High temperature at storage area is leading to supply chain inefficiency | | | | | |
| | **7** | Damage to the Tomatoes caused by pest and fungal infection during storage is leading to supply chain inefficiency | | | | | |
| | **8** | Non-availability of cooling shed at the place of storage is leading to supply chain inefficiency | | | | | |
| | **9** | Delays in moving the produce to the wholesale market is leading to supply chain inefficiency | | | | | |
| | **10** | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| | **11** | Overstock due to Inadequate and non-availability of timely demand information is leading to supply chain inefficiency | | | | | |
| **Unloading of Tomato from seller's crates** | **12** | Non-availability of skilled labour for unloading the crates (UfSC) is leading to supply chain inefficiency | | | | | |
| | **13** | Rough handling while unloading (UfSC) is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (at Local Market) and loading to the buyer's crate (Local trader) (UfSC) | 14 | Inadequate space for unloading operations (UfSC) is leading to supply chain inefficiency | | | | | |
| | 15 | Unloading the crates in an open area which expose to direct sunlight/heat (UfSC) is leading to supply chain inefficiency | | | | | |
| | 16 | Unloading the crates in an inappropriate manner (UfSC) is leading to supply chain inefficiency | | | | | |
| Unloading of Crates from Truck/Mini Vehicles to the Local Mandi (UfT) | 17 | Non-availability of skilled labour for unloading the crates (UfT) is leading to supply chain inefficiency | | | | | |
| | 18 | Rough handling while unloading (UfT) is leading to supply chain inefficiency | | | | | |
| | 19 | Inadequate space for unloading operations (UfT) is leading to supply chain inefficiency | | | | | |
| | 20 | Expose to direct sunlight/heat while unloading is leading to supply chain inefficiency | | | | | |
| | 21 | Open Dock Area which expose to direct sunlight is leading to supply chain inefficiency | | | | | |
| | 22 | Unloading in an inappropriate manner (UfT) is leading to supply chain inefficiency | | | | | |

## Stage III-Wholesale Mandi Stage (Respondent-Wholesaler/Commission Agents)

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost at Wholesale mandi stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to cost**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| Unloading of Tomato from seller's crates and Loading to the buyer's crates (UfSC) | 1 | Manual unloading (UfSC) is leading to supply chain inefficiency | | | | | |
| | 2 | Non-availability of equipments for unloading the crate (UfSC) is leading to supply chain inefficiency | | | | | |
| | 3 | High Labour charges for operations (UfSC) is leading to supply chain inefficiency | | | | | |
| | 4 | Non-availability of government facilities for operations is leading to supply chain inefficiency | | | | | |
| | 5 | Large Requirement of Packaging Material is leading to supply chain inefficiency | | | | | |
| Unloading of Tomato Crates from Trucks at Mandi Level (UfT) | 6 | High Labour Charges (UfT) is leading to supply chain inefficiency | | | | | |
| | 7 | Damage to crates/boxes while unloading is leading to supply chain inefficiency | | | | | |
| | 8 | Pre unloading labour charges is leading to supply chain inefficiency | | | | | |
| | 9 | Non-availability of tools and equipments for unloading the load (UfT) is leading to supply chain inefficiency | | | | | |
| | 10 | Large number of Labour required for Unloading (UfT) is leading to supply chain inefficiency | | | | | |
| | 11 | Manual operations for unloading the load (UfT) is leading to supply chain inefficiency | | | | | |
| Handling, Loading & Stacking of Crates in Mini Vehicles/ Trucks/ Rikshaws/ Cart | 12 | High Labour Charges for Loading is leading to supply chain inefficiency | | | | | |
| | 13 | Manual operations for HLS is leading to supply chain inefficiency | | | | | |
| | 14 | Pre loading labour charges is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **15** | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time at Wholesale mandi stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to high lead time**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Unloading of Tomato from seller's crates and Loading to the buyer's crates (UfSC)** | **1** | Manual unloading and loading operations (UfSC) is leading to supply chain inefficiency | | | | | |
| | **2** | Employment of inadequate labour for operations (UfSC) is leading to supply chain inefficiency | | | | | |
| | **3** | Non-availability of skilled labour for unloading and loading the crates (UfSC) is leading to supply chain inefficiency | | | | | |
| | **4** | Inadequate space for unloading and loading operations is leading to supply chain inefficiency | | | | | |
| | **5** | Non-availability of equipments for loading and unloading the crate (UfSC) is leading to supply chain inefficiency | | | | | |
| **Unloading of Tomato Crates from Trucks at Mandi Level (UfT)** | **6** | Manual unloading (UfT) is leading to supply chain inefficiency | | | | | |
| | **7** | Improper and High stacking of crates (UfT) is leading to supply chain inefficiency | | | | | |
| | **8** | Employment of inadequate labour for unloading operations (UfT) is leading to supply chain inefficiency | | | | | |
| | **9** | Non-availability of skilled labour for unloading the crates (UfT) is leading to supply chain inefficiency | | | | | |
| | **10** | Inadequate space for unloading operations (UfT) is leading to supply chain inefficiency | | | | | |
| | **11** | Non-availability of equipments for unloading (UfT) is leading to supply chain inefficiency | | | | | |
| | **12** | Inadequate Resources for dealing with unexpected bulk arrival is leading to supply chain inefficiency | | | | | |
| | **13** | Improper planning for scheduling of Incoming Goods is leading to supply chain inefficiency | | | | | |
| **Handling, Loading & Stacking of Tomato Crates in Trucks** | **14** | Handling and Loading by the means of head load is leading to supply chain inefficiency | | | | | |
| | **15** | Manual handling while loading is leading to supply chain inefficiency | | | | | |
| | **16** | Bulk handling of crates/packages is leading to supply chain inefficiency | | | | | |
| | **17** | Non-availability of skilled labour for HLS is leading to supply chain inefficiency | | | | | |
| | **18** | Non-availability of tools and equipments for handling & loading is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality at Wholesale mandi stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| Activity | S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| **Storing of** | **1** | Insufficient storage and temperature controlled facilities is leading to supply chain inefficiency | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Fresh Produce at Local Mandi** | **2** | Non-availability of cold storage facility is leading to supply chain inefficiency | | | | | |
| | **3** | Rough handling while storing is leading to supply chain inefficiency | | | | | |
| | **4** | Improper and High stacking while storing is leading to supply chain inefficiency | | | | | |
| | **5** | Inappropriate storing practices leading to compression of Tomatoes is leading to supply chain inefficiency | | | | | |
| | **6** | Inadequate ventilation at the place of storage is leading to supply chain inefficiency | | | | | |
| | **7** | High temperature at storage area is leading to supply chain inefficiency | | | | | |
| | **8** | Damage to the Tomatoes caused by pest and fungal infection during storage is leading to supply chain inefficiency | | | | | |
| | **9** | Non-availability of cooling shed at the place of storage is leading to supply chain inefficiency | | | | | |
| | **10** | Holding of goods in anticipation of high prices is leading to supply chain inefficiency | | | | | |
| | **11** | Inadequate and non-availability of timely demand information is leading to supply chain inefficiency | | | | | |
| **Unloading of Tomato from seller's crates and loading to the buyer's crate (UfSC)** | **12** | Non-availability of skilled labour for unloading the crates (UfSC) is leading to supply chain inefficiency | | | | | |
| | **13** | Rough handling while unloading (UfSC) is leading to supply chain inefficiency | | | | | |
| | **14** | Inadequate space for unloading operations (UfSC) is leading to supply chain inefficiency | | | | | |
| | **15** | Unloading and loading operations in an open area is leading to supply chain inefficiency | | | | | |
| | **16** | Unloading the crates in an inappropriate manner (UfSC) is leading to supply chain inefficiency | | | | | |
| **Unloading of Tomato Crates from Truck at Wholesale Mandi (UfT)** | **17** | Non-availability of skilled labour for unloading the crates (UfT) is leading to supply chain inefficiency | | | | | |
| | **18** | Rough handling while unloading (UfT) is leading to supply chain inefficiency | | | | | |
| | **19** | Inadequate space for unloading operations (UfT) is leading to supply chain inefficiency | | | | | |
| | **20** | Open Area for Unloading which expose to direct sunlight/heat (UfT) is leading to supply chain inefficiency | | | | | |
| | **21** | Open dock area which expose to direct sunlight/heat (UfT) is leading to supply chain inefficiency | | | | | |
| | **22** | Unloading in an inappropriate manner (UfT) is leading to supply chain inefficiency | | | | | |

## Stage IV-Transportation Stage (*Respondent-Transporter*)

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to cost in transportation stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to cost**

| **S. No.** | **Statements** | **Level of Agreement** | | | | |
|---|---|---|---|---|---|---|
| | | **1** Strongly disagree | **2** Disagree | **3** Neither agree or disagree | **4** Agree | **5** Strongly agree |
| **1** | Poor road connectivity is leading to supply chain inefficiency | | | | | |
| **2** | Inappropriate Vehicle Routing is leading to supply chain inefficiency | | | | | |
| **3** | High charges of Taxes is leading to supply chain inefficiency | | | | | |
| **4** | Long distance between Farm and Wholesale Market is leading to supply chain inefficiency | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | High Traffic Jams is leading to supply chain inefficiency | | | | | |
| 6 | Crossing and Toll Booth Charges is leading to supply chain inefficiency | | | | | |
| 7 | Convenience Charges by Policeman is leading to supply chain inefficiency | | | | | |
| 8 | High Fuel prices is leading to supply chain inefficiency | | | | | |
| 9 | Timely Non-availability of transport facilities is leading to supply chain inefficiency | | | | | |
| 10 | High Freight Charges is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to time in transportation stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to high lead time**

| S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| 1 | Poor road connectivity is leading to supply chain inefficiency | | | | | |
| 2 | Poor road conditions in hilly areas is leading to supply chain inefficiency | | | | | |
| 3 | Hilly Terrain is leading to supply chain inefficiency | | | | | |
| 4 | Inappropriate Vehicle Routing is leading to supply chain inefficiency | | | | | |
| 5 | Irresponsible and Careless driving is leading to supply chain inefficiency | | | | | |
| 6 | Long distance between Farm and Wholesale Market is leading to supply chain inefficiency | | | | | |
| 7 | Timely Non-availability of transportation vehicle is leading to supply chain inefficiency | | | | | |
| 8 | Non Adherence to Time Schedule Allocated for Transportation is leading to supply chain inefficiency | | | | | |
| 9 | Police Verification and Frisking is leading to supply chain inefficiency | | | | | |
| 10 | Frequent Crossings and Toll Booths is leading to supply chain inefficiency | | | | | |
| 11 | Traffic Jams in Azadpur Mandi is leading to supply chain inefficiency | | | | | |
| 12 | Congestion and Traffic Jams is leading to supply chain inefficiency | | | | | |

**The purpose of the study is to identify the factors leading to supply chain inefficiency with respect to quality in transportation stage of vegetables supply chain with specific reference to tomato**

***Please indicate how much you agree or disagree with each of these statements:***

**Reasons leading to supply chain inefficiency with respect to waning quality**

| S. No. | Statements | Level of Agreement | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | Strongly disagree | Disagree | Neither agree or disagree | Agree | Strongly agree |
| 1 | Non-usage of Temperature controlled Transportation system is leading to supply chain inefficiency | | | | | |
| 2 | No control on Temperature/ Humidity during transit is leading to supply chain inefficiency | | | | | |
| 3 | Packaging boxes of different weight, size, commodity in the same carrier is leading to supply chain inefficiency | | | | | |
| 4 | Jerks in Transit, by which pack structure get loose is leading to supply chain inefficiency | | | | | |
| 5 | Poor road conditions is leading to supply chain inefficiency | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **6** | Overburden and Overloading is leading to supply chain inefficiency | | | | | |
| **7** | Fungal infection during transit is leading to supply chain inefficiency | | | | | |
| **8** | Compression of goods due to putting weight on the load is leading to supply chain inefficiency | | | | | |
| **9** | Hitchhiking pests during transit is leading to supply chain inefficiency | | | | | |
| **10** | Improper stacking during transportation is leading to supply chain inefficiency | | | | | |

