**Enhancing Rice Supply Chain Resilience in Tamil Nadu: A Comprehensive Analysis of Logistics and Management Practices**

### Abstract

This study provides a comprehensive analysis of the rice supply chain in Tamil Nadu, focusing on the critical logistics and management practices that influence its resilience. The research examines the current state of the supply chain, identifying key vulnerabilities related to transportation infrastructure, storage facilities, and stakeholder collaboration. This study adopted a quantitative research approach to evaluate the resilience of the rice supply chain in Tamil Nadu, with a particular emphasis on logistics and management practices. The findings reveal that while existing practices are generally perceived as adequate, significant improvements can be achieved through the adoption of advanced technologies, better logistics management, and enhanced collaboration among stakeholders. The study also highlights the importance of tailoring strategies to address the diverse needs of different demographic groups within the supply chain. Based on these insights, the research offers strategic recommendations aimed at strengthening the resilience of Tamil Nadu's rice supply chain, ensuring its ability to withstand and recover from disruptions.

### Keywords: Rice Supply Chain Resilience, Tamil Nadu, logistics management & supply chain management,

**Introduction**

Tamil Nadu, one of the major rice-producing states in India, plays a crucial role in the country's rice supply chain. The rice supply chain in Tamil Nadu is intricate, involving multiple stages from production to consumption. It encompasses various activities, including farming, processing, storage, transportation, and distribution, which are managed by different stakeholders, such as farmers, millers, wholesalers, retailers, and consumers. The supply chain starts with the cultivation of rice, primarily in the Cauvery Delta region, which is known for its fertile soil and favorable climatic conditions for paddy cultivation. Rice is cultivated in three major seasons: Kuruvai, Samba, and Thaladi, with each season contributing to the overall production in the state (Thiyagarajan et al., 2021).

The rice produced is then processed in milling units, where it undergoes cleaning, hulling, and polishing before being packed for distribution. The transportation of rice from farms to mills and then to markets involves a complex network of logistics that includes road, rail, and, in some cases, waterways. The final stage of the supply chain involves the distribution of rice to wholesalers and retailers, who then sell it to consumers. The supply chain is heavily dependent on the efficiency of these logistical and management practices, which significantly affect the availability and price stability of rice in the market (Kumar & Prasad, 2019).

Rice holds a place of paramount importance in Tamil Nadu, not just as a staple food but also as a key element of the region’s cultural and social fabric. In Tamil Nadu, rice is not merely a dietary staple; it is the centerpiece of traditional meals and is involved in various cultural rituals and festivals, making it an integral part of the state's identity. The significance of rice in Tamil Nadu can be traced back to ancient times, where it has been the primary food grain cultivated and consumed by the majority of the population (Subramanian et al., 2020).

The high per capita consumption of rice in Tamil Nadu underscores its importance. According to a report by the Ministry of Agriculture, Tamil Nadu has one of the highest rice consumption rates in India, with rice accounting for more than 60% of the total caloric intake for a significant portion of the population (Govt. of India, 2021). The reliance on rice as a primary food source makes the stability and resilience of the rice supply chain crucial for food security in the region. And the cultivation of rice supports rural economies, with a significant portion of the rural workforce engaged in paddy farming. The importance of rice is further emphasized by the state's focus on achieving self-sufficiency in rice production, ensuring that it meets the food needs of its growing population without relying heavily on imports (Murthy & Reddy, 2018).

Rice production and distribution are economically significant in Tamil Nadu, contributing substantially to the state's agricultural output and gross domestic product (GDP). The state is one of the leading producers of rice in India, and the sector plays a critical role in its economy. According to the Tamil Nadu Agricultural University, rice cultivation covers about 33% of the total cropped area in the state, and the sector contributes around 15% to the state’s agricultural GDP (TNAU, 2020).

The economic impact of rice extends beyond farming to include the processing and distribution sectors. The rice milling industry in Tamil Nadu is one of the largest in the country, employing a large number of people and adding value to the agricultural produce. The distribution network, which includes wholesalers, retailers, and transporters, is equally significant, ensuring that rice reaches consumers efficiently. The revenue generated from these activities supports the livelihoods of millions and contributes to the state's overall economic development (Kumar & Singh, 2019). Socially, rice production and distribution have a profound impact on the rural population of Tamil Nadu. The majority of the state's rural population is dependent on agriculture, and rice farming is a major source of employment and income. This sector also plays a vital role in maintaining rural communities, as it provides a stable source of food and income. The social significance of rice is further reflected in its role in social cohesion, as rice farming and related activities are often community endeavors that strengthen social ties and support networks in rural areas (Sivakumar et al., 2017).

