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# LOSSES IN FOOD SUPPLY CHAINS AS A RESULT OF FORCE MAJEUR DISRUPTIONS- A CONCEPTUAL FRAMEWORK FOR RESILIENCE AND MITIGATION

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## 1. *Abstract*

*Food losses in supply chains represent a critical global challenge, with force majeure events—such as pandemics, natural disasters, and conflicts - exacerbating these inefficiencies. While extensive literature exists on food loss management and supply chain resilience separately, there is limited integration of the two, leaving a gap in understanding how systemic disruptions specifically drive food losses and what mitigation strategies can effectively address them.*

*This paper develops a conceptual framework to explore the pathways through which force majeure events lead to food losses and to identify mechanisms for building resilience. The objectives of the study are fourfold: (1) to conceptualize the relationship between disruptions and food losses, (2) to identify systemic causes of such losses, (3) to highlight mitigation mechanisms, and (4) to propose research propositions for future empirical testing. Methodologically, this study adopts a conceptual approach by synthesizing insights from the literature on food loss, disaster-induced disruptions, and supply chain resilience. The framework is supported by four propositions linking disruption pathways (e.g., transportation breakdowns, cold storage failures, labor shortages, market inaccessibility) with food loss outcomes, and highlighting the moderating role of resilience strategies such as cold chain infrastructure, supplier diversification, digital monitoring, and contingency planning.*

*The results, presented as theoretical insights, suggest that food losses during force majeure events are systemic outcomes of vulnerability across supply chain nodes rather than isolated inefficiencies. The study contributes to bridging food loss and resilience literature, provides managerial implications for risk reduction, and offers a roadmap for future empirical research.*

## 2. ***Keywords: Sustainability, Food Security, Perishable Goods, Resilient Logistics, Risk Management.***

## 3. Introduction

Any event which cannot be reasonably predicted in advance and may also be unavoidable and which in turn can hinder the successful execution of the obligations as defined in contracts can be defined as a “Force Majeure”. This could include fires, rains, cyclones, floods, pandemics etc. The force major clause if incorporated in a contract always clarifies what happens during a force majeure and the ways in which the contract obligations can be handled or paused.

A serious force majeure event can severely impact a nation’s supply chain to bring the nation to a standstill by disrupting the flow of goods from source to destination. Shutdowns as per instructions from the Government, quarantines or damages caused by cyclonic storms and rains can cause halt of production leading to shortages of essential goods in the market. Production and logistics activities are paralysed due to illness, civil unrest or restrictions imposed by Government for varied reasons. Import and Export activities at Border ports and check posts are other casualties. Natural disasters like Tsunami’s or famine’s can destroy crops, livestock as well as important infrastructure leading to food

shortages, price rises as well as issues in quality of the produce. Since a force majeure can result in a contract disputes over issues of delays and damages it becomes necessary to carefully draft the contract with respect to Force majeure clauses also mentioning the obligations and remedies for all parties concerned.

Hence it goes without saying that robust Force majeure clauses serve as critical supply chain risk management tools for both suppliers as well as customers in the food supply chain which in turn prepares them adequately to face such shocks rising out of force majeure events.

## 4. Conceptual framework

### 4.1 Variables

Independent variable – Force Majeure Disruptions
Dependent Variable – Supply Chain Losses
Mediating variable – Supply Chain Resilience capabilities
Moderating Variable – Mitigation Strategies

### 4.2 Proposed relationships

Force Majeure Disruptions leads to increase in losses.
Resilience capabilities tend to mediate the relationship which has the ability to reduce losses.
Mitigation Strategies moderate the relationships, which in turn strengthen resilience
Combined Resilience –mitigation interaction offers synergistic effects.