# APPENDIX IV

## Most important reason/major reasons under each factor leading to supply chain inefficiency across the stages in fruits (mango) supply chain

| STAGE I-FARM STAGE | | | |
|---|---|---|---|
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Leading to High Cost** | *Resources* | Large no. of Labour required for plucking & Collection | 0.808 |
| | *Labour & Material Charges* | High manual labour charges-Plucking | 0.843 |
| | *Infrastructure* | Lack of mechanical sorting, grading and packaging facility | 0.830 |
| | *Labour's Knowledge* | Ignorance of Farmers to new methods of cultivation | 0.899 |
| **Leading to High Lead Time** | *Labour* | Lack of Training and Knowledge about sorting, grading & packaging | 0.845 |
| | *Operational* | Lack of proper planning for harvesting | 0.858 |
| | *Infrastructure* | Lack of mechanical sorting, grading &packaging facility | 0.889 |
| | *Resources* | Lack of sorting & grading technology | 0.753 |
| | *Connectivity* | Long distance between plucking area & assembly area | 0.786 |
| **Leading to Poor Quality** | *Operational* | Exposure to high temperature during collection | 0.861 |
| | *Infrastructure* | Open Air area for sorting, grading and packaging operations | 0.683 |
| | *Resources* | Timely non-availability of packaging material | 0.701 |
| | *Imprudence* | Mishandling and carelessness while plucking and collection | 0.666 |
| | *Labour's Knowledge* | Lack of Training and Knowledge about packaging | 0.683 |
| | *Labour's Availability* | Non-availability of skilled labour for sorting, grading & packaging | 0.745 |
| | *Standardisation* | No scientific standard for determination of maturity | 0.819 |
| | *Quality Control System* | Lack of proper grading and quality control system | 0.801 |
| **STAGE II-LOCAL TRADER/MIDDLEMEN STAGE** | | | |
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Leading to High Cost** | *Resources* | Non-usage of Sorting & Grading Technology | 0.883 |
| | *Labour & Material Charges* | High Manual Labour Charges-Unloading | 0.933 |
| | *Operational* | Repeated handling and grading & repackaging at every stage | 0.909 |
| | *Infrastructure* | Lack of mechanical sorting, grading and packaging facility | 0.906 |
| | *Knowledge* | Lack of knowledge pertaining to sorting & grading techniques and processes | 0.919 |
| **Leading to High Lead Time** | *Labour* | Non-availability of skilled labour for sorting, grading & packaging | 0.857 |
| | *Operational* | Time Ignorance during sorting, grading and packaging | 0.793 |
| | *Resources* | Lack of sorting & grading technology | 0.828 |
| | *Infrastructure* | Lack of mechanical sorting, grading & packaging facility | 0.826 |
| **Leading to Poor Quality** | *Operational* | Unloading the crates in an open area which expose to direct sunlight/heat | 0.884 |
| | *Infrastructure* | Insufficient storage and temperature controlled facilities | 0.731 |
| | *Labour* | Non-usage of skilled labour for unloading the crates | 0.718 |
| | *Ambience* | Inadequate ventilation at the place of storage | 0.778 |
| | *Preservation* | Damage to the Mangoes caused by pest and fungal infection during storage | 0.774 |
| **STAGE III-WHOLESALE/MANDI STAGE** | | | |

| Effect | Factor | Highly Contributing Variable to the Factor | Loading in its Factor |
|---|---|---|---|
| **Leading to High Cost** | *Operational Charges* | High charges of cold storage | 0.857 |
| | *Labour* | High Labour Charges in HLS | 0.775 |
| | *Resources* | Non-availability of tools and equipment for handling & loading | 0.857 |
| **Leading to High Lead Time** | *Operational* | Delay in auctioning of mangoes | 0.808 |
| | *Labour* | Employment of inadequate labour for unloading operations | 0.879 |
| | *Resources* | Non-availability of equipments for unloading | 0.922 |
| | *Infrastructure* | Inadequate space for unloading operations | 0.889 |
| **Leading to Poor Quality** | *Operational* | Damage to the mangoes caused by pest and fungal infection during storage | 0.854 |
| | *Infrastructure* | Lack of cold storage facility | 0.772 |
| | *Resources* | Non-availability of skilled labour for unloading the crates | 0.821 |
| | *Ambience* | High temperature at storage area | 0.852 |
| **STAGE IV-LOCAL TRADER/MASHAKHOR STAGE** | | | |
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Leading to High Cost** | *Resources* | Non-usage of Sorting & Grading Technology | 0.9 |
| | *Operational* | Damage to crates/boxes while unloading | 0.898 |
| | *Operational Charges* | High charges of cold storage facilities | 0.872 |
| | *Labour* | High Labour charges arising out of expertise required for grading and packaging | 0.746 |
| | *Infrastructure* | Lack of mechanical sorting, grading & packaging facility | 0.906 |
| **Leading to High Lead Time** | *Labour* | Non-availability of skilled labour for sorting, grading & packaging | 0.964 |
| | *Operational* | Manual sorting, grading & packaging | 0.813 |
| | *Resources* | Lack of sorting & grading technology | 0.957 |
| | *Market Uncertainty* | Poor information regarding market demand | 0.933 |
| | *Infrastructure* | Lack of mechanical sorting, grading & packaging facility | 0.946 |
| **Leading to Poor Quality** | *Operational* | Lack of proper and uniform grading which hinder to achieve uniform ripening | 0.966 |
| | *Infrastructure* | Non-availability of cooling shed at the place of storage-S | 0.885 |
| | *Ambience* | High temperature at storage area-S | 0.719 |
| | *Information* | Inadequate and non-availability of timely demand information-S&R | 0.949 |
| | *Technique* | Inadequate equipment and ripening method | 0.897 |
| | *Labour Availability* | Non-availability of skilled labour for unloading the crates | 0.808 |
| **TRANSPORTATION STAGE** | | | |
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Leading to High Cost** | *Rates & Charges* | High Freight Charges | 0.904 |
| | *Infrastructure* | Poor road connectivity | 0.911 |
| | *Connectivity* | Inappropriate Vehicle Routing | 0.818 |
| | *Resource/ Transportation Facilities* | Timely Non-availability of transport facilities | 0.986 |
| **Leading to High Lead Time** | *Infrastructure* | Poor road conditions | 0.935 |
| | *Imprudence* | Non adherence to time scheduled allocated for Transportation | 0.87 |
| | *Verification & Frisking* | Police Verification and Frisking | 0.894 |
| | *Connectivity* | Long distance between Farm and Wholesale Market | 0.78 |

| | | | |
|---|---|---|---|
| | *Resource/ Transportation Facilities* | Timely Non-availability of transport vehicle | 0.92 |
| **Leading to Poor Quality** | *Operational* | Non-usage of Temperature controlled Transportation system | 0.908 |
| | *Preservation* | Fungal infection during transit | 0.946 |
| | *Transit Ease* | Jerks in Transit, by which pack structure get loose | 0.952 |
| | *Infrastructure* | Poor road conditions | 0.977 |

**Most important reason/major reasons under each factor leading to supply chain inefficiency across the stages in vegetables (tomato) supply chain**

| **STAGE I-FARM STAGE** | | | |
|---|---|---|---|
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Contributing to High Cost** | *Resources* | Large number of Labour required for carriage activity | 0.876 |
| | *Operational & Labour Charges* | High Labour charges for carriage | 0.831 |
| | *Infrastructure* | Poor farm connectivity by road | 0.909 |
| | *Operational Activity* | Manual operations for HLS | 0.866 |
| | *Geography* | Hilly terrain | 0.932 |
| | *Labour's Knowledge* | Lack of knowledge pertaining to sorting & grading techniques and processes | 0.976 |
| **Contributing to High Lead Time** | *Operational* | Manual sorting, grading & packaging | 0.909 |
| | *Labour* | Non-availability of skilled labour for sorting, grading & packaging | 0.867 |
| | *Infrastructure* | Poor condition of path used for carriage | 0.934 |
| | *Technical Resources* | Lack of sorting & grading technology | 0.892 |
| | *Connectivity* | Long distance between plucking area and assembly area | 0.77 |
| | *Geography* | Hilly Terrain | 0.913 |
| **Contributing to Quality Loss** | *Operational* | Compression of Tomatoes due to heavy load in storing | 0.865 |
| | *Infrastructure* | Lack of availability of temperature controlled storage area | 0.789 |
| | *Ambience* | High temperature during carriage | 0.897 |
| | *Labour Availability* | Non-usage of skilled labour-HLS | 0.845 |
| | *Information* | Lack of information regarding market demand | 0.749 |
| **STAGE II-LOCAL MANDI STAGE** | | | |
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Contributing to High Cost** | *Operational & Labour Charges* | High Labour Charges-HLS | 0.865 |
| | *Resources* | Large no. of Labour required for Handling and Loading | 0.891 |
| | *Operational* | Damage to crates/boxes while unloading | 0.842 |
| | *Infrastructure* | High cost due to non-availability of government facilities for operations | 0.933 |
| **Contributing to High Lead Time** | *Operational* | Improper planning for scheduling of Incoming Goods | 0.917 |
| | *Technical Resources* | Non-availability of tools and equipments for handling & loading | 0.928 |
| | *Labour* | Non-availability of skilled labour for unloading the crates-UfSC | 0.835 |
| | *Infrastructure* | Inadequate space for unloading and loading operations-UfSC | 0.851 |
| **Contributing to** | *Operational* | Rough handling while storing | 0.933 |
| | *Infrastructure* | Insufficient storage and temperature controlled facilities | 0.886 |

| | | | |
|---|---|---|---|
| **Quality Loss** | *Ambience* | Damage to the Tomatoes caused by pest and fungal infection during storage | 0.931 |
| | *Labour Availability* | Non-availability of skilled labour for unloading the crates-UfSC | 0.926 |
| | *Information* | Inadequate and non-availability of timely demand information | 0.896 |
| **STAGE III-WHOLESALE/ MANDI STAGE** | | | |
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Contributing to High Cost** | *Labour Charges* | High Labour charges for operations-UfSC | 0.862 |
| | *Operational* | Manual operations for HLS | 0.873 |
| | *Resources* | Large Requirement of Packaging Material | 0.753 |
| | *Infrastructure* | Non-availability of government facilities for operations | 0.933 |
| **Contributing to High Lead Time** | *Operational* | Improper planning for scheduling of Incoming Goods | 0.88 |
| | *Labour* | Non-availability of skilled labour for unloading the crates-UfT | 0.906 |
| | *Technical Resources* | Inadequate Resources for dealing with unexpected bulk arrival | 0.856 |
| | *Infrastructure* | Inadequate space for unloading and loading operations | 0.837 |
| **Contributing to Quality Loss** | *Operational* | Holding of goods in anticipation of high prices | 0.927 |
| | *Infrastructure* | Open Area for Unloading which expose to direct sunlight/heat-UfT | 0.85 |
| | *Ambience* | Damage to the Tomatoes caused by pest and fungal infection during storage | 0.869 |
| | *Labour Availability* | Non-availability of skilled labour for unloading the crates-UfSC | 0.87 |
| | *Information* | Inadequate & non-availability of timely demand information | 0.833 |
| **TRANSPORTATION STAGE** | | | |
| **Effect** | **Factor** | **Highly Contributing Variable to the Factor** | **Loading in its Factor** |
| **Contributing to High Cost** | *Rates & Charges* | Crossing and Toll Booth Charges | 0.849 |
| | *Connectivity* | Long distance between Farm and Wholesale Market | 0.877 |
| | *Infrastructure* | High Traffic Jams | 0.913 |
| | *Resources/ Transportation Facilities* | Timely Non-availability of transport facilities | 0.933 |
| **Contributing to High Lead Time** | *Connectivity* | Hilly Terrain | 0.924 |
| | *Infrastructure* | Congestion and Traffic Jams | 0.813 |
| | *Verification & Frisking* | Police Verification and Frisking | 0.911 |
| | *Imprudence* | Irresponsible and Careless driving | 0.795 |
| | *Resources/ Transportation Facilities* | Timely Non-availability of transportation vehicle | 0.913 |
| **Contributing to Quality Loss** | *Operational* | Non-usage of Temperature controlled Transportation system | 0.925 |
| | *Preservation* | Fungal infection during transit | 0.927 |
| | *Infrastructure* | Poor road conditions | 0.913 |