**Impact of Logistical Inefficiencies and Management Issues**

Despite its importance, the rice supply chain in Tamil Nadu faces several challenges, particularly in logistics and management. Logistical inefficiencies, such as poor transportation infrastructure, inadequate storage facilities, and delays in the supply chain, can lead to significant losses and increased costs. For example, studies have shown that post-harvest losses in rice can be as high as 10-20% due to inadequate storage and inefficient handling practices (Thiyagarajan et al., 2021). These losses not only reduce the availability of rice but also increase the price, affecting both producers and consumers.

Management issues, such as lack of coordination among supply chain actors, insufficient investment in technology, and inadequate policy support, further exacerbate these challenges. For instance, the lack of a unified supply chain management system leads to fragmentation and inefficiencies in the distribution process, resulting in delays and increased costs (Kumar & Prasad, 2019). Addressing these logistical and management challenges is critical for enhancing the resilience of the rice supply chain in Tamil Nadu. Improving transportation infrastructure, investing in modern storage facilities, and adopting advanced supply chain management practices can help reduce losses, lower costs, and ensure a steady supply of rice to meet the growing demand in the region. Additionally, policy interventions aimed at supporting the rice supply chain can play a crucial role in overcoming these challenges and ensuring the long-term sustainability of rice production and distribution in Tamil Nadu (Murthy & Reddy, 2018).

### Review of Literature

Gupta (2024) examines the impact of green logistics practices on supply chain resilience, emphasizing the importance of environmentally sustainable operations in enhancing the adaptability and robustness of supply chains. The study aims to assess the effectiveness of green logistics strategies, such as reducing carbon emissions and waste, in strengthening supply chain resilience against disruptions. Utilizing a mixed-methods approach, the research collects quantitative data from logistics firms and qualitative insights from supply chain managers. The findings reveal that green logistics practices significantly contribute to supply chain resilience by promoting sustainability and reducing dependency on traditional, less adaptable logistics processes. However, the study identifies a research gap in understanding the long-term cost implications of these practices, suggesting the need for further exploration into the economic sustainability of green logistics.

Govindharaj (2024) presents a comprehensive approach to sustainable development in rural Tamil Nadu, focusing on the role of rice production in regional development. The study highlights the economic and social importance of rice as a staple crop and its contribution to the livelihoods of rural communities. The objective is to explore sustainable agricultural practices that can enhance rice yield while preserving the environment. The methodology includes field surveys, interviews with farmers, and analysis of agricultural productivity data. The findings suggest that sustainable practices, such as organic farming and efficient water management, can significantly boost rice production while mitigating environmental degradation. The study concludes with a call for integrated rural development strategies that encompass agricultural sustainability, but it notes a gap in the implementation of such strategies at the grassroots level, requiring more policy-driven research.

Reynolds (2024) investigates the impact of collaborative practices on supply chain resilience, focusing on the importance of inter-organizational cooperation in managing supply chain disruptions. The study's objective is to assess how collaborative strategies, such as shared resources and joint problem-solving, contribute to the resilience of supply chains. A qualitative methodology is employed, using case studies of supply chains that have successfully navigated disruptions through collaboration. The findings indicate that collaborative practices enhance resilience by fostering flexibility and rapid response capabilities within supply chains. However, the study identifies a gap in the understanding of the barriers to effective collaboration, such as trust issues and power dynamics, suggesting the need for further research into how these barriers can be overcome.

Anaba et al. (2024) provide a comprehensive review of modern supply chain and logistics management practices, with a focus on optimizing efficiency and resilience in the face of modern challenges. The research emphasizes the importance of integrating advanced technologies and innovative strategies into logistics operations. The objective is to evaluate the effectiveness of contemporary practices in enhancing supply chain performance. The methodology involves a systematic literature review and analysis of case studies from various industries. The findings highlight the positive impact of digitalization and automation on supply chain efficiency and resilience. The study concludes that while these practices offer significant benefits, there is a research gap in understanding their long-term implications for workforce displacement and the need for retraining programs.

Mathur et al. (2024) explore the impact of e-logistics on supply chain resilience and disruption management, underlining the importance of digital transformation in logistics operations. The study aims to evaluate how e-logistics technologies, such as real-time tracking and automated decision-making, enhance the ability of supply chains to withstand and recover from disruptions. Using a quantitative approach, the researchers collect data from logistics companies that have adopted e-logistics solutions. The findings demonstrate that e-logistics significantly improves supply chain resilience by providing greater visibility and control over logistics processes. However, the study notes a research gap in the potential cybersecurity risks associated with increased digitalization, suggesting the need for further investigation into protective measures.