### 4.3 Conceptual Model

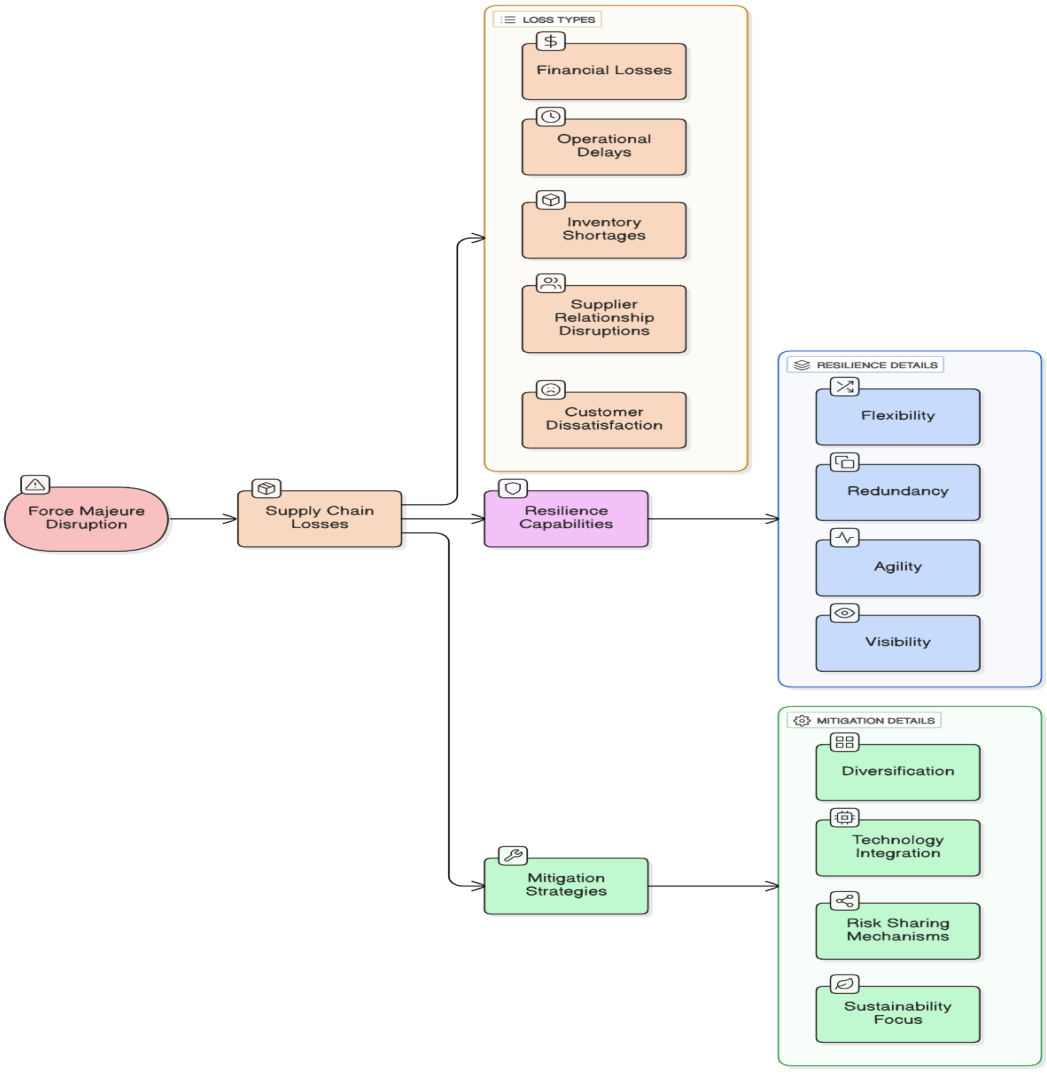


**Fig 1:- Conceptual Model**

## 6. Theoretical foundations

The conceptual framework shown has been sourced from three theories which are related to each other,. They are the the Resource-Based View (RBV), the Dynamic Capabilities Theory**, and** Systems Theory. Each of them gives individual viewpoints on the methods by which food supply chains can tolerate and then recover from *force majeure* disruptions.

The Resource-Based View (RBV) (Barney, 1991; Wernerfelt, 1984) argues that firms achieve sustained competitive advantage through resources which may not be easily replaceable but at the

same time holds tremendous value. These resources enable firms to preserve continuity and reduce losses even under severe disruptions.

The Dynamic Capabilities Theory (Teece, Pisano, & Shuen, 1997) strongly affirms that firms are fully capable of integrating, building, and reconfiguring internal and external competencies to address rapidly changing environments. In this framework, resilience represents a *reactive* dynamic capability—absorbing shocks and restoring operations—while mitigation embodies a *proactive* dynamic capability—anticipating and preparing for disruptions. Together, these capabilities allow supply chain actors to sense, seize, and transform in response to *force majeure* events.

Systems Theory (Bertalanffy, 1968) viewed the food supply chain as an interconnected and interdependent system. Disruptions in one node (e.g., production or logistics) propagate across the entire network, highlighting the need for holistic and coordinated responses. From this perspective, resilience and mitigation are not isolated firm-level attributes but emergent properties of the entire supply chain ecosystem.

The conceptual model extends the above theories by integrating them into a unified framework that links *force majeure* disruptions, resilience, and mitigation to supply chain losses. While RBV explains *what* resources matter, Dynamic Capabilities Theory clarifies *how* they are reconfigured under pressure, and Systems Theory illustrates *where* and *why* interdependencies magnify disruption impacts. By synthesizing these perspectives, the proposed model advances theoretical understanding of how systemic resilience and proactive mitigation jointly enhance supply chain survivability and reduce losses. It also positions digital technologies and collaborative governance mechanisms as modern enablers that extend traditional resource and capability-based explanations of resilience.

**7. Propositions**

P1: Force majeure disruptions are positively associated with food supply chain losses.
P2: Greater supply chain resilience capabilities reduce losses caused by disruptions.
P3: Implementation of mitigation strategies negatively moderates the disruption–loss relationship.
P4: The interaction of resilience and mitigation has a synergistic effect, amplifying disruption resistance.
P5: Digital technologies strengthen both resilience and mitigation outcomes.

**8. Research gaps & future Research directions**

Despite progress in understanding supply chain resilience, research gaps remain regarding food systems' response to force majeure disruptions. These gaps include measurement of losses, causal linkages between disruption types and losses, identification of effective resilience capabilities, interactions between resilience and mitigation, and the role of technology and policy. Future studies should empirically validate the conceptual model through surveys, structural modeling, and comparative case studies across food sectors.

**9. Conclusion**

Future empirical research can operationalize the proposed variables to measure resilience, mitigation, and loss reduction. Cross-sectoral surveys and case studies can validate the hypothesized relationships and reveal context-specific moderators. Grounding theoretical constructs in data will refine this conceptual model into a practical framework for building resilient and adaptive food supply chains.

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