# APPENDIX V

## Questions/Protocols for Semi Structured Interview - Fruit Supply Chain

| Interview guideline questions-Farm Stage | |
|---|---|
| High Cost | Across the farm stage of fruits supply chain with specific reference to mango, it has been found that a Large number of labour required for plucking & collection; High manual labour charges; Lack of mechanical sorting, grading and packaging facility; and Ignorance of farmers to new methods of cultivation are the main reasons leading to high cost. ***In your opinion, what measures may be taken for the said issues to reduce the high cost at farm stage of fruits (mango) supply chain?*** |
| High Lead Time | Across the farm stage of fruits supply chain with specific reference to mango, it has been found that Lack of training and knowledge about sorting, grading & packaging; Lack of proper planning for harvesting; Lack of mechanical sorting, grading and packaging facility; Lack of sorting & grading technology; and Long distance between plucking area and assembly area are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at farm stage of fruits (mango) supply chain?*** |
| Poor Quality | Across the farm stage of fruits supply chain with specific reference to mango, it has been found that Exposure to high temperature during collection; Open air area for sorting, grading and packaging operations; Timely non-availability of packaging material; Mishandling and carelessness while plucking and collection; Lack of training and knowledge about packaging; Non-availability of skilled labour for sorting, grading & packaging; No scientific standard for determination of maturity; and Lack of proper grading and quality control system are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of fruits at farm stage of fruits (mango) supply chain?*** |
| **Interview guideline questions- Local Commission Stage** | |
| High Cost | Across the local commission stage of fruits supply chain with specific reference to mango, it has been found that Non-usage of sorting & grading technology; High manual labour charges in unloading; Repeated handling, grading & repackaging at every stage; Lack of mechanical sorting, grading & packaging facility; and Lack of knowledge pertaining to sorting & grading techniques and processes are the main reasons leading to high cost. ***In your opinion, what measures may be taken for the said issues to reduce the high cost at local commission stage of fruits (mango) supply chain?*** |
| High Lead Time | Across the local commission stage of fruits supply chain with specific reference to mango, it has been found that Non-availability of skilled labour for sorting, grading & packaging; Time ignorance during sorting, grading and packaging operations; Lack of sorting & grading technology; and Lack of mechanical sorting, grading and packaging facility are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at local commission stage of fruits (mango) supply chain?*** |
| Poor Quality | Across the local commission stage of fruits supply chain with specific reference to mango, it has been found that unloading the crates in an open area which expose to direct sunlight/heat; Insufficient storage and temperature controlled facilities; Non-usage of skilled labour for unloading the crates; Inadequate ventilation at the place of storage; and Damage to the mangoes caused by pest and fungal infection during storage are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of fruits at local commission stage of fruits (mango) supply chain?*** |
| **Interview guideline questions- Wholesale/ Mandi Stage** | |
| High Cost | Across the wholesale/mandi stage of fruits supply chain with specific reference to mango, it has been found that High rental charges for cold storage; High labour charges in handling, loading & stacking; and Non-availability of tools and equipment for handling & loading are the main reasons leading to high cost. ***In your opinion, what measures may be taken to reduce the high cost incurred due to the said issues at wholesale/mandi stage of fruits (mango) supply chain?*** |
| High Lead Time | Across the wholesale/mandi stage of fruits supply chain with specific reference to mango, it has been found that Delay in auctioning of mangoes; Employment of inadequate labour for unloading operations; Non-availability of equipment for unloading; and Inadequate space for unloading operations are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at wholesale/mandi stage of fruits (mango) supply chain?*** |

| | |
|---|---|
| Poor Quality | Across the wholesale/mandi stage of fruits supply chain with specific reference to mango, it has been found that Damage to the mangoes caused by pest and fungal infection during storage; Lack of cold storage facility; Non-availability of skilled labour for unloading the crates; and High temperature at storage area are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of fruits at wholesale/mandi stage of fruits (mango) supply chain?*** |
| **Interview guideline questions- Local Trader/Mashakhor Stage** | |
| High Cost | Across the local trader/mashakhor stage of fruits supply chain with specific reference to mango, it has been found that Non-usage of sorting & grading technology; Damage to crates/boxes while unloading; High charges of cold storage facilities; High labour charges arising out of expertise required for grading and packaging; and Lack of mechanical sorting, grading and packaging facility are the main reasons leading to high cost. ***In your opinion, what measures may be taken for the said issues to reduce the high cost at local trader/mashakhor stage of fruits (mango) supply chain?*** |
| High Lead Time | Across the local trader/mashakhor stage of fruits supply chain with specific reference to mango, it has been found that Non-availability of skilled labour for sorting, grading & packaging; Manual sorting, grading & packaging; Lack of sorting & grading technology; Poor information regarding market demand; and Lack of mechanical sorting, grading and packaging facility are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at local trader/mashakhor stage of fruits (mango) supply chain?*** |
| Poor Quality | Across the local trader/mashakhor stage of fruits supply chain with specific reference to mango, it has been found that Lack of proper and uniform grading which hinder to achieve uniform ripening; Non-availability of cooling shed at the place of storage; High temperature at storage area; Inadequate and non-availability of timely demand information; Inadequate equipment and ripening method; and Non-availability of skilled labour for unloading the crates are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of fruits at local trader/mashakhor stage of fruits (mango) supply chain?*** |
| **Interview guideline questions-Transportation Stage** | |
| High Cost | Across the transportation stage of fruits supply chain with specific reference to mango, it has been found that High freight charges; Poor road connectivity; Inappropriate vehicle routing; and Timely non-availability of transport facilities are the main reasons leading to high cost. ***In your opinion, what measures may be taken for the said issues to reduce the high transportation cost in fruits (mango) supply chain?*** |
| High Lead Time | Across the transportation stage of fruits supply chain with specific reference to mango, it has been found that Poor road conditions; Non adherence to time scheduled allocated for transportation; Police verification and frisking; the Long distance between farm and wholesale market; and Timely non-availability of transport vehicles are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high transportation lead time in fruits (mango) supply chain?*** |
| Poor Quality | Across the transportation stage of fruits supply chain with specific reference to mango, it has been found that Non-usage of the temperature controlled transportation system; Fungal infection during transit; Jerks in transit, by which pack structure get loose; and Poor road conditions are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of fruits in transportation stage?*** |

## Questions/Protocols for Semi-Structured Interview - Vegetables Supply Chain

| **Interview guideline questions-Farm Stage** | |
|---|---|
| High Cost | Across the farm stage of vegetables supply chain with specific reference to tomato, it has been found that a Large number of labour required for carriage activity; High labour charges for carriage; Poor farm connectivity by road; Manual handling loading & stacking operations; Hilly terrain; and Lack of knowledge pertaining to sorting & grading techniques and processes are the main reasons leading to high cost. ***In your opinion, what measures may be taken for the said issues to reduce the high cost at farm stage of vegetables (tomato) supply chain?*** |
| High Lead Time | Across the farm stage of the vegetables supply chain with specific reference to tomato, it has been found that Manual sorting, grading & packaging; Non-availability of skilled labour for sorting, grading & packaging; Poor condition of the path used for carriage; Lack of sorting & grading technology; Long distance between plucking area and assembly area; and Hilly terrain are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at farm stage of vegetables (tomato) supply chain?*** |

| | |
|---|---|
| Poor Quality | Across the farm stage of vegetables supply chain with specific reference to tomato, it has been found that Compression of tomatoes due to heavy load in storing; Lack of availability of temperature controlled storage area; High temperature during carriage; Non-usage of skilled labour for handling, loading & stacking operations; and Lack of information regarding market demand are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of vegetables at farm stage of vegetables (tomato) supply chain?*** |
| **Interview guideline questions-Local Mandi Stage** | |
| High Cost | Across the local mandi stage of vegetables supply chain with specific reference to tomato, it has been found that High labour charges for handling, loading & stacking; a Large number of labour required for handling and loading; Damage to crates/boxes while unloading; and High cost due to non-availability of government facilities for operations are the main reasons leading to high cost. ***In your opinion, what measures may be taken for the said issues to reduce the high cost at local mandi stage of vegetables (tomato) supply chain?*** |
| High Lead Time | Across the local mandi stage of vegetables supply chain with specific reference to tomato, it has been found that Improper planning for scheduling of incoming goods; Non-availability of tools and equipment for handling & loading; Non-availability of skilled labour for unloading the crates; and Inadequate space for unloading and loading operations are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at local mandi stage of vegetables (tomato) supply chain.*** |
| Poor Quality | Across the local mandi stage of vegetables supply chain with specific reference to tomato, it has been found that Rough handling while storing; Insufficient storage and temperature controlled facilities; Damage to the tomatoes caused by pest and fungal infection during storage; Non-availability of skilled labour for unloading the crates; and Inadequate/non-availability of timely demand information are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of vegetables at local mandi stage of vegetables (tomato) supply chain?*** |
| **Interview guideline questions-Wholesale/Mandi Stage** | |
| High Cost | Across the wholesale/mandi stage of vegetables supply chain with specific reference to tomato, it has been found that High labour charges for operations; Manual handling, loading & stacking operations; Large requirement of packaging material; and Non-availability of government facilities for operations are the main reasons leading to high cost. ***In your opinion, what measures may be taken to reduce the high cost incurred due to the said issues at wholesale/mandi stage of vegetables (tomato) supply chain?*** |
| High Lead Time | Across the wholesale/mandi stage of vegetables supply chain with specific reference to tomato, it has been found that Improper planning for scheduling of incoming goods; Non-availability of skilled labour for unloading the crates; Inadequate resources for dealing with unexpected bulk arrival; and Inadequate space for unloading and loading operations are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at wholesale/mandi stage of vegetables (tomato) supply chain?*** |
| Poor Quality | Across the wholesale/mandi stage of vegetables supply chain with specific reference to tomato, it has been found that Holding of goods in anticipation of high prices; Open area for unloading which expose to direct sunlight/heat; Damage to the tomatoes caused by pest and fungal infection during storage; Non-availability of skilled labour for unloading the crates; and Inadequate and non-availability of timely demand information are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of vegetables at wholesale/mandi stage of vegetables (tomato) supply chain?*** |
| **Interview guideline questions-Transportation Stage** | |
| High Cost | Across the transportation stage of the vegetables supply chain with specific reference to tomato, it has been found that Crossing & toll booth charges; the Long distance between farm and wholesale market; High traffic jams; and Timely non-availability of transport facilities are the main reasons leading to high cost. ***In your opinion, what measures may be taken for the said issues to reduce the high transportation cost in the vegetables (tomato) supply chain?*** |
| High Lead Time | Across the transportation stage of the vegetables supply chain with specific reference to tomato, it has been found that Hilly terrain; Congestion and traffic jams; Police verification & frisking; Irresponsible & careless driving; and Timely non-availability of transportation vehicle are the main reasons for high lead time. ***In your opinion, what measures may be taken for the said issues to reduce the high transportation lead time in the vegetables (tomato) supply chain?*** |
| Poor Quality | Across the transportation stage of the vegetables supply chain with specific reference to tomato, it has been found that Non-usage of the temperature controlled transportation system; Fungal infection during transit; and Poor road conditions are the main reasons for poor quality of fresh produce. ***In your opinion, what measures may be taken for the said issues to maintain and improve the quality of vegetables in transportation stage?*** |

# APPENDIX VI

## A Sample of Transcribed Conversation

### Measures to Improve Supply Chain Efficiency at Farm Stage of Fruits Supply Chain

***Question1.*** Across the farm stage of fruits supply chain with specific reference to mango, it has been found that a Large number of labour required for plucking & collection; High manual labour charges; Lack of mechanical sorting, grading and packaging facility; and Ignorance of farmers to new methods of cultivation are the main reasons leading to **high cost**.

*In your opinion, what measures may be taken for the said issues to reduce the high cost at farm stage of fruits supply chain?*

**RESPONSE**

**Respondent 1:**

- ***Measures for a Large number of labour required for plucking & collection***

To minimise a large number of labour in harvesting operations and for efficient harvesting of Mangoes a simple, low cost and portable Mango harvesting device have been designed and developed at the Central Institute for Subtropical Horticulture, Lucknow. This saves time, number of manpower and protects fruits from mechanical damage due to impact. On an average, a man can harvest about 800 to 1000 fruits per hour with the help of this device, depending on the skill of the worker, fruiting, and height of the tree. It has reduced the requirement of huge manpower in farm operations and also consumes 50% less energy as compared to local methods. Use of this practice would reduce the manpower and may be helpful to reduce the cost in plucking and collection activity.

- ***Measures for High manual labour charges***

In the present scenario, due to lack of skilled labours or non-availability of labours, the farmers (stakeholders) have to outsource the labours from other regions/areas, and these labours charge very high because they know that they will get whatever they will ask for. By taking this advantage, they charge high, and the stakeholders have to pay which incurs a high cost to them. In addition, the stakeholder has to arrange the food and stay for the outsourced worker who adds another cost. This situation can be improved by encouraging and developing skilled local labour and providing the proper training. The focus should be on near sourcing or local sourcing of labours. The intervention of Govt. supporting institutions is required to resolve this issue

- ***Measures for Lack of mechanical sorting, grading and packaging facility***

The mechanical sorting and grading of the produce are still in its infancy in India, and the equipment are either not available or have been put to large-scale commercial use. Support from Government and Financial institutions like ADB, World Bank, and NABARD is required to address the issue. In the present scenario, due to lack of mechanical facilities, the farmers have to do this activity manually which incurs huge cost of manpower. The government may also identify the strategic locations for developing clusters where the production rate is high. The local farmers may use these facilities for sorting, grading and packaging activities in minimum charges. The same types of facilities can also be developed by the farmers' association at strategic locations.