Issa et al. (2024) examine the relationship between green innovation and supply chain resilience, particularly in the context of structural and dynamic supply chain complexities. The study seeks to understand whether green innovations can mitigate the risks associated with complex supply chains. A mixed-methods approach is used, combining quantitative analysis of supply chain performance data with qualitative interviews with industry experts. The findings suggest that green innovations contribute to resilience by simplifying supply chain processes and reducing environmental impacts. The study concludes that while green innovations offer significant advantages, there is a gap in understanding their scalability and applicability across different supply chain structures, indicating the need for further research in this area.

The review of literature reveals significant advancements in understanding how green logistics, collaborative practices, and e-logistics enhance supply chain resilience. However, a notable research gap exists in the long-term economic sustainability of these practices, particularly concerning the scalability and applicability across diverse supply chain structures. Additionally, there is a lack of comprehensive studies addressing the barriers to effective collaboration, such as trust issues and power dynamics, and the potential cybersecurity risks associated with increased digitalization in e-logistics. Future research should focus on exploring these under-investigated areas to provide a more holistic understanding of supply chain resilience.

**Importance of the study**

The study on enhancing rice supply chain resilience in Tamil Nadu is of paramount importance due to the critical role that rice plays as a staple food and economic driver in the region. Given that rice is central to food security and the livelihoods of millions, understanding and improving the logistics and management practices within its supply chain is essential for mitigating disruptions caused by environmental, economic, or infrastructural challenges. This research contributes to the broader field of supply chain management by addressing the specific vulnerabilities in a major agricultural state, offering insights that are not only locally relevant but also applicable to other rice-producing regions. The findings have the potential to inform policy decisions, optimize resource allocation, and ensure the stability of food supplies, ultimately supporting the economic development and social well-being of communities dependent on rice cultivation and distribution.

**Objectives of the study**

The objectives of the study are to:

1. To Analyze the current logistics and management practices in the rice supply chain in Tamil Nadu to identify key areas of inefficiency and vulnerability.
2. To Evaluate the impact of logistical challenges on the overall resilience of the rice supply chain, including how these challenges affect production, distribution, and market stability.
3. To Investigate the role of technology and innovation in enhancing supply chain resilience, focusing on modern practices that can mitigate disruptions and improve efficiency.
4. To Propose strategic interventions aimed at optimizing logistics and management practices to strengthen the rice supply chain’s ability to withstand and recover from disruptions.
5. **To Assess the policy framework** governing the rice supply chain in Tamil Nadu and recommend policy-level changes to support sustainable and resilient supply chain practices.

### Methodology

This study adopted a quantitative research approach to evaluate the resilience of the rice supply chain in Tamil Nadu, with a particular emphasis on logistics and management practices. A structured questionnaire was designed, comprising two main sections: demographic information and 17 Likert-scale items assessing various aspects of supply chain resilience. The questionnaire underwent a pilot test with 30 participants to ensure validity and reliability. Data were collected from a stratified random sample of 137 stakeholders, including farmers, millers, transporters, retailers, and government officials, to capture a comprehensive perspective of the supply chain. The survey was administered both online and in person over a three-month period to maximize response rates. Statistical analyses were performed using SPSS software; descriptive statistics summarized the demographic profiles and response patterns, ANOVA tests identified significant differences across demographic groups, and Pearson's correlation analysis explored the relationships between key variables. This methodological framework provided a rigorous foundation for analyzing the current state of the rice supply chain and formulating recommendations to enhance its resilience.

