

Exploring Cultural Identity: Perspectives from Social Sciences and Humanities

Resilience and adaptation in food supply chains during disasters: A comprehensive literature review

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Abstract Resilience and adaptation in food supply chains are critical considerations in ensuring food security during times of disaster. This review investigates the challenges and opportunities that arise in the face of natural and man-made disasters by examining their impacts on the stability and functionality of food supply chains. The purpose of our research is to facilitate the development of more sustainable and resilient food supply chains that can navigate through the challenges posed by the COVID-19 pandemic and other potential disasters in the future. By analyzing case studies and empirical data, the review highlights the importance of proactive measures in building a resilient supply chains and adaptability that increases the export volumes to raise national economy wealth in profit motive as well as the implementation of robust contingency plans, the development of adaptive strategies and the integration of technological innovations can boost a food supply chain. Furthermore, it explores the role of stakeholders, policymakers and international organizations in fostering a collaborative framework for mitigating risks and enhancing the capacity of food systems to withstand and recover from adverse events. The findings underscore the need for a comprehensive approach that prioritizes risk management, fosters sustainable practices and promotes inclusive decision-making to ensure the long-term resilience of food supply chains in the face of diverse and evolving challenges.

Keywords: COVID-19, adaptability, Food Supply Chain (FSC), agriculture

1. Introduction

With a growing consumer appetite for a wider variety of meals and the rising interconnection of world economies, the food supply chain (FSC) is becoming more complex and vulnerable to numerous kinds of problems. The structure and functioning of the supply line for food are influenced by variables such as rising populations, warming temperatures, evolving tastes among consumers and volatility in the economy (Anbumozhi et al 2020). As a result, the system is susceptible to interruptions, which can have an effect on food safety, costs and accessibility (Michel et al 2021). Disasters affecting food supply chains, such as floods, outbursts, tropical cyclones and landslides, are examples of unforeseen catastrophes that can significantly influence a region's economy and infrastructure, as well as the well-being of its residents (Orengo Serra and Sanchez-Jauregui 2022, Hecht et al 2019). Earthquakes affect island countries, upsetting the FSC and having a catastrophic impact on the local population (Downs et al 2021). FSC is able to maintain connections during an interruption, facilitating their customers' access to agricultural products and chains of possession (JermsittiparsertK and Kampoomprasert 2019). Resilience is the ability of an organization to bounce back from setbacks and go on with business as usual within an acceptable period of time (Hingley et al 2021, Ibrahim et al 2020). Interruption within an FSC occurs when links in the manufacturing and distribution process fall apart. The supply line is vulnerable to disturbance at any point (Rezaei et al 2020). Disasters caused by unforeseen circumstances have far-reaching effects across the entire FSC (Khan et al 2022, Klibi et al 2021). Recovering FSCs while an explosion in critical facilities occurs as a result of a natural disaster is an uncharted field of study (Hendry et al 2019). The greatest issue of the century is undoubtedly increasing temperatures, which have adverse effects on companies, the environment, and culture (Thangavelu et al 2020). According to scientists studying the effects of warming temperatures, change is occurring more swiftly than previously thought; therefore, urgent action is needed for heat storms, droughts, floods, freezing snaps and cyclones, which are examples of severe storms that are becoming a result of changing climate (Das 2019) (Fahad et al 2023). These types of challenges plague today's worldwide supply chains, yet the costs associated with disruptions brought about by bad weather have increased (Stevenson et al 2020). Regardless of existing regulatory efforts, ecological issues are growing and affecting the productivity of businesses (Ali et al 2021). The political implications of worldwide warming are