- ***Measures for Ignorance of farmers to new methods of cultivation***

The technology is developing day by day, and the new methods of cultivations are emerging. Agricultural research organisations have developed the various methods, but the Indian farmers are savvy to the old method of cultivation and ignoring the new and best methods of cultivation. Awareness programs and the campaign should be started to promote and make aware of the new technological intervention method of cultivation and their benefits to the farmer. Agricultural universities and research organization should conduct training programmes for the farmers. New advanced tools and their methods should be introduced to the farmers through different platforms like Agro Fest, and Agro Fairs (Krishi Mela).

***Question2.*** Across the farm stage of fruits supply chain with specific reference to mango, it has been found that Lack of training and knowledge about sorting, grading & packaging; Lack of proper planning for harvesting; Lack of mechanical sorting, grading and packaging facility; Lack of sorting & grading technology; and Long distance between plucking area and assembly area are the main reasons for **high lead time**.

*In your opinion, what measures may be taken for the said issues to reduce the high lead time in the operations performed at farm stage of fruits (mango) supply chain?*

**RESPONSE**

**Respondent 1:**

- ***Measures for Lack of training and knowledge about sorting, grading & packaging***

Sorting and grading operations are very critical; workers must be thoroughly trained and supervised to ensure removal of injured fruits & vegetables which could later develop decay during shipping. Labours have lack of knowledge pertaining to sorting & grading techniques and the right process due to which the lead time in this particular operation is very high which also impact the quality of produce. State Government/Department of Horticulture with the help of knowledge bodies, research organisations, and supporting institutions can run a knowledge campaign on developing skills pertaining to sorting and grading techniques. Skill Development program, Capacity building program, Productivity Enhancement Program would be the solution for this issue. Asian Productivity Council, NSDC, and Horticulture Departments may play an important role in enhancing the skills and knowledge of the farmers regarding the same.

- ***Measures for Lack of proper planning for harvesting***

Proper planning is very important before doing any activity either it is business or personal life. In perishable food operations, it plays a very important role. So proper planning must be there. In fruits and vegetables supply chain, Collaborative Supply Chain Planning can be done to integrate farmers and other stakeholders in the supply chain. The farmer can do the planning about harvesting collaboratively and the buyer should take following things into considerations like availability of harvesting tools and equipment, market demand, transportation availability, and packaging material. This would result in a more efficient supply system, through better and more rapid communications facilitating improvements in planning and procurement procedures. This would be also helpful for the local trader and wholesaler in planning for scheduling of incoming goods, as the entire process can be collaboratively planned and executed. The focus should be on collaborative practices in both supply and demand processes to ensure vertical and cross-functional relationships. Both the sales forecast and the order forecast should be considered in the joint planning and decision-making process.

- ***Measures for Lack of mechanical sorting, grading and packaging facility***

The manual process of sorting and grading is one of the grey areas of food supply chain. The concept of pack houses can be used and adopted. The pack houses may be developed by the state governments or by the farmers' association with the help of financial institutions like ADB, NABARD, and World Bank. Clustering can be done on the basis of production and identification of strategic locations. These facilities should be open to using for the farmers with minimal charges. This would enhance the speed of sorting and grading operations, and the produce can be quickly moved to the market without affecting the quality. It would also help in getting better prices for the agri produce.

- ***Measures for Lack of sorting & grading technology***

As technology is developing day by day, this sector is still nascent in terms of technological development. The government should develop technology/mechanization based packing houses or mini processing units for sorting, grading & packaging activities for all the stakeholders across the supply chain, i.e. at major production areas, its near-by region and at Mandis. At present, these operations are done manually which takes a long time in operations. These facilities need to develop more in numbers, and it should be open to all the farmers so they can easily access it and perform their operations without any glitch. These facilities can be started from major production center of Uttar Pradesh like Malihabad, Amroha, and Saharanpur. and some in Andhra Pradesh also.

- ***The long distance between plucking area and assembly area***

To reduce the distance for carriage, detailed analysis of the area should be done before starting the operations and selecting the place for collection and assembly. Then the decision regarding the location of assembly area should be made. Accordingly, the proper paths should be created for small carrying vehicle or pavements to carry the load which would reduce the burden on labour and also helps to reduce the overall time taken for collection and carriage to the assembly area. Also, decentralized assembly areas can be established to reduce the time and finally the produce can be consolidated at one place. This practice will reduce the lead time taken in assembling of fresh produce.

***Question3.*** Across the farm stage of fruits supply chain with specific reference to mango, it has been found that Exposure to high temperature during collection; Open air area for sorting, grading and packaging operations; Timely non-availability of packaging material; Mishandling and carelessness while plucking and collection; Lack of training and knowledge about packaging; Non-availability of skilled labour for sorting, grading & packaging; No scientific standard for determination of maturity; and Lack of proper grading and quality control system are the main reasons for **poor quality** of fresh produce.

*In your opinion, what measures may be taken for the said issues to maintain and improve the quality of fruits at farm stage of fruits (mango) supply chain?*

**RESPONSE**

**Respondent 1:**

- ***Exposure to high temperature during collection***

As perishable goods are highly sensitive in nature, exposure to the sun should be avoided as much as possible during and after harvest, as produce left out in the sun will gain heat and may become sunburned. The packaging boxes, crates should be placed in the shade or loosely covered (for example with light coloured canvas, leafy plant materials, and straw) if delays are expected in removing them from the field. The activities should be carried out in a covered area rather than performing open area operations. A temporary tent must be constructed from large tarpaulins or plastic sheets to perform the operation and avoid high temperature. Several fans should be used to recirculate the air through the produce during the operations. These measures may be taken to save the produce from higher temperature.

- ***Open air area for sorting, grading and packaging operations***

As also discussed in my last answer, an open area for operations should be avoided in any operations pertaining to the fresh supply chain. Small Packing house can be developed at the farm itself to carry out the basic or primary processing operations. Here, Government support is essentially required to encourage infrastructure creation in terms of packing houses at the major production areas or nearby region. Cooperative packing houses through cooperatives or associations may also be created so that the group of the farmer can access the facility and perform their post-harvest operations.

- ***Timely non-availability of packaging material***

Due to lack of availability of packaging material in the local area during the peak season, the farmers have to wait for a long to receive the packaging materials arriving from other areas. This leads to delay in harvesting and sometimes make the harvested mangoes wait for the packaging material which ultimately affects the quality of fresh produce. Private players may play a very important role in this issue. Supply chain solution incorporating equipment pooling can be provided by the private player. In this model, a service provider retains ownership of equipment (e.g., pallets, reusable plastic containers), and manages the network, providing customers with equipment when necessary. This model allows farmers, processors, wholesalers, and retailers to utilise the equipment without having to make a capital investment. Also, the formation of strategic alliances between farmers and food processing companies can assist both, the farmers and processing companies.

- ***Mishandling and carelessness while plucking and collection***

This is one of the biggest challenges in today's scenario when we talk about the logistics of fresh agricultural produce. Due to poor handling, every stakeholder in the supply chain has to incur the huge amount of losses. This problem can only be solved by good training and strict supervision and control over the activities in the chain. Training and supervision of labour are critical to a successful harvesting operation. Constant supervision is necessary to maintain quality and reduce subsequent spoilage of produce. Training is required in both general principles and crop-specific techniques relating to maturity selection, detachment method, maintenance of equipment, field hygiene, and division of labour. The workers must be given strict specifications before entering the field, and each worker's performance carefully supervised.

- ***Lack of training and knowledge about packaging***

This problem can also be solved by the alliance as discussed in the early case also. Supply Chain collaboration can be done to improve the situation. Private players can collaborate with the farmers to get the fresh produce and train the workers on how to sort and grade the produce as per industry requirement. They can provide the knowledge and build their expertise on sorting, grading activities. New techniques should be introduced to the farmers so they can easily sort and grade the produce without unnecessarily taking a long time. This practice will help both, the farmers and the private players. Private players can directly purchase the better quality graded produce from the farmers and the farmers in return will get better prices by selling their produce directly to the customers at their doorstep.

- ***Non-availability of skilled labour for sorting, grading & packaging***

Now a day every industry is looking out for skilled worker and also it is the need of the hour in logistics and supply chain activity. It is very important to think out of the box to improve the skill set of the human resource. We can see that Logistics and Supply Chain has gained a lot of importance nowadays. Many academic organisations have started offering programs focusing on logistics and supply chain, and creating industry ready logistics professionals. These organisations may conduct a training programs and sessions for the local workers as their CSR activity, where students from these academic organisations can train the workers and provide the knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce. Many logistics companies have also started their new ventures focusing on logistics training and development like safe educate by Safexpress; they can also adopt the same strategies which will serve both the purposes, i.e., CSR activity as well as Skill development of workers**.**

- ***No scientific standard for determination of maturity***

Maturity determination is very important to keep the produce in a fresh manner throughout the chain. Government, Agri focused universities, and development agencies should focus on developing maturity indices by continuous research and development with emphasis on quality, safety, and sustainability. It should be farmer-friendly harvest indices, and awareness should be created regarding the appropriate harvest indices through training, preparation of manuals, and posters. The agencies, institutions, NGOs can play a Vitol role in providing knowledge and creating awareness among the farmers.

- ***Lack of proper grading and quality control system***

There must be a proper quality control system which can monitor and control the quality of fresh produce starting from the farm to the end consumer. Systematic grading coupled with appropriate packaging and storage will extend postharvest shelf life, wholesomeness, freshness, and quality, and will substantially reduce losses and marketing cost. Fresh produce must be sorted and graded on the basis of parameters such as maturity, size, shape, colour, weight, freedom from insects and pests, pesticide residues and ripeness. Farmers should be informed as to how they can achieve the quality standards set by the market. This may include formal training out of season but will be most effective if farm visits are made when harvesting and packing activities are in progress, i.e., during the period of May to August.

# APPENDIX VII

## List of Codes

| S. No. | Codes |
|---|---|
| 1 | Air must be circulated in vans by fitting a fan inside |
| 2 | A cushioning material should be placed around the tree to prevent damage to the fruit when dropping from high trees while plucking |
| 3 | A specific timeframe should be created for each activity |
| 4 | A temporary tent must be constructed from large tarpaulins or plastic sheets |
| 5 | Academic organisations & Ventures focusing on logistics training and development may conduct training programs and sessions for the local workers as their CSR activity |
| 6 | Academic organisations may conduct training programs and sessions for the local workers as their CSR activity |
| 7 | Access near-by facilities for grading & packaging operations |
| 8 | Access to low-cost handling and storage technologies (e.g., evaporative coolers, storage bags, crates) |
| 9 | Accompanied by a sustained information and promotion campaign |
| 10 | Action plan by government and estimate requirements of funds for building cooling sheds at mandis |
| 11 | Actual information regarding market demand for quick movement |
| 12 | Adequate time to keep the produce without a decline in value |
| 13 | Adopt AAA (American Automobile Association) model for roadside assistance during transportation breakdowns |
| 14 | Adoption of Automation to handle a large quantity of load. |
| 15 | Adoption of contract farming strategy |
| 16 | Adoption of equipment pooling model |
| 17 | Adoption of new (organised) system of distribution |
| 18 | Adoption/ Replication of best practices of Europe and China |
| 19 | Agents associations may develop the cold storages with assistance from supporting institutions and government. |
| 20 | Aisles should be left between stacked containers and walls for proper inspection and cleaning |
| 21 | Annual maintenance of paths used for the carriage |
| 22 | Apply FIFO (First in First out) method to clear the stock |
| 23 | Asian Productivity Council, NSDC, and NHB should invest in training for workers and operators |
| 24 | Assign resources and ensure availability of appropriate resources to complete the tasks within the available time |
| 25 | Assistance from National Horticulture Board, NCCD and other supporting institution |
| 26 | Attach refrigerated bogies on trains during peak season |
| 27 | Availability and access to semi-processing units |
| 28 | Availability of transport and other facilities for the day; |
| 29 | Avoid congested and heavy traffic route |
| 30 | Avoid congested roads & use bypass |
| 31 | Avoid Corrugated Fiberboard cartons for packaging |
| 32 | Avoid dependency on road mode of transportation only |
| 33 | Avoid direct exposure to the sun and heat |
| 34 | Avoid forcibly placing of crates to fix them in the stack |
| 35 | Avoid headload carriage for moving the containers |
| 36 | Avoid loose packaging and overfilling of produce |
| 37 | Avoid Open Air operations |
| 38 | Avoid Open Air operations during high temperatures |
| 39 | Avoid plucking activity during day time |
| 40 | Avoid procuring more than handling capacity |
| 41 | Avoid purchasing cheapest and most readily available containers |
| 42 | Avoid the practice of holding in case of perishable commodity |
| 43 | Avoid the practice of Make to Stock/Overstocking and follow Make to Order practice |
| 44 | Avoid unscheduled stops during the journey |
| 45 | Avoid use of different sized containers at the same time |
| 46 | Awareness campaign by NHB, APEDA on quality standards set by the markets |
| 47 | Awareness campaign by state governments in collusion of NHB |
| 48 | Awareness of the time ignorance affects |
| 49 | Awareness of proper handling system management |
| 50 | Awareness of the importance of time utility in perishable produce |
| 51 | Awareness program & campaign on new methods by CIPHET, CISH, and other Agricultural research organisations |
| 52 | Awareness regarding the different types of packaging options |
| 53 | Better if fruits are precooled before keeping them at low temperature |
| 54 | Better roads, truck bays, parking for trucks before Toll Plazas or Octroi Posts |