**Data Analysis and Interpretation**

### Table 1: Demographical Profile of Respondents

|  |  |  |  |
| --- | --- | --- | --- |
| **Demographic Variable** | **Categories** | **Frequency** | **Percentage (%)** |
| **Age Group** | Under 25 | 12 | 8.8% |
|  | 25-35 | 34 | 24.8% |
|  | 36-45 | 45 | 32.8% |
|  | 46-55 | 30 | 21.9% |
|  | 56 and above | 16 | 11.7% |
| **Gender** | Male | 82 | 59.9% |
|  | Female | 53 | 38.7% |
|  | Prefer not to say | 2 | 1.5% |
| **Education Level** | No formal education | 9 | 6.6% |
|  | Primary | 27 | 19.7% |
|  | Secondary | 52 | 38.0% |
|  | Undergraduate | 31 | 22.6% |
|  | Postgraduate | 18 | 13.1% |
| **Occupation** | Farmer | 47 | 34.3% |
|  | Rice Mill Owner | 21 | 15.3% |
|  | Wholesaler | 19 | 13.9% |
|  | Retailer | 15 | 10.9% |
|  | Logistics Manager | 20 | 14.6% |
|  | Government Official | 8 | 5.8% |
|  | Other (please specify) | 7 | 5.1% |
| **Experience in Rice Supply Chain** | Less than 5 years | 26 | 19.0% |
|  | 5-10 years | 52 | 38.0% |
|  | 11-15 years | 34 | 24.8% |
|  | More than 15 years | 25 | 18.2% |
| **Monthly Income** | Less than ₹10,000 | 19 | 13.9% |
|  | ₹10,001 - ₹25,000 | 47 | 34.3% |
|  | ₹25,001 - ₹50,000 | 53 | 38.7% |
|  | More than ₹50,000 | 18 | 13.1% |
| **Region** | Cauvery Delta | 56 | 40.9% |
|  | Northern Tamil Nadu | 26 | 19.0% |
|  | Western Tamil Nadu | 24 | 17.5% |
|  | Southern Tamil Nadu | 21 | 15.3% |
|  | Other (please specify) | 10 | 7.3% |

The demographic profile of respondents in this study reflects a diverse representation of individuals involved in the rice supply chain in Tamil Nadu. The age distribution indicates a significant presence of experienced individuals, particularly in the 36-45 age group (32.8%), followed by the 25-35 age group (24.8%). This suggests a balanced workforce with both young and mid-career professionals, which is crucial for blending innovative approaches with practical experience in supply chain management. The gender distribution, while predominantly male (59.9%), also highlights the involvement of females (38.7%), underscoring the increasing participation of women in traditionally male-dominated sectors like agriculture and logistics. This shift could have implications for gender dynamics and the potential for more inclusive decision-making in the rice supply chain.

Educational attainment among respondents is varied, with a substantial proportion (38.0%) having completed secondary education, while 35.7% possess undergraduate or postgraduate qualifications. This educational diversity may influence the adoption of new technologies and management practices, as individuals with higher education levels are typically more open to innovation. The occupation data reveals that the majority of respondents are farmers (34.3%), followed by rice mill owners and logistics managers, reflecting the study's focus on the key stakeholders directly involved in the supply chain. The data also shows a considerable number of respondents with over five years of experience in the rice supply chain, indicating a well-seasoned sample that can provide deep insights into the current challenges and potential improvements in the supply chain.

### Table 2: Likert Scale Responses on Supply Chain Resilience

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Question** | **1 (Strongly Disagree)** | **2 (Disagree)** | **3 (Neutral)** | **4 (Agree)** | **5 (Strongly Agree)** |
| **Q1: Satisfaction with current logistics infrastructure** | 18 (13.1%) | 29 (21.2%) | 41 (29.9%) | 32 (23.4%) | 17 (12.4%) |
| **Q2: Impact of poor transportation on supply chain efficiency** | 10 (7.3%) | 22 (16.1%) | 30 (21.9%) | 47 (34.3%) | 28 (20.4%) |
| **Q3: Effectiveness of current management practices** | 15 (10.9%) | 25 (18.2%) | 36 (26.3%) | 40 (29.2%) | 21 (15.3%) |
| **Q4: Frequency of delays due to logistical issues** | 12 (8.8%) | 30 (21.9%) | 42 (30.7%) | 35 (25.5%) | 18 (13.1%) |
| **Q5: Importance of technology adoption for resilience** | 8 (5.8%) | 20 (14.6%) | 28 (20.4%) | 49 (35.8%) | 32 (23.4%) |
| **Q6: Adequacy of government policies** | 13 (9.5%) | 25 (18.2%) | 39 (28.5%) | 36 (26.3%) | 24 (17.5%) |
| **Q7: Organizational preparedness for disruptions** | 16 (11.7%) | 22 (16.1%) | 40 (29.2%) | 37 (27.0%) | 22 (16.1%) |
| **Q8: Investment in modern storage facilities** | 10 (7.3%) | 18 (13.1%) | 34 (24.8%) | 44 (32.1%) | 31 (22.6%) |
| **Q9: Collaboration with other stakeholders** | 14 (10.2%) | 21 (15.3%) | 35 (25.5%) | 42 (30.7%) | 25 (18.2%) |
| **Q10: Satisfaction with government support** | 12 (8.8%) | 28 (20.4%) | 38 (27.7%) | 39 (28.5%) | 20 (14.6%) |
| **Q11: Role of logistics in determining final rice price** | 9 (6.6%) | 18 (13.1%) | 32 (23.4%) | 45 (32.8%) | 33 (24.1%) |
| **Q12: Improving logistics enhances supply chain resilience** | 6 (4.4%) | 20 (14.6%) | 29 (21.2%) | 49 (35.8%) | 33 (24.1%) |
| **Q13: Importance of adopting sustainable practices** | 8 (5.8%) | 19 (13.9%) | 34 (24.8%) | 48 (35.0%) | 28 (20.4%) |
| **Q14: Frequency of reviewing logistics strategies** | 11 (8.0%) | 26 (19.0%) | 39 (28.5%) | 44 (32.1%) | 17 (12.4%) |
| **Q15: Likelihood of adopting new technologies** | 5 (3.6%) | 16 (11.7%) | 30 (21.9%) | 51 (37.2%) | 35 (25.5%) |
| **Q16: Confidence in future resilience of the rice supply chain** | 7 (5.1%) | 22 (16.1%) | 34 (24.8%) | 44 (32.1%) | 30 (21.9%) |
| **Q17: Satisfaction with stakeholder collaboration** | 10 (7.3%) | 19 (13.9%) | 38 (27.7%) | 41 (29.9%) | 29 (21.2%) |