contested (AdayS and Aday 2020). Disasters and other events cause interruptions in industrial supply systems (Galanakis et al 2021). Production and logistics for supply chains are among the industries and operations that have been affected by the worldwide spread of COVID-19. Correct reaction strategies have been developed to guide activities in the dietary distribution system during disasters, minimizing the effects of COVID-19 on nourishment employees (Song et al 2021). Sanitation, staff surveillance, assessment, sanitation, hygiene in buildings and other similar measures are part of these crisis reactions (McClements et al 2021). Because of reduced revenue and rising costs, food pantries are struggling to keep up with increasing demand in the marketplace (Kokini et al 2021). Certain companies stopped operating, indicating that many sectors of the global economy are interdependent (Singh et al 2020). Managing the well-being of staff and their accessibility, either from sickness or deliberate absence of the usual contagious cause, are key points of dispute for establishments (Barman et al 2021). It is crucial that food-related businesses take measures to ensure their workers' wellbeing during the crisis at hand. Systems for ensuring an uninterrupted supply chain throughout the dietary supply are important for meeting client requirements through the use of efficient organizational techniques (Davis et al 2021). Although food supply chains managed to handle the extraordinary difficulties brought about by the COVID-19 pandemic, investigators, customers and executives of organizations have considered ways to make agricultural networks more resilient to the causes of unforeseen instability (Tan et al 2021). It is expected that transport systems will return to their original configuration after any accidental, planned or ecological disruption (including destruction, violence, or strikes) (Scholten et al 2020). The capacity to foresee and prepare for these kinds of disturbances appears to be essential to successfulizing these endeavors (Boyaçlı- Gündüz et al 2021). Using electronic devices and reducing value chains are two recommended methods for accomplishing this goal of increasing FSC responsiveness (JouzdaniJ and Govindan 2021). Food is grown and eaten in a uniform way because of the intricate structure of global FSC (HallegatteS et al 2020). However, disasters, catastrophic events, and other unexpected emergencies can disturb this complicated structure (GunesseeS and Subramanian 2020). Cataclysms can have a major effect on the accessibility of fundamental nutritional supplies, possibly resulting in malnutrition and even turmoil (Hameed et al 2020). The globe has experienced logistics interruptions amid major calamities, such as the COVID-19 disaster, severe conditions and international conflict (Nasereldin et al 2020). Resilient and adaptable tracts can withstand and recover from a range of adversities that have been highlighted by such events (Gholami et al 2021). Increasing the capacity of the framework to anticipate, incorporate and recuperate through disruptions and preserving the supply of healthy food to people who require them is necessary to strengthen the resilience of the supply network (Ball et al 2019).

2. Examining resilience and adaptation in FSC during disasters

2.1. Natural disasters that affect FSC

2.1.1. FSC impact due to floods

Tragic events causing rainwater to pour into dry ground and disrupt outputs from agriculture, shipment and accessibility to nourishment are known as flooding, which harms the food manufacturing process. High rains, stream overload, surges of water, reservoir or embankment breaches and an additional occurrence can contribute to flash flooding. The following are the factors of floods that affect the FSC: crop damage, livestock damage and contamination of foods, as well as compromised food storage facilities (Rozenberg et al 2020, Hossain et al 2023).

2.1.2. FSC impact due to droughts

The cost and accessibility of nourishment are impacted by a lack of water during agriculture, slowed agricultural development, decreased production of crops and the demise of whole harvests. All the alimentary chains, including agriculture and manufacturing to shipping, marketplace accessibility and travel, can be affected by drought. This disturbance, especially in areas primarily dependent upon agricultural activity, is an important means for wealth and subsistence that results in rising food costs, food scarcity, hunger and extreme circumstances of starvation (Moradkhani et al 2020).

2.1.3. FSC down cause of earthquakes

A natural disaster is characterized by a rapid, powerful tremor of the ground and is usually generated through the shifting of tectonic plates under the outermost layer of Earth's crust. The supply network for food can be disrupted by these earthquake tremors, which impact the different phases of manufacturing, distribution and consumption (Afsahi et al 2020).