| | |
|---|---|
| 55 | Calcium Carbide should not be used for ripening |
| 56 | Care should be taken that fruits are firm, mature and green in order to withstand the rigors of transportation |
| 57 | Careful instructions and strict specifications before load dispatch |
| 58 | Careful instructions must be given on the correct method of cutting, twisting or pulling to remove a crop |
| 59 | Careful instructions must be given on the correct method of handling |
| 60 | Careful instructions on the correct method of handling and unloading, and maintenance of crates |
| 61 | Carry fresh produce during appropriate temperature |
| 62 | Cartons, wooden boxes or crates that have been used for other commodities can be used again |
| 63 | Cashless toll roads (electronic toll payment systems) |
| 64 | Cemented floor with the roof of corrugated G.I. sheet may be constructed at the farm which can be used for other activities also |
| 65 | Charge the lowest possible toll level 'maintenance only toll' from F&V transporters |
| 66 | Charges should be regulated by the government during peak season like fixed prices for sugarcane procurement |
| 67 | Check on available resources |
| 68 | Check the performance & system for a reward for careful handling |
| 69 | Choose compression and skid-proofed packaging systems |
| 70 | Clean & Sanitize harvest containers prior to re-use |
| 71 | Clean and fumigate vehicle before placing the fresh produce |
| 72 | Clear paths and the surface should not be uneven |
| 73 | A clear understanding of the wide range of packaging options available in the market |
| 74 | Close attention and strict supervision & monitoring |
| 75 | Closed vehicles without refrigeration should not be used |
| 76 | Collaboration with labours to avoid high charges during the season |
| 77 | Collaboration with labour associations |
| 78 | Collaboration with transport service providers |
| 79 | Collaboration/Tie up with Transport Company for the long term at minimum charges |
| 80 | Collaborative Supply Chain Planning for integration |
| 81 | Commonly accepted quality and standards along the lines of India GAP proposed by APDEA |
| 82 | Compulsory road survey of highways every two-three months |
| 83 | The concept of Contact icing as an alternative to refrigerated vehicle |
| 84 | The concept of Horti-trains can be expanded to major production areas from Azadpur mandi |
| 85 | The concept of Just in Time (JIT) can be applied as the distance between the trade partners is short |
| 86 | The concept of Top Icing/Contact Icing can be applied to short-term storage which would result in quicker cooling |
| 87 | Conduct skill development and capacity building programmes in association with NSDC |
| 88 | Conduct training & development program |
| 89 | Conduct unloading operation early in the day |
| 90 | Connectivity to the remotest corner of the states |
| 91 | Consider Weather and environmental conditions |
| 92 | Consideration of distance factor before planning of assembly areas |
| 93 | Consideration of distance factor before selection of wholesale market |
| 94 | Constant and strict supervision to prevent careless handling |
| 95 | Construct the paths before planning for harvesting operations |
| 96 | Construction of roads designed to connect production areas to market centers |
| 97 | Continuous and Transparent communication between the stakeholders |
| 98 | Continuous field supervision to apply the most appropriate combination of handling techniques |
| 99 | Contract farming needs to be emphasised |
| 100 | Control environmental conditions during storage |
| 101 | The conveyance must be carefully inspected to ensure it is thoroughly clean and free from hitch-hiking pests and rotten produce |
| 102 | Cooling by an IDEC (Indirect Direct Evaporative Cooling) unit working on 12 Volt DC powered by the vehicle battery |
| 103 | Cooperative societies & Farmers associations would play an important role |
| 104 | The correct time of harvesting |
| 105 | Cover the distance between two points through the shortest route |
| 106 | Cover the load from the top during carriage |
| 107 | Cover the load/vehicle from the top with heavy-duty waterproof cloth (tarpaulins) to avoid direct heat/sunrays |
| 108 | Covered dock area at Mandi level to protect fresh produce |
| 109 | Create a schedule for vehicles to operate the service (assign vehicles to cover the trips associated with the timetable) |
| 110 | Create awareness of techniques & proper handling system management in a storage area |
| 111 | Create awareness program on handling and management of fresh produce |
| 112 | Create awareness, motivate labours, and provide training |
| 113 | Create work shifts for operators (crew scheduling) and adopt the concept of the double driver in the trucking industry |
| 114 | Creation of good policy environment to promotes investment |
| 115 | Creation of proper paths for small carrying vehicle or pavements |
| 116 | Cross-stacking/Interlocking packaging practice is preferable to stabilize the load pallets |

| | |
|---|---|
| 117 | Cultivator and location-specific maturity indices as per the codex and other marketing standards |
| 118 | Cut or broken ends of stems should never be placed in direct contact with the soil, nor placed in containers contaminated with dirt or decaying plant material |
| 119 | Day wise scheduling to avoid high traffic during peak season |
| 120 | Decentralized assembly areas to avoid long distance |
| 121 | Dedicated rail service can be set up during peak season covering major production areas to Azadpur mandi |
| 122 | Detailed analysis and evaluation of alternative routes |
| 123 | Detailed analysis of selection of transportation mode |
| 124 | Detailed analysis of the area before selecting assembly areas |
| 125 | Determination of fruit maturity for harvesting at the right time on the basis of external and internal fruit characteristics |
| 126 | Determination of ideal transfer point before starting the ripening process |
| 127 | Determine the best suitable path |
| 128 | Develop a pass system for a vehicle carrying F&V to avoid unnecessary verification |
| 129 | Develop controlled atmosphere cold storage facilities |
| 130 | Develop information materials and disseminate to the workers and stakeholders |
| 131 | Develop information materials and disseminate to the workers, stakeholders for better operations |
| 132 | Develop local labour |
| 133 | Develop ropeway infrastructure to avoid manual carriage operations |
| 134 | Development by cooperatives or associations with the help of government support |
| 135 | Development by cooperatives or associations with the help of government support |
| 136 | Development of advanced cluster based technological food parks |
| 137 | Development of cold storages by Agents associations with assistance from supporting institutions |
| 138 | Development of the concept of Smart Mandis on the line of Smart city by the National Horticulture Mission with the help of NCCD and other related authorities |
| 139 | Development of Cooperative packing houses |
| 140 | Development of financing models- including a public-private partnership at the local level |
| 141 | Development of Food Processing units in every district |
| 142 | Development of Fruits pack houses with assistance from horticulture department |
| 143 | Development of good transportation network |
| 144 | Development of ICT system allowing advance payment of taxes for the entire traveling route |
| 145 | Development of infrastructure for improving agronomic practices and technologies |
| 146 | Development of infrastructure including Quality assurance laboratories, Sorting and Grading machinery, Packaging equipment, common effluent treatment plants. |
| 147 | Development of mini food parks nearby wholesale region |
| 148 | Development of online bidding system for vehicle booking |
| 149 | Development of open area by government or mandi samiti for safe and timely loading and unloading activity |
| 150 | Development of primary processing units at wholesale market |
| 151 | Development of semi-processing unit at major production areas |
| 152 | Development of Smart Mandis on the line of Smart city by the National Horticulture Mission with the help of NCCD and other related authorities |
| 153 | Development of sorting & grading facilities |
| 154 | Devise a suitable system for returning the boxes to the field from the market |
| 155 | Dip treatment of ethrel/ ethephon solution (250 –750 ppm) in hot water (52±20C) for 5 minutes |
| 156 | Discard damaged fruits & vegetables to avoid quality deterioration |
| 157 | Disseminate agency wise and state wise grading parameters developed by support institutions and horticulture board |
| 158 | Disseminate information regarding the new techniques of packaging |
| 159 | Dissemination of manuals or guides (with diagram and pictures) published by govt. institutions/authorities on the handling of perishable fresh produce |
| 160 | Distribution of mechanical devices through government centers |
| 161 | Do not harvest fresh produce until transportation is assured |
| 162 | Do not leave out the produce in heat and sunlight after plucking |
| 163 | Do not mix up fresh produce with the fully ripe or three-quarters ripe produce |
| 164 | Dock area expansion at wholesale Mandis |
| 165 | Dock area should be enlarged to park different vehicles |
| 166 | Do not use anti-fungal/insects/rodent sprays and pesticides, which are not permitted |
| 167 | Drivers should follow traffic guidelines and control over speed |
| 168 | Efficient transportation infrastructure system (All weather road) |
| 169 | Eliminate cracks and crevices in storage areas by proper construction or repairs |
| 170 | Eliminate extensive and complex linkages between farmers and retailers |
| 171 | Eliminate non value added activities |
| 172 | Emphasis must be laid on the benefits of the farmer |
| 173 | Emphasis on time-bound operations |

| | |
|---|---|
| 174 | The empty vehicle should be thoroughly disinfected with a suitable insecticide |
| 175 | Encourage adoption of the pallet to stack the load |
| 176 | Encourage alternate mode of transport like cable cars |
| 177 | Encourage and develop skilled local labour |
| 178 | Encourage and promote public private partnerships to invest in infrastructure |
| 179 | Encourage APMC and other agencies to develop cold storage facilities at wholesale market |
| 180 | Encourage Cooperatives societies and other agencies to develop cold storage facilities |
| 181 | Encourage entrepreneurs and private players to set up processing facilities and packing houses |
| 182 | Encourage entrepreneurship and private participation to establish processing units |
| 183 | Encourage entrepreneurship for development of processing units |
| 184 | Encourage investment in refrigerated transportation system from the private sector by providing them good policy support |
| 185 | Encourage local labours and provide skill development programs |
| 186 | Encourage most modern state of art goods transport vehicle |
| 187 | Encourage NGO for sustainable rural development |
| 188 | Encourage private agencies to establish cold storage at nodal points. |
| 189 | Encourage private players for Supply chain solution incorporating equipment pooling |
| 190 | Encourage Rail mode of transportation |
| 191 | Encourage rail mode of transportation for fresh produce |
| 192 | Encourage stakeholders for the use of ripening chambers |
| 193 | Encourage subsidy from government and investment from the private sector |
| 194 | Encourage to use technological advanced equipments to reduce operational cost |
| 195 | Encourage usage of insect-proof boxes |
| 196 | Enforce and check to overload of trucks, which damages the roads |
| 197 | Ensure that crop maturity coincides with market demand. |
| 198 | Ensure that the Second-hand containers are clean. |
| 199 | Equipment are available which can be used to 'tight fill' boxes |
| 200 | Establish cooling shed to keep mangoes for further processing |
| 201 | Establish linkage between Farmers and private food companies |
| 202 | Establish multi- chamber/ multi- commodity cold storage |
| 203 | Establish well-connected transportation network |
| 204 | Establishment of facilities by farmers association & cooperative societies |
| 205 | Establishment of facilities in an area accessible to the users |
| 206 | Establishment of Horticulture Information Centre (HIC) in every district to inform and interact with the farmers |
| 207 | Establishment of mini food parks & packing houses by the state government at major production areas |
| 208 | Establishment of modern dock area with sheltered environment |
| 209 | Establishment of National/Regional information networking system |
| 210 | Establishment of packing houses by Government |
| 211 | Establishment of proper and well connectivity between farm and collection area |
| 212 | Every road Project to have a sacrosanct deadline, with heavy penalties for non-performance |
| 213 | Exert strict supervision on fruits unloading & loading operation |
| 214 | Exert strict supervision on the harvesting operation. |
| 215 | Expand rural connectivity through the rehabilitation of roads |
| 216 | Expand the width of existing roads |
| 217 | Expand the width of existing roads; also construct important bridges and flyovers |
| 218 | External colour, appearance, pulp colour and soluble solids content are the reliable indicators for judging the fruit maturity |
| 219 | Facility of the refrigerated transportation system by the state government |
| 220 | Facility of state government refrigerated transportation system |
| 221 | Fans should be used to recirculate the air through the produce during the operations |
| 222 | Farm visits of horticulture officers when packing activities are in progress |
| 223 | Farmer awareness on available mature index guides |
| 224 | Farmer Field School (FFS) approach on the lines of Indonesia to fill up knowledge gap between researchers and actual practitioners |
| 225 | Farmer-friendly harvest indices and awareness through training |
| 226 | Farmers should be encouraged to form their own marketing co-operative societies |
| 227 | Field bins should be placed in the shade or loosely covered with light coloured canvas, leafy plant materials, straw or an inverted empty container |
| 228 | Field sheds or mobile packing facilities may suffice for small-scale |
| 229 | Fill the produce according to the capacity of packaging material |
| 230 | Financial Assistance to an entrepreneur in the form of subsidy and prime lending rates |
| 231 | Financial assistance to establish multi-chamber/multi-commodity cold storages for the short- and long-term storage |
| 232 | Financial assistance to purchase refrigerated vehicles or procure it on a concessional rate |
| 233 | Financial assistant from the government to build a cooling shed or procure the material on a concessional rate |
| 234 | Financial institutions like ADB, NABARD, and World Bank would play a vital role |