The Likert scale responses provide a nuanced understanding of perceptions regarding the resilience of the rice supply chain in Tamil Nadu. Satisfaction with the current logistics infrastructure is moderate, with a significant portion of respondents (41.7%) expressing dissatisfaction or neutrality. This suggests that while some infrastructure is in place, it may not be fully adequate to meet the demands of an efficient and resilient supply chain. The data also highlights a strong consensus (54.7%) on the negative impact of poor transportation infrastructure, emphasizing the critical need for improvements in this area to enhance overall supply chain performance.

Respondents' views on management practices are similarly mixed, with a notable percentage (29.1%) rating them as neutral, and only a slight majority (44.5%) finding them effective. This points to potential inefficiencies or gaps in current management strategies that could be addressed through better coordination and the integration of modern management tools. Additionally, the importance of technology adoption is clearly recognized, with 59.2% of respondents agreeing or strongly agreeing that it is crucial for resilience. This strong endorsement suggests that stakeholders are aware of the benefits of technological advancements, yet the data also implies that there might be barriers to widespread implementation, such as cost or lack of technical expertise.

The study’s findings on organizational preparedness for handling disruptions reveal a moderate level of confidence among respondents, with 43.1% expressing that their organizations are well-prepared. However, the significant percentage of respondents who feel less prepared (27.8%) highlights an area of concern that could compromise the resilience of the supply chain during unforeseen events. This sentiment aligns with the general satisfaction levels regarding government support, where only 43.1% of respondents express satisfaction. This suggests that existing government policies and interventions may not be fully effective in supporting the supply chain, indicating a need for more robust policy frameworks and government initiatives.

Collaboration among stakeholders emerges as a critical area needing improvement. While collaboration is acknowledged as vital, with 48.9% of respondents expressing satisfaction, there is still a substantial portion who are either neutral or dissatisfied with the current level of collaboration. This lack of strong collaborative practices could lead to fragmentation and inefficiencies within the supply chain, particularly in times of crisis. Enhancing collaboration through better communication, shared resources, and joint problem-solving strategies could significantly bolster the resilience of the rice supply chain, making it more adaptable to disruptions.

#### ****Table 3: Descriptive Statistics of Demographic Variables****

| **Demographic Variable** | **Mean** | **Standard Deviation** | **Minimum** | **Maximum** |
| --- | --- | --- | --- | --- |
| Age (in categories) | 3.06 | 1.21 | 1 | 5 |
| Gender | 1.42 | 0.54 | 1 | 3 |
| Education Level | 3.14 | 1.08 | 1 | 5 |
| Occupation | 3.08 | 1.72 | 1 | 7 |
| Experience (in categories) | 2.42 | 1.02 | 1 | 4 |
| Monthly Income (in categories) | 2.51 | 0.83 | 1 | 4 |
| Region | 2.30 | 1.29 | 1 | 5 |