2.2. The implications and requirements of resilience in FSCs

Short FSC (SFSC) explores a kind of FSC where vendors and customers are connected by a handful of middlemen. These are distinguished by close or restricted relationships that concentrate on nearby sectors among vendors and customers. SFSCs work to shorten the FSC path and decrease the number of middlemen while fostering accountability, openness and a preference for derived goods. The ability of an FSC to withstand unforeseen shocks, pressures, or interruptions, which can be caused by difficulties, natural disasters, or shifts in the market, is emphasized when discussing the significance of robustness

in FSC systems. Given their regional and distributed structure, SFSCs are viewed as a way to improve the resiliency of FSCs. This can lead to improved nutritional safety, less reliance on global networks of suppliers and additional resilient adaptation to unanticipated obstacles. It can lessen the ecological effect of extended distances that transport food while fostering regional economic development in communities (Canavari et al 2021, Wicaksono and Illés 2022). Figure 1 depicts the SFSC strategies and resilience capabilities.

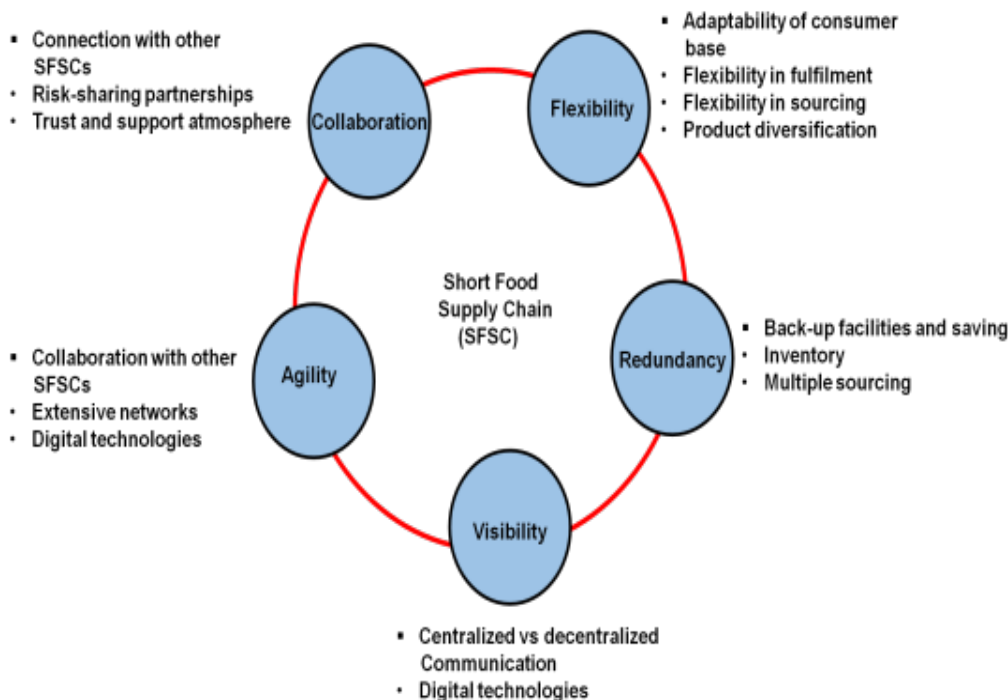


Figure 1 SFSC resilience.

Source:

<https://www.bing.com/images/search?view=detailV2&ccid=a3sRvMOA&id=57B875E8C2364E1645E3CBD5B7B8B0F6BCA87D03&thid=OIP.a3sRvMOAyxLCm8CPoM1pAgHaHE&mediaurl=https%3a%2f%2fwww.researchgate.net%2fpublication%2f351818390%2ffigure%2ffig%2fAS%3a1027352968568832%401621951443254%2fSFSC-resilience-capabilities-and-associated-strategies-own-elaboration.png&exph=811&expw=850&q=1SFSC+resilience+capabilities&simid=607990833690389339&FORM=IRPRST&ck=1F47BC6AB465B14167DAA4682825C743&selectedIndex=0&ajaxhist=0&ajaxserp=0>

2.3. Resilience enhancement and adaptability

2.3.1. Resilience enhancement in FSC

Three main factors, resistance capability, healing ability and time, can be employed to measure resiliency. For instance, improving animal immunity, adhering to established manufacturing standards and examining food-borne shock trends can help to increase resistance. The ability to achieve enhanced recuperation can be achieved through, for instance, allowing redundant manufacturing ability (for example, through the use of labor, ingredients, or systems) or FSC (alternate vendor or transporter) and prompt identification of meal security dangers via the use of sensors to feed continuous tracking and assertive tracking schemes. One can develop adaptability to adapt to unforeseen risks during the hygiene of food. Moreover, enhancing smooth cooperation and communication between FSC subjects accelerates the recovery process in the case of food safety problems (Mu et al 2021).