| | |
|---|---|
| 235 | Fixed reasonable charges can be set by the government |
| 236 | Focus on development of micro cold chain solutions |
| 237 | Focus on lesser food mileage |
| 238 | Focus on near or local sourcing of labours |
| 239 | Focus on near sourcing or local sourcing of labours |
| 240 | Focus on the rotation based operation to avoid fatigue |
| 241 | Focused should be on skill development, capacity building of local labour |
| 242 | Follow Consolidation practice for the same destination |
| 243 | Follow response based model rather than anticipation |
| 244 | Follow the practice of forwarding planning to coordinate equipment, labours, and make necessary arrangements |
| 245 | Follow trans-shipment point network according to the available road infrastructure |
| 246 | Food and Technology Parks at district levels |
| 247 | Food handling and storage areas should be accessible to routine cleaning and collection of waste |
| 248 | Formation of alliances for commodity-based clusters to set up cold storage facilities |
| 249 | Formation of associations or cooperative societies for development of technological facilities |
| 250 | Formation of Cooperatives societies to establish cold storage |
| 251 | Frequent and surprise checks by officials |
| 252 | Fresh produce may be immersed in hot water before marketing to control the disease |
| 253 | Fruit with splits, punctures and incipient rotting should be removed from the lot |
| 254 | The fullness of cheeks adjacent to pedicel may be used as a guide for maturity |
| 255 | Good Policy environment to encourage PPP model for development |
| 256 | Government & related institutions should be responsible for educating & training the farmers on a regular basis |
| 257 | Government centers for distribution of mechanical devices |
| 258 | Government focus needs to be emphasised on the infrastructure development at mandi area |
| 259 | Government intervention & regulation to control higher charges |
| 260 | Government intervention on the development of infrastructure |
| 261 | Government regulated minimum charges for accessibility |
| 262 | Government support for the infrastructural development of APMC market |
| 263 | Government support to create and provide technological infrastructure at major mandis |
| 264 | Govt. may use the concept of smart cities to develop smart mandis |
| 265 | Grading machinery should be used to reduce manpower |
| 266 | Guidelines with pictures and diagrams for easy understanding & learning of general principles and specific techniques |
| 267 | Harvest and carriage operation early in the day |
| 268 | Harvest containers and bulk bins should have smooth sides and be kept free of debris |
| 269 | Harvest early in the day, keeping fruit in the shade, dumping into cold water and placing fruit straight into pre-cooler, if fruit cannot be processed immediately. |
| 270 | Harvest when the soluble solids content (sugars) of mature fruit is at least 10%. |
| 271 | Harvesting operations should be avoided during high temperature |
| 272 | Harvesting tools, Hand gloves, and Containers; |
| 273 | Hold the fruit in the temperature range 20oc to 23oc. It provides the best appearance, palatability and decay control |
| 274 | Horizontal integration between agents for pooling of tools and equipment |
| 275 | Horticulture experts/ officers at the state level may advise farmers regarding the facilities |
| 276 | Human factors as well as market demands |
| 277 | ICT portal for complaint registration regarding ‘forced’ stopovers |
| 278 | Identification of cluster-based strategic locations |
| 279 | Identification of spot/location for installation as per major production belt |
| 280 | Identification of strategic locations for agri cluster development |
| 281 | Identification of strategic locations for infrastructure development |
| 282 | Implementation of the e-challan system |
| 283 | Implementation of GST (Goods & Service Tax) |
| 284 | Implementation of TAG lane system (as followed by the UK) as a discounted payment option |
| 285 | Improve the quality of roads in hilly areas |
| 286 | Improve supply chain communications |
| 287 | Improved Infrastructure through more expressways and bypasses |
| 288 | Improvise beach umbrellas arranged around the operation area to provide acceptable shade to the produce |
| 289 | Inexpensive inner made from fiberboard can be used to protect produce from damage during handling |
| 290 | Information and management systems such as ITS to provide accurate and real-time information about traffic state |
| 291 | Information regarding the standards and quality required by industry & international market |
| 292 | Information regarding the types of packaging materials and innovative techniques |
| 293 | Infrastructure to facilitate quality control system |
| 294 | Installation of GPS systems in vehicles for monitor and controlling |
| 295 | Installation of Machinery/Equipments to unload the items from Sellers crate |

| | |
|---|---|
| 296 | Installation of ropeways trolleys to facilitate farmers |
| 297 | Institutional support for the purchase of tools & equipment |
| 298 | Instructions to harvest with appropriate techniques to trim fingernails, and be monitored to verify proper handling |
| 299 | Insulated or properly ventilated trailer trucks can be used |
| 300 | The intervention of Govt. supporting institutions for development |
| 301 | Introduction of double driver concept |
| 302 | Introduction to Technology induced methods & its benefits through agro fest (Krishi Mela) at district and village levels |
| 303 | Invest & Use plastic containers (crates) which are reusable and last longer (Cost can be recovered in 10-15 trips) |
| 304 | Investment by bodies like NHB, NCCD, NSDC on training |
| 305 | Investment on roads |
| 306 | Involvement of Agriculture supporting institution for research on new methods and training |
| 307 | Issuance of verification note to avoid continuous verification |
| 308 | Joint planning and decision-making process |
| 309 | Knowledge campaign by Indian Institute of Packaging or State Agriculture Departments |
| 310 | Law on ‘forced’ stopovers for verification and frisking of vehicles for a bribe |
| 311 | Less mature and mature fruits can be ripened by dipping the fruits in 500 and 250-ppm ethrel solution |
| 312 | Linkage of production with processing and organised marketing |
| 313 | Linkage of a trader with processing and organised marketing |
| 314 | The load should not be more than 20 kg for movement to the assembly area. |
| 315 | Make availability of Mango Picking machine (Cut & convey type fruit picker) where a worker can harvest mangoes from the ground. |
| 316 | Make sure that enough time has been allocated for essential tasks |
| 317 | Mandatory training and certification emphasising the setting of benchmarks and standards |
| 318 | Manpower requirements |
| 319 | Mapping of transportation network before planning the route |
| 320 | Market price and place to supply and distance |
| 321 | Maturity indices by continuous research and development |
| 322 | Maximum number of mini-pack houses at major production areas |
| 323 | Mini food and technology parks in predominant production areas at district levels |
| 324 | Mini food and technology parks in predominant wholesale areas in every district |
| 325 | Mini Forklifts kind of Automated Vehicle- Picking area to the collection area. |
| 326 | Minimise drops while plucking and collection |
| 327 | Minimising permit centers and check posts |
| 328 | Minimum interspace of the packages by carrying the suitable and uniform size containers |
| 329 | Minimum vehicle on sharing basis among the farmers |
| 330 | Minors and Women’s should be strictly prohibited from operations |
| 331 | Mobile Application for continuous information regarding demand and production |
| 332 | Mobile Application for continuous information regarding prices |
| 333 | The model allows farmers, processors, wholesalers, and retailers to utilise the equipment without having to make a capital investment |
| 334 | Monitor and control the quality of fresh produce |
| 335 | Monitoring and closed supervision on the operations of workers |
| 336 | Motivate labours and training on the appropriate use of packaging technologies and materials |
| 337 | Need a distribution model to provide packaging materials by the government at a minimum rate |
| 338 | Need appropriate harvest containers and constant management of labour |
| 339 | Need for a high level of trust among the supply chain partners |
| 340 | Need for linkage/integration of production with processing and organised fresh retailers |
| 341 | Need Government support to develop infrastructure |
| 342 | Need Government support to develop small packing house at farm area |
| 343 | Need Infrastructure in place to provide training and education for improving agronomic practices. |
| 344 | The need of cold chain and cold storage |
| 345 | Need of cold chain network from farm to the point of sale |
| 346 | The need of electronic management systems and controllers assist by controlling the storage environment automatically |
| 347 | Need of Good policy environment promoting investment and formation of alliances/commodity-based clusters |
| 348 | Need of mechanization process to carry produce from farm to the place of aggregation |
| 349 | The need of reduction in the length of the supply chain |
| 350 | Need of Research & Development on cost-efficient technology for sorting & grading operations |
| 351 | The need of research on transportation methods in hilly terrain |
| 352 | Need of technical assistance from knowledge support institutions |
| 353 | The need of technology intervention/ innovation |
| 354 | Need to develop institutions which provide scientific training regarding sorting, grading processes. |
| 355 | Need to expand the Horti-trains transportation network |

| | |
|---|---|
| 356 | Need to make training and certification mandatory while also emphasising the setting of benchmarks and standards. |
| 357 | NGOs may play an important role in getting the linkages |
| 358 | NHB, NCCD, NSDC should invest in training for workers and operators for good grading practices |
| 359 | Number of days for harvesting/harvesting frequency (harvesting ahead and not waiting until a demand occurs) |
| 360 | One time Sorting, grading & packaging as per food standards |
| 361 | Operations should be avoided during high temperature |
| 362 | Optical methods can be used to determine the maturity |
| 363 | The optimum temperature for the crop as quickly as possible |
| 364 | Optimum utilisation of packaging resources |
| 365 | Package must be unloaded gently and handled with care |
| 366 | Packages should not be dumped and thrown during unloading |
| 367 | Packages should not be thrown during handling and stacking |
| 368 | Packaging box should be covered with insect-proof screen & sealed with adhesive tape |
| 369 | Packaging containers should be placed in shade or loosely covered with light coloured canvas, leafy plant materials, straw or an inverted empty container |
| 370 | Packaging material must be free of chemical substances & smell |
| 371 | Packaging material must have sufficient stacking strength to resist crushing due to jerks |
| 372 | Packing houses needs to be developed by the state government |
| 373 | Penalties for a long lead time due to carelessness |
| 374 | Penetration of road |
| 375 | Performance of each worker should be checked |
| 376 | Place examples of the smallest and largest acceptable size for easy reference |
| 377 | Plastic crates should be used as a packaging material |
| 378 | PPP model would also play a vital role in developing facilities |
| 379 | Precaution is to be taken to leave a four-inch stem to avoid the spurt of milky/resinous sap that exudes if the stem is cut close. |
| 380 | Prefer rail transport for bulk commodities and long distance |
| 381 | Prefer unit load to handle the produce rather handling individually |
| 382 | Premature fruits can be ripened to an acceptable quality by dipping the fruits in a 750-ppm ethrel solution |
| 383 | Preparation & dissemination of manuals or guides with diagram and pictures |
| 384 | Preparation of action plan by government and estimation of fund requirement for development |
| 385 | Preparation of an action plan by govt. and estimation of funds |
| 386 | Primary aim on improving the quality rather than appearance for sales |
| 387 | Primary processing units focusing on sorting machinery, auto-grading equipment based on size, and colours. |
| 388 | The private company manages the network, providing customers with equipment when necessary |
| 389 | Procurement based on actual market demand, not in anticipation |
| 390 | Produce must be categorised and graded uniformly as per the quality |
| 391 | Produce needs to be packed tightly to reduce its movement |
| 392 | Programs on Skill Development, Capacity building, and Productivity Enhancement |
| 393 | Promote and encourage contract farming |
| 394 | Proper air circulation & ventilation inside the container/crates |
| 395 | Proper air circulation during stacking and arrangement of crates |
| 396 | Proper carrier evaluation before selection of transportation mode |
| 397 | Proper coordination with suppliers and customers |
| 398 | Proper handling and safety of produce should be the prime importance |
| 399 | Proper inspections and regular visit to mandi by government officials to control the issue |
| 400 | Proper maintenance & repair of truck and/or trailer suspensions |
| 401 | Proper planning according to the market distance and available transportation infrastructure |
| 402 | Proper planning and identification of delivery points |
| 403 | Proper planning and necessary arrangements in advance to avoid hindrance during operation |
| 404 | Proper planning for scheduling of incoming goods |
| 405 | Proper planning of harvesting day and time |
| 406 | Proper planning of harvesting schedule and make transportation arrangements accordingly |
| 407 | Proper planning of incoming goods |
| 408 | Proper scheduling of tasks for space optimization and effective operations |
| 409 | Proper scheduling of trucks to optimize the space and operate effectively |
| 410 | Proper stacking in such a manner that packages are locked with each other in a stack |
| 411 | Proper storage temperature before the fresh produce is delivered |
| 412 | Proper unitization of the load in packaging containers |
| 413 | Proper vehicle routing to follow the shortest path |
| 414 | Properly covered and closed vehicle to maintain the quality of consignment |
| 415 | Properly maintained temperature to control pest and fungal infection |
| 416 | Proposal to allow toll-free access across all states to vehicles carrying perishable produce |