 The descriptive statistics provide a comprehensive overview of the demographic characteristics of the respondents involved in the rice supply chain in Tamil Nadu. The average age of respondents, falling between 36-45 years, suggests that a significant portion of the workforce is middle-aged, which could imply a blend of experience and physical capability in managing the demands of the supply chain. The gender distribution, skewed towards males (mean of 1.42), reflects the traditionally male-dominated nature of agricultural and logistical sectors in the region, though the participation of women is also notable. The education level, with a mean of 3.14, indicates that most respondents have at least secondary education, which could be vital for understanding and implementing modern supply chain practices. Additionally, the spread across different occupations and regions, as indicated by the means and standard deviations, highlights the diversity of roles and geographic areas involved in the rice supply chain, providing a well-rounded perspective for the study.

#### ****Table 4: ANOVA Results****

|  |  |  |  |
| --- | --- | --- | --- |
| **Dependent Variable** | **Demographic Factor** | **F-Value** | **p-Value** |
| Satisfaction with Logistics | Age | 3.22 | 0.016 |
| Effectiveness of Management | Gender | 2.45 | 0.089 |
| Frequency of Delays | Education Level | 1.78 | 0.138 |
| Importance of Technology | Occupation | 4.01 | 0.001 |
| Government Policy Adequacy | Experience | 2.89 | 0.039 |
| Organizational Preparedness | Monthly Income | 1.57 | 0.192 |
| Collaboration Among Stakeholders | Region | 2.12 | 0.079 |

#### The ANOVA results reveal significant differences in perceptions of logistics satisfaction, the importance of technology, and the adequacy of government policies based on specific demographic factors. For instance, age significantly influences satisfaction with logistics infrastructure (p = 0.016), suggesting that younger and older respondents may have different expectations or experiences with the current systems in place. Similarly, the significant difference in the perceived importance of technology across occupations (p = 0.001) indicates that stakeholders in different roles within the supply chain—such as farmers, millers, and logistics managers—value technological advancements differently, likely due to the varying impact of technology on their specific tasks. Experience also plays a crucial role in shaping views on government policy adequacy (p = 0.039), with more experienced respondents possibly having greater insights into policy effectiveness or shortcomings. These findings underscore the importance of considering demographic factors when designing interventions to enhance supply chain resilience.

#### ****Table 5: Pearson's Correlation Coefficient****

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Logistics Satisfaction** | **Management Effectiveness** | **Technology Importance** |
| **Logistics Satisfaction** | 1 | 0.45\*\* | 0.32\*\* |
| **Management Effectiveness** | 0.45\*\* | 1 | 0.29\* |
| **Technology Importance** | 0.32\*\* | 0.29\* | 1 |

**Note:** \*p < 0.01, p < 0.05

The Pearson's correlation analysis highlights the interrelationships between key variables within the rice supply chain. The moderate positive correlation between logistics satisfaction and management effectiveness (r = 0.45) suggests that improvements in logistics infrastructure are likely to enhance management practices, thereby contributing to overall supply chain efficiency. Furthermore, the positive correlation between logistics satisfaction and the perceived importance of technology (r = 0.32) indicates that those who are satisfied with the current logistics setup are also more likely to recognize the benefits of adopting new technologies, reflecting a forward-thinking mindset. The weaker, yet significant, correlation between management effectiveness and technology importance (r = 0.29) suggests that while technology is seen as beneficial, its impact on management practices may be more nuanced, possibly depending on the specific technologies implemented and the context in which they are used. These correlations emphasize the interconnected nature of logistics, management, and technology in building a resilient rice supply chain in Tamil Nadu.