2.3.2. Adaptability

Accepting the assurance of development and creating an environment suitable for responding to novel situations and goals constitute two traits of adaptable capacities. FSC can recover from disruptions and return to its initial or improved form if it is able to adjust to new circumstances with ease. The main emphasis of FSC resiliency is the framework's adaptability to brief adverse events (Patrucco and Kähkönen 2021, Jermittiparsert and Kampoomprasert 2019).

2.4. COVID-19 impact on FSC

According to the Food and Agricultural Organization, COVID-19 has had a significant impact on the meal and farm industry from two significant perspectives: food supply and hunger. These two characteristics impact food security, which is



under jeopardy (Aday and Aday 2020). Disease outbreaks are caused by their actual detrimental consequences for the financial sector as a whole (Gunessee and Subramanian 2020). With reference to the nutritional inventory system, which may serve as a representation of key economic zones, Figure 2 illustrates the obvious impact of COVID-19 on every step of the process from the farm to the customer. Manufacturing, preparation, motion, and appeal are under significant stress due to recent issues in the field of nutritional stock systems (Das et al 2021). The crisis overcomes the restrictions on employee progress and trading methods, including financial growth inside the meal manufacturing chain. Handling problems with meat has the potential to disconnect the grocery marketplace, creating shortages for consumers and overstocking for suppliers (Deconinck et al 2020). Consumption drops or decreases a few particular items, suggesting a temporary oversupply. During the initial phases of the epidemic, consumers sometimes saw empty shelves in shops due to the sudden increase in demand, which changed the availability of foodstuffs at the exact moment. Moreover, the challenges of FSC during the COVID-19 pandemic include the national lockdown, which has led to a lack of available labor, delays in activity and poor customer behavior (Kumar et al 2021, Avery et al 2020).