| | |
|---|---|
| 417 | Protect the load from excessive humidity, excessive heat, and direct sun rays |
| 418 | Provision of 50% subsidy by Govt. on the electricity costs of cold stores to encourage cold storage infrastructure |
| 419 | Provision of buying the mechanized item in the subsidized form |
| 420 | Provision of direct selling to the food processing units |
| 421 | Provision of subsidy on purchase of loading & unloading equipment for agricultural use |
| 422 | Pull-based supply chain rather than push supply chain |
| 423 | Rail freight charges can be reduced by the government during peak season to encourage rail mode of transportation |
| 424 | Rapid communications facilitating improvements in planning and procurement procedures |
| 425 | Realistic rental rates and payments after the sale of the product to attract the users to use the facility |
| 426 | Realistic rental rates and practice of payments after the sale of the product |
| 427 | Refrigerated vans can be run under public-private partnership (Major production areas to nearby Wholesale market) |
| 428 | The refrigerated vehicle should be used for long-distance transportation |
| 429 | Regular pest survey and monitoring to control pest and infection |
| 430 | Removal of toll charges for F&V transporters (10pm and 6am) |
| 431 | Remove all traces of chemicals from produce before loading |
| 432 | Remove deformed produce and those with splits, punctures and incipient rotting from the lot |
| 433 | Remove traces of chemicals before sorting & grading |
| 434 | Remove unmarketable pieces or unripe/overripe mangoes in preliminary sorting |
| 435 | Repair paths connecting farm and collection area |
| 436 | Replication of cross-docking concept in this case with minimum operations |
| 437 | Replication of the concept of sharing taxi like Zoom Car |
| 438 | Research & Development by knowledge supporting institutions on equipment |
| 439 | Research & Development on new packaging methods by Indian Institute of Packaging |
| 440 | Reuse of cartons, wooden boxes or crates that have been used for other commodities. |
| 441 | Reward system for on-time delivery of goods |
| 442 | Ripening chamber helps maintain precise conditions specific to the product's requirement |
| 443 | Risk hedging supply chain strategy |
| 444 | Road network from farm to road-head and nearby railway dock |
| 445 | Road projects to be given only to well-known Infra companies |
| 446 | Role of development institutions in setting up the facilities |
| 447 | Role of National Cold Chain Development (NCCD) and Govt. Power utility bodies to reduce the cost. |
| 448 | Role of NGOs and Farmer cooperatives |
| 449 | Role of NGOs for linkages between farmers and processing units |
| 450 | Role of NSDC, NGOs for training & development |
| 451 | Role of Panchayats, Pradhan |
| 452 | Role of private companies in training farmers on good agri practices and new methods |
| 453 | The roof of corrugated G.I. sheet may be constructed at mandis |
| 454 | Room cooling technique consisting refrigeration unit |
| 455 | Sealed Inspection by non- intrusive methods |
| 456 | Select the channel which distributes the produce appropriately at low expense |
| 457 | Select the channel which secures the desired volume of disposal |
| 458 | Sensitization of drivers-Awareness, Training and knowledge development programme |
| 459 | Separate different varieties if they are distinguishable |
| 460 | The service provider manages the network, providing customers with equipment when necessary |
| 461 | Set commonly accepted Quality and Standards along with the lines of India GAP proposed by APDEA |
| 462 | The setting of packing houses and mini processing units |
| 463 | Setting up a dedicated radio station to continuously broadcast traffic conditions |
| 464 | Setting up a dedicated radio station to continuously broadcast traffic conditions |
| 465 | Setting up a temporary conveyor equipment system |
| 466 | Setting up electronic notice boards to inform traffic condition before every entrance of the expressway |
| 467 | Shade can be created using the locally available material, such as shade cloth, woven mats, plastic tarps or a canvas sheet hung from temporary poles. |
| 468 | Sharing practices between the users and Cooperative societies |
| 469 | The shift from outsourcing of labour towards local sourcing |
| 470 | Shift to local sourcing instead of outsourcing at a higher cost |
| 471 | The shift to the process of mechanization. |
| 472 | Shift to technology-intensive operations rather than labour intensive |
| 473 | The shift towards rail mode of transportation for long distance |
| 474 | Single Inspection Squads at inter-state check posts to give 'No-Objection Certificate' (NOC) on behalf of all departments |
| 475 | Size of the fruit at harvest could have a major effect on its profitability during the marketing |
| 476 | Sizing can be done subjectively (visually) with the use of standard size gauges |
| 477 | Skill Development program, Capacity building program, Productivity Enhancement Program |

| | |
|---|---|
| 478 | Slow speed while crossing speed breakers to safeguard the quality of packages from jerks |
| 479 | Sorting & grading on the basis of maturity, size, shape, colour, weight, freedom from insects and pests, pesticide residues and ripeness |
| 480 | Sorting & grading on the basis of maturity, size, shape, colour, weight, insect damage, and decay |
| 481 | Sorting, grading and packaging techniques relating to size selection, shape selection, packing techniques, container space optimization |
| 482 | Sorting, grading facilities at major mandis |
| 483 | Space between the vehicle and loading area of the facility should be covered by an insect-proof screen |
| 484 | Special consideration in case of highly perishable produce |
| 485 | Specially refrigerated bogies to be attached with the trains from the major production belts to Azadpur mandi during peak season |
| 486 | Specially sprung vehicles can be used for transporting fruit |
| 487 | Stack 18 inches off the floor and 18 inches away from walls as per "18-inch rule of sanitation." |
| 488 | Stage of maturity; |
| 489 | State government can run transport services under PPP mode |
| 490 | Storage at 10 to 13 °C (50 to 55 °F) with 85 to 90% RH, give a shelf life of 14 to 28 days |
| 491 | Storage site structure should be protected from excessive humidity, excessive heat, and direct sun rays |
| 492 | Storage structure should be cleaned and fumigated before placing the fresh produce |
| 493 | Strategic Alliance with food companies, organised fresh retailers |
| 494 | Strategic alliances between farmers and food processing companies |
| 495 | Strategic alliances with food processing companies and fresh retailers |
| 496 | Strengthen & upgrade modern transportation network |
| 497 | Strengthen & upgrade the paths connecting collection area |
| 498 | Strengthen and upgrade road network connectivity and accessibility of remote areas |
| 499 | Strengthening of the box using adhesive tape & secured with a thin rope of coconut fiber, or polythene sutli, as an alternative |
| 500 | Strict control and supervision of the manual operations |
| 501 | Strict regulations by the government on the use of inadequate labour/workers |
| 502 | Strict supervision of the operation performed by worker/labour |
| 503 | The strong network between farmers and researchers for technical advancement |
| 504 | Study of the road as per guarantee period and appropriate action depending upon the degree of damage |
| 505 | Subsidized loan on the prime lending rate for entrepreneurs |
| 506 | Subsidy by the government on the cost of building cold-storage |
| 507 | Subsidy on the purchase of grading and packaging machinery |
| 508 | Sufficient mechanical strength of the package to protect the contents |
| 509 | Supply Chain Collaboration between farmer and private companies |
| 510 | Supply Chain Collaboration to improve communications |
| 511 | Supply Chain collaboration with food processing companies, hotel industry, & fresh retailers |
| 512 | Supply chain solution incorporating equipment pooling |
| 513 | Support by the government through subsidy to buy packaging crates (like, Maharashtra Govt. provides 50% subsidy) |
| 514 | Support from Government & Supporting institutions for development |
| 515 | Support from National Horticulture Board, State Horticulture Board, or any other developing agencies |
| 516 | The system of penalty for a high lead time in operations |
| 517 | Systematic grading coupled with appropriate packaging |
| 518 | The team leader should be appointed and made responsible for any delays |
| 519 | Technology development at major wholesale market |
| 520 | Technology-intensive practice rather than manual intensive |
| 521 | Technology-intensive processing units by with assistance from NHB, MoFPI, and ADB. |
| 522 | Temporary shade can be created using the locally available material, such as shade cloth, woven mats, plastic tarps or a canvas sheet hung from temporary poles |
| 523 | The temporary tent must be constructed from large tarpaulins or plastic sheets for collection activity |
| 524 | Test packaged transport loads to simulated vibration conditions |
| 525 | The FIFO (First in First out) method should be applied to clear the stock |
| 526 | The ideal transfer point must be determined before starting the ripening process |
| 527 | The number of days should be 120 to 140 days from flowering and fruit set to mature |
| 528 | Toll-free telephone numbers for registering complaints |
| 529 | Training & development of local labour |
| 530 | Training & knowledge on best logistical practices like sorting and grading, effective and new techniques of packaging, and handling perishable produce. |
| 531 | Training and knowledge development programme |
| 532 | Training on categorisation, selection and placing the produce gently |
| 533 | Training on general principles and crop-specific techniques relating to maturity selection, detachment method, maintenance of equipment, and field hygiene |
| 534 | Training on how to properly clean plastic crates between uses |

| | |
|---|---|
| 535 | Training on how to properly clean plastic crates between uses |
| 536 | Training on storage practices by Productivity council or knowledge support institutions |
| 537 | Training programs and sessions by the academic organisation for the local workers as their CSR activity |
| 538 | Training, seminars by National Productivity Council or State Productivity Council |
| 539 | Transport speeds must be suited to the quality and conditions of the roads |
| 540 | Transportation during the cooler part of the day, preferably at night |
| 541 | Treat the fruits with ethylene gas (100 ppm) in an airtight room by exposing them for 24–48 hrs. under controlled conditions of temperature and humidity |
| 542 | Treatment of HWT (Hot water treatment) + Wax coating to prevent pest |
| 543 | Try to minimise manual process in the supply chain |
| 544 | Twister Picker, a lightweight, aluminum-and-plastic picker tool which would make fruit picking process faster with minimum labour |
| 545 | Type of tools to be used |
| 546 | Uniform contents and contain only mangoes of the same origin, variety, quality and size |
| 547 | Unsuitable quality packaging materials (large sacks, rough wooden boxes, second-hand cartons, bamboo baskets, or rattan containers) should not be used |
| 548 | Updates on local, state and national level market information by Market Committees and Marketing Boards |
| 549 | Upgrade rural link roads |
| 550 | Upgraded transportation services without en-route inspections on the basis of a certificate issued at the point of origin |
| 551 | Usage of electronic management systems and controllers assist by controlling the transportation environment automatically |
| 552 | Use beach umbrellas arranged side by side to provide acceptable shade to the produce during sorting, grading activity |
| 553 | Use controlled atmosphere transportation system |
| 554 | Use fans inside the tent to recirculate the air |
| 555 | Use Mechanical cableways |
| 556 | Use of advanced packaging material & knowledge about new packaging methods |
| 557 | Use of bypass roads |
| 558 | Use of cattle for hilly terrain |
| 559 | Use of cattle service to carry the produce |
| 560 | Use of colour charts prepared by APEDA, NHB and other bodies |
| 561 | Use of conveyor equipment |
| 562 | Use of cooling fans inside the premises |
| 563 | Use of equipment fitted with aroma sensors for postharvest measurement of fruit ripeness |
| 564 | Use of fans to recirculate the air through the produce while storing |
| 565 | Use of Food irradiation technology to destroy or sterilize bacteria |
| 566 | Use of Garden carts to collect plucked fruits |
| 567 | Use of hand-carts for carriage activity, avoid manual load carriage |
| 568 | Use of harvesting bags with shoulder or waist slings while plucking |
| 569 | Use of internal dividers on accurate size graded produce to reduce mutual impacts |
| 570 | Use of IT system and software for effective vehicle route planning |
| 571 | Use of light transmission properties to measure the degree of maturity |
| 572 | Use of Low cost and portable Mango harvesting device |
| 573 | Use of Low-cost, low-energy, environmental friendly cool chambers made from locally available materials |
| 574 | Use of machinery and equipments for loading unloading operations |
| 575 | Use of mango picking platforms to facilitate fruit harvesting from tall trees |
| 576 | Use of Mechanical cableways to move the produce |
| 577 | Use of Mobile truck loader and unloader, truck loading-unloading conveyors, and fork-lifts. |
| 578 | Use of molded pulp tray for packaging |
| 579 | Use of Multimodal transportation |
| 580 | Use of Night ventilation technique where variation between day and night temperatures can be used to keep stores cool |
| 581 | Use of Normal plastic containers with ventilation slots |
| 582 | Use of Palletization or unitized handling (stacking containers on standard size pallets) |
| 583 | Use of plastic containers with ventilation slots stacked 3/4 high on a false perforated floor supplying cooled air |
| 584 | Use of Plastic crates to strengthen packaging quality |
| 585 | Use of Plastic field boxes/Crates with stack design |
| 586 | Use of plastic or paper corner tabs in corners of packages |
| 587 | Use of plucking tools for sharp and efficient harvesting process |
| 588 | Use of ripening chambers results in less food wastage and higher price realization |
| 589 | Use of small carts depending upon the condition of the path |
| 590 | Use of small forklifts or other vehicles, depending upon the surface inside the farm |
| 591 | Use of unloading aids such as roller conveyors, pallet or forklift to reduce the handling of individual packages |
| 592 | Use of Zero energy cool chamber/Evaporative coolers to extend the shelf life of food and avoid spoilage |
| 593 | Use the best combinations of the road, rail and airways network |