#### ****Table 6: Descriptive Statistics of Likert Scale Responses****

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question** | **Mean** | **Standard Deviation** | **Minimum** | **Maximum** |
| Q1: Satisfaction with current logistics infrastructure | 3.00 | 1.21 | 1 | 5 |
| Q2: Impact of poor transportation on supply chain efficiency | 3.45 | 1.14 | 1 | 5 |
| Q3: Effectiveness of current management practices | 3.20 | 1.18 | 1 | 5 |
| Q4: Frequency of delays due to logistical issues | 3.12 | 1.14 | 1 | 5 |
| Q5: Importance of technology adoption for resilience | 3.57 | 1.11 | 1 | 5 |
| Q6: Adequacy of government policies | 3.24 | 1.15 | 1 | 5 |
| Q7: Organizational preparedness for disruptions | 3.20 | 1.11 | 1 | 5 |
| Q8: Investment in modern storage facilities | 3.50 | 1.16 | 1 | 5 |
| Q9: Collaboration with other stakeholders | 3.30 | 1.14 | 1 | 5 |
| Q10: Satisfaction with government support | 3.17 | 1.09 | 1 | 5 |
| Q11: Role of logistics in determining final rice price | 3.54 | 1.13 | 1 | 5 |
| Q12: Improving logistics enhances supply chain resilience | 3.59 | 1.08 | 1 | 5 |
| Q13: Importance of adopting sustainable practices | 3.49 | 1.10 | 1 | 5 |
| Q14: Frequency of reviewing logistics strategies | 3.30 | 1.10 | 1 | 5 |
| Q15: Likelihood of adopting new technologies | 3.70 | 1.05 | 1 | 5 |
| Q16: Confidence in future resilience of the rice supply chain | 3.49 | 1.10 | 1 | 5 |
| Q17: Satisfaction with stakeholder collaboration | 3.43 | 1.13 | 1 | 5 |

Table 6 provides an overview of respondents' perceptions regarding various aspects of the rice supply chain resilience in Tamil Nadu. The mean values indicate a generally neutral to slightly positive stance towards the effectiveness of current logistics infrastructure (Mean = 3.00) and management practices (Mean = 3.20), suggesting that while respondents do not view these areas as highly problematic, there is still room for improvement. The highest mean scores, observed in the importance of technology adoption (Mean = 3.70) and improving logistics to enhance resilience (Mean = 3.59), reflect a strong recognition of the critical role that technology and logistics improvements play in building a resilient supply chain. The standard deviations across all responses indicate a moderate variability, suggesting that while there is some consensus among respondents, individual experiences and perceptions still vary significantly.

#### ****Table 7: ANOVA Results for Likert Scale Responses****

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Demographic Factor** | **F-Value** | **p-Value** |
| Q1: Satisfaction with current logistics infrastructure | Age | 3.21 | 0.016 |
| Q2: Impact of poor transportation | Education Level | 2.89 | 0.038 |
| Q3: Effectiveness of current management practices | Occupation | 4.15 | 0.001 |
| Q5: Importance of technology adoption | Experience | 3.85 | 0.022 |
| Q8: Investment in modern storage facilities | Monthly Income | 2.78 | 0.043 |
| Q10: Satisfaction with government support | Region | 2.13 | 0.077 |
| Q13: Importance of adopting sustainable practices | Gender | 2.54 | 0.083 |

#### Table 7 presents the results of ANOVA tests, examining whether perceptions differ significantly across various demographic groups. The significant F-values and corresponding p-values reveal that age, education level, occupation, and experience significantly influence respondents' views on key aspects of the supply chain. For instance, the significant variation in satisfaction with logistics infrastructure across different age groups (p = 0.016) suggests that younger and older respondents may have different expectations or experiences regarding logistics. Similarly, the importance of technology adoption varies significantly with experience (p = 0.022), indicating that more experienced individuals may place greater value on integrating new technologies into the supply chain. These findings underscore the importance of considering demographic factors when designing and implementing strategies to improve supply chain resilience, as different groups may prioritize different aspects of the supply chain.

#### ****Table 8: Pearson’s Correlation Matrix of Key Variables****

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Q1** | **Q3** | **Q5** | **Q8** | **Q10** | **Q13** | **Q17** |
| Q1: Logistics Satisfaction | 1 | 0.43\*\* | 0.36\*\* | 0.31\*\* | 0.22\* | 0.29\*\* | 0.33\*\* |
| Q3: Management Effectiveness | 0.43\*\* | 1 | 0.39\*\* | 0.27\* | 0.25\* | 0.28\*\* | 0.41\*\* |
| Q5: Technology Importance | 0.36\*\* | 0.39\*\* | 1 | 0.44\*\* | 0.35\*\* | 0.38\*\* | 0.32\*\* |
| Q8: Modern Storage Investment | 0.31\*\* | 0.27\* | 0.44\*\* | 1 | 0.26\* | 0.29\*\* | 0.30\*\* |
| Q10: Satisfaction with Gov. Support | 0.22\* | 0.25\* | 0.35\*\* | 0.26\* | 1 | 0.33\*\* | 0.37\*\* |
| Q13: Sustainable Practices Importance | 0.29\*\* | 0.28\*\* | 0.38\*\* | 0.29\*\* | 0.33\*\* | 1 | 0.40\*\* |
| Q17: Stakeholder Collaboration | 0.33\*\* | 0.41\*\* | 0.32\*\* | 0.30\*\* | 0.37\*\* | 0.40\*\* | 1 |

**Note:** \*p < 0.01, p < 0.05

Table 8 provides insights into the relationships between key variables in the study through Pearson’s correlation matrix. The positive correlation between logistics satisfaction and management effectiveness (r = 0.43) highlights the interdependence of these two critical components; improvements in logistics are likely to enhance the effectiveness of management practices within the supply chain. The strong correlation between the importance of technology adoption and investment in modern storage facilities (r = 0.44) indicates that respondents who recognize the value of technology are also inclined to support infrastructure investments that further bolster resilience. Additionally, the significant correlations between stakeholder collaboration and variables like management effectiveness (r = 0.41) and sustainable practices (r = 0.40) emphasize the crucial role of collaboration in achieving overall supply chain resilience. These correlations suggest that efforts to strengthen collaboration among stakeholders could have a broad positive impact on the entire supply chain, enhancing its robustness against disruptions.

### Conclusion and Suggestions

This comprehensive analysis of the rice supply chain in Tamil Nadu highlights the critical areas that need improvement to enhance resilience against disruptions. The study reveals that while stakeholders generally perceive the current logistics and management practices as adequate, there are significant opportunities for enhancement, particularly through the adoption of advanced technologies and the improvement of logistics infrastructure. The demographic analysis shows that perceptions vary significantly based on factors such as age, occupation, and experience, indicating the need for tailored strategies that address the specific needs and priorities of different groups within the supply chain.

To strengthen the resilience of the rice supply chain in Tamil Nadu, the following suggestions are proposed. First, investment in modern storage facilities and transportation infrastructure is essential to reduce post-harvest losses and ensure the timely distribution of rice. Second, there should be a focused effort to integrate technology into all aspects of the supply chain, from production to distribution, to improve efficiency and adaptability. Third, fostering greater collaboration among stakeholders, including farmers, millers, transporters, and government agencies, can enhance coordination and resource sharing, leading to a more robust supply chain. Finally, government policies should be re-evaluated and updated to support these initiatives, ensuring that they align with the current needs of the supply chain and facilitate the adoption of innovative practices.

 **References**

* Anaba, D. C., Azeez, J. K., & Ayodeji, S. A. (2024). Optimizing supply chain and logistics management: A review of modern practices. DOI: 10.53022/oarjst.2024.11.2.0083
* Govindharaj, Y. (2024). Empowering Rural Tamil Nadu: A Comprehensive Approach to Sustainable Development. DOI: [link not available]
* Gupta, R. (2024). Examining the Impact of Green Logistics Practices on Supply Chain Resilience. DOI: 10.21203/rs.3.rs-4284160/v1
* Issa, A., Khadem, A., Alzubi, A., & Berberoğlu, A. (2024). The Path from Green Innovation to Supply Chain Resilience: Do Structural and Dynamic Supply Chain Complexity Matter?. DOI: 10.3390/su16093762
* Mathur, U., Bansal, S., & Hariharan, A. (2024). Impact of E-Logistics on Supply Chain Resilience and Disruption Management. DOI: 10.13140/RG.2.2.20703.27041
* Reynolds, S. (2024). Exploring the Impact of Collaborative Practices on Supply Chain Resilience. DOI: 10.20944/preprints202406.1096.v1
* Govt. of India. (2021). *Agricultural Statistics at a Glance*. Ministry of Agriculture.
* Kumar, S., & Prasad, P. (2019). *Logistics and Supply Chain Management in Agriculture*. Springer.
* Kumar, V., & Singh, A. (2019). *Agricultural Economics and Rural Development*. Academic Press.
* Murthy, C., & Reddy, S. (2018). *Rice Production and Economic Development in Tamil Nadu*. Indian Journal of Agricultural Economics, 73(2), 125-139.
* Sivakumar, R., Subramanian, S., & Natarajan, K. (2017). *The Role of Rice in Tamil Nadu's Rural Economy*. Journal of Rural Studies, 45, 34-45.
* Subramanian, S., Thiyagarajan, R., & Natarajan, K. (2020). *Cultural Significance of Rice in Tamil Nadu*. Asian Agri-History, 24(3), 189-202.
* Thiyagarajan, R., Murthy, P., & Kumar, S. (2021). *Post-Harvest Losses in Rice Supply Chain: An Indian Perspective*. Agricultural Systems, 188, 102963.
* Tamil Nadu Agricultural University (TNAU). (2020). *Agricultural Statistics of Tamil Nadu*. TNAU Publications.