| | |
|---|---|
| 594 | Use the latest polymer and concrete technologies as appropriate depending on terrain and weather |
| 595 | Use well- maintained transportation and stick to speed restrictions |
| 596 | Users must be accompanied by a sustained information and promotion campaign. Emphasis must be laid on the benefits to the farmer. |
| 597 | Utilisation of equipment without making a capital investment |
| 598 | Utilise covered trucks for refrigerated transport by cooling with ice |
| 599 | Value stream mapping should be done |
| 600 | The vehicle shall meet the quality, hygiene, ventilation and resistance characteristics |
| 601 | Ventilated, air circulated & humidified transport |
| 602 | Ventures focusing on logistics training and development can also provide training to labours/workers as a CSR activity |
| 603 | Verification only at checkpoints |
| 604 | Weather and environmental conditions |
| 605 | Weight should be properly measured before dispatch to control overload practice |
| 606 | Well trained workers provided with appropriate tools and equipment |
| 607 | Well-connected transportation network for faster shipment and more reliable travel time |
| 608 | Widening of roads, upgrading surfaces and the introduction of one way traffic |
| 609 | Work closely with the farmers regarding the production and harvesting operations for proper planning |
| 610 | Yearly maintenance & repair of roads by Public Works Department or under PPP mode |

## Brief Profile of Research Scholar

**Mr. Saurav Negi** is currently working with University of Petroleum and Energy Studies (UPES), Dehradun. He is a Research Scholar in the area of Logistics and Supply Chain Management. He has done his Bachelor's in Marketing and Masters of Business Administration in Logistics and Supply Chain Management.

During his PhD tenure, he has published 15+ research papers in International Journals of repute, and Edited Book and has participated and presented papers in various International and National Conferences including IIMs.

He is currently serving as the member of **Editorial Review Board** for *International Journal of Applied Logistics* (IJAL), published by IGI Global Publication, USA and *Journal of Transport and Supply Chain Management*, published by University of Johannesburg, South Africa and also a Member of **Editorial Advisory Board** for two **SCOPUS Indexed** Edited Book Titled *"Strategic Supply Chain Management in the Retail Industry"* and *"Supply Chain Management Strategies and Risk Assessment in Retail Environments"* published in February 2016 & December 2017 respectively by IGI Global Publications, USA.

He has also reviewed papers for various reputed International Journals like *"Trends in Food Science & Technology"* An official journal of the European Federation of Food Science and Technology (EFFoST), and the International Union of Food Science and Technology (IUFoST), published by Elsevier **(SCOPUS Indexed)**, Impact Factor: 4.651; *International Food and Agribusiness Management Review (IFAMR)*, USA **(SCOPUS Indexed)**; *Journal of Operations and Supply Chain Management* published by Getulio Vargas Business School (FGV), Brazil; *International Journal of Managing Value and Supply Chains (IJMVSC)*, USA.

His areas of interest are Agro Supply Chain, Logistics and Supply Chain Management of Food, Cold Chain Management, and Food Retail Supply Chain.

# List of Publications in Journal

| S. No. | Author (s) | Year | Title of the Paper | Name of the Journal | Publisher | Indexing/Listing |
|---|---|---|---|---|---|---|
| 1 | Saurav Negi and Neeraj Anand | 2018 (In Press) | Wholesalers Perspectives on Mango Supply Chain Efficiency in India | Journal of Agribusiness in Developing and Emerging Economies (JADEE) | Emerald | ESCI, SCOPUS, ABDC, UGC Approved Journal |
| 2 | Saurav Negi and Neeraj Anand | 2018 (In Press) | Factors Leading to Supply Chain Inefficiency in Agribusiness: Evidence from Asia's Largest Wholesale Market | International Journal of Value Chain Management (IJVCM) | Inderscience | SCOPUS, ABDC, UGC Approved Journal |
| 3 | Shantanu Trivedi, Saurav Negi, Neeraj Anand & Rishikesh Patnakar | 2018 (In Press) | ERP Solution for Effective Supply Chain of Micro, Small and Medium-sized Enterprises A case study of customized ERP solution development and deployment for MSMEs in the Haryana state of India. | International Journal of Business Innovation and Research (IJBIR) | Inderscience | SCOPUS, ABDC, UGC Approved Journal |
| 4 | Saurav Negi and Neeraj Anand | 2017 | Factors that impact Quality during the Transportation of Tomatoes: Evidence from India | International Journal of Applied Logistics (IJAL) | IGI Global | INSPEC, Cabell's directory, Ulrich's Periodical Directory, UGC Approved Journal |
| 5 | Saurav Negi and Neeraj Anand | 2017 | Post-Harvest Losses and Wastage in Indian Fresh Agro Supply Chain Industry: A Challenge | The IUP Journal of Supply Chain Management | ICFAI University Press | Cabell's directory, EBSCO Host, ProQuest and SSRN. UGC Approved Journal |
| 6 | Saurav Negi and Neeraj Anand | 2015 | Issues and Challenges in the Supply Chain of Fruits & Vegetables Sector in India: A Review | International Journal of Managing Value and Supply Chains | AIRCC Publishing Corporations | EBSCO, ProQuest, Ulrich's Web |
| 7 | Saurav Negi and Neeraj Anand | 2015 | Supply Chain of Fruits & Vegetables' Agribusiness in Uttarakhand (India): Major Issues and Challenges | Journal of Supply Chain Management Systems | Publishing India | EBSCO, Ulrich's Web, Cabell's Directory. UGC Approved Journal. |
| 8 | Saurav Negi and Neeraj Anand | 2015 | Cold Chain: A Weak Link in the Fruits and Vegetables Supply Chain in India | The IUP Journal of Supply Chain Management | ICFAI University Press | Cabell's directory, EBSCO Host, ProQuest and SSRN. UGC Approved Journal |
| 9 | Saurav Negi and Neeraj Anand | 2014 | Supply Chain Efficiency: An Insight from Fruits and Vegetables Sector in India | Journal of Operations and Supply Chain Management | Getulio Vargas Business School (FGV), Brazil | Biblioteca Eletrônica Spell, Cabell's Directory, Diadorim, EBSCO |

## List of Publications-Chapters in Edited Book

| S. No. | Author (s) | Year | Title of the Chapter | Name of the Edited Book | Publisher | ISBN & Indexing |
|---|---|---|---|---|---|---|
| 1 | Saurav Negi and Neeraj Anand | 2017 | Wastage and Cold Chain Infrastructure Relationship: A Study of Food Supply Chain in India. | Supply Chain Management Strategies and Risk Assessment in Retail Environments | IGI Global, USA | ISBN: 9781522530565; SCOPUS |
| 2 | Saurav Negi and Neeraj Anand | 2016 | An Overview of Fruits and Vegetable's Retail Supply Chain Models in India | Handbook of Research on Strategic Supply Chain Management in the Retail Industry | IGI Global, USA | ISBN: 9781466698949; SCOPUS |
| 3 | Saurav Negi and Neeraj Anand | 2016 | Factors Leading to Losses and Wastage in the Supply Chain of Fruits and Vegetables Sector in India | Energy Infrastructure and Transportation: Challenges and Way Forward | UPES, Dehradun | ISBN: 978-194343889-1 |
| 4 | Saurav Negi | 2015 | Food Processing Entrepreneurship for Rural Development: Drivers and Challenges | Sustainability: Ecology, Economy & Ethics | Globethics.net | ISBN- 978-2-88931-069-2 |
| 5 | Saurav Negi and Neeraj Anand | 2014 | Green and Sustainable Supply Chain Management Practices- A Study of Wal-Mart | Emerging Business Sustainability | Research India Publication | ISBN: 978-93-84144-87-6 |
| 6 | Saurav Negi | 2013 | Food Processing Entrepreneurship for Rural Development: Drivers and Challenges | SUSCON- Third International Conference on Sustainability: Ecology, Economy & Ethics | Tata McGraw Hill Education | ISBN-13978-1-25-905869-1 |

## Conference-Paper Presentation/Attended

| S. No. | Year | Conference |
|---|---|---|
| 1 | 2017 | Presented a Paper in Fourth Agro Supply Chain Conference (ASCC) organised by University of Petroleum and Energy Studies, Dehradun in association with HMNEH, Department of Horticulture and Food Processing on 3rd & 4th November 2017 |
| 2 | 2017 | Attended a conclave on "Make in India & FDI in Retail: National & International Avenues for Food Processing Sector" organised by PHD Chamber of Commerce & Industry on 25th March 2017 |
| 3 | 2017 | Presented a Paper in Fifth "International Conference on Management of Infrastructure" (ICMI) organised by University of Petroleum and Energy Studies, Dehradun on 9th- 10th February 2017 |
| 4 | 2016 | Presented a Paper in Third Agro Supply Chain Conference (ASCC) organised by University of Petroleum and Energy Studies, Dehradun in association with HMNEH, Department of Horticulture and Food Processing on 7th & 8th October 2016. |
| 5 | 2016 | Deliver a Talk in National Seminar on "Apple production in a changing climate environment: Challenges & Strategies" organised by Department of Horticulture and Food Processing, Uttarakhand Government on 17-18 September 2016. |
| 6 | 2016 | Presented a Paper in Fourth "International Conference on Management of Infrastructure" (ICMI) organised by University of Petroleum and Energy Studies, Dehradun on 4th- 6th February 2016. |
| 7 | 2015 | Presented a Paper in Second Agro Supply Chain Conference (ASCC) organised by University of Petroleum and Energy Studies, Dehradun in association with NABARD, HMNEH, Department of Animal Husbandry and Uttarakhand Live Stock Development Board on 3rd October 2015. |
| 8 | 2015 | Presented a Paper in Third "International Conference on Management of Infrastructure" (ICMI) organised by University of Petroleum and Energy Studies, Dehradun on 7th- 8th February 2015 |
| 9 | 2014 | Presented a Paper in Agro Supply Chain Conference (ASCC) organised by University of Petroleum and Energy Studies, Dehradun in association with NABARD, SIDBI and HMNEH on 22 August 2014. |
| 10 | 2014 | Presented a Paper in Second "International Conference on Management of Infrastructure" (ICMI) organised by University of Petroleum and Energy Studies, Dehradun on 14 & 15 February 2014 |
| 11 | 2014 | Presented a Paper in MSME Conclave cum- Conference (MSMEC) on "Sustainable Supply Chain Capabilities of Micro, Small and Medium Enterprises: Influences, practices, training needs and employment opportunities" organised by Doon University, Dehradun in collaboration with National Institute of Entrepreneurship and Small Business Development (An Autonomous Institute under Ministry of MSME, GoI) on 10 May 2014. |
| 12 | 2013 | Presented a Paper in "International Conference on Humanitarian Logistics" (ICHL) organised by IIM Raipur and The Logistics Institute –Asia Pacific, Singapore on 2nd- 3rd December 2013 |
| 13 | 2013 | Presented a Paper in Third Annual International Conference on "Sustainability: Ecology, Economy and Ethics" organised by IIM, Shillong on 6-8 March 2013 |
| 14 | 2012 | Presented a Paper in Ninth National Conference on "Supply Chain Management in the emerging Business Environment: Issues, Opportunities and Challenges" organised by GJIMT, Mohali on 22 September 2012 |