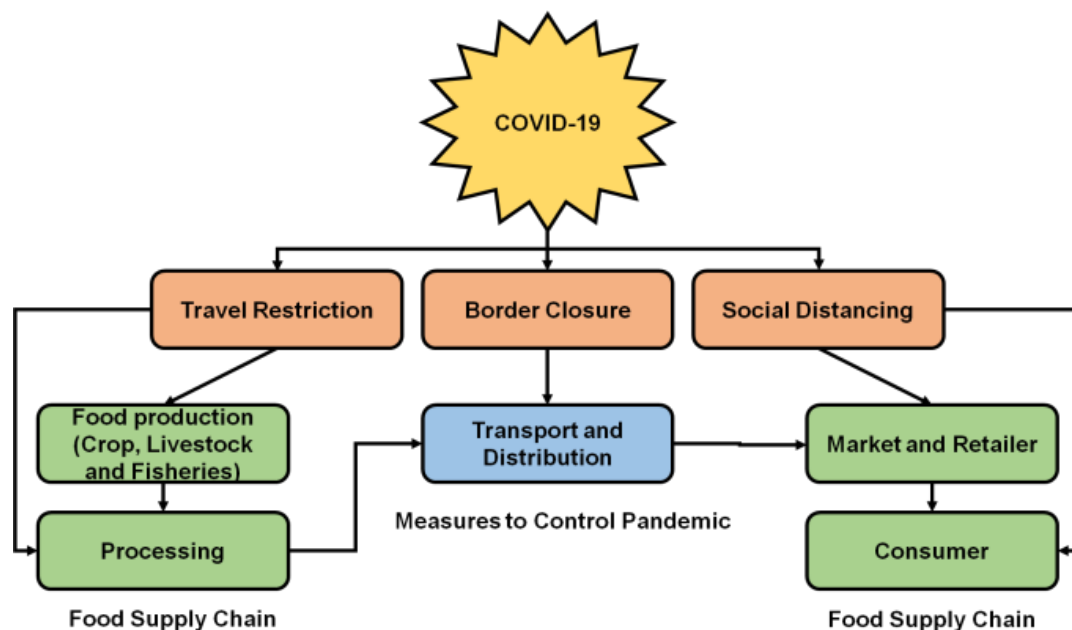


Figure 2 Impact of COVID-19 on every stage of FSC.

2.5. Developing FSC models and forecasting markets

Within the FSC, distribution creation is a planned method of creating and executing a workable structure that guarantees the seamless passage of meals through the point of production to the final customer. This calls for melding a number of different processes, including manufacturing, distribution, the retail sector and substance procurement. The creation of an FSC structure seeks to maximize methods such as the ecological footprint and affordability, as well as performance. It encompasses the application of technology, statistical analysis, or forecasting techniques to enhance decision making, reduce waste and satisfy customer requests. To predict shifts in the popularity of certain food products, this method involves assessing variables such as consumer tastes, eating habits, community statistics and financial circumstances. Landowners, producers, sellers and retailers are a few of the FSC participants who benefit from forecasting markets in regard to making well-informed choices in terms of production rates, inventory control, price schemes and shipment routes. Investors can reduce dangers, improve the distribution of resources and guarantee an ongoing supply of food items to fulfill the needs of customers by forecasting an economic pattern (Jouzani and Govindan 2021).

3. Results and Discussion

The ideas of resiliency and adaptation in food distribution networks during catastrophes have a significant impact due to their focus on the supply chain's ability to withstand, recover and adapt to a range of disruptions, such as storms, diseases, downturns, or unforeseen events. Meal manufacturing, delivery and access are negatively impacted by these changes, which might result in a scarcity of food, market swings and instability.

During the COVID-19 pandemic, all-encompassing approaches are needed to improve FSC resiliency on a national and global scale. India has to continue trying to handle the dangers associated with the worldwide pandemic by boosting its manufacturing capacity, fortifying its logistical capabilities and broadening its trade in goods as planned to preserve food security and the balance of its populace, as shown in Figure 3 and Table 1.



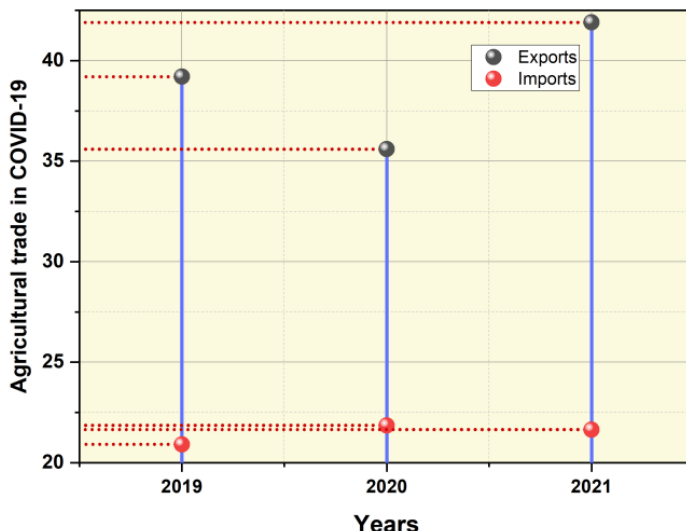


Figure 3 Imports and exports of foods during the COVID-19 pandemic.

Source: <https://i0.wp.com/compass.rauias.com/wp-content/uploads/2023/05/image-121.png>

Table 1 Numerical outcomes of the import and export of foods during the COVID-19 pandemic.

Years	Agricultural trade in COVID-19	
	Exports	Imports
2019	39.2	20.92
2020	35.6	21.86
2021	41.9	21.65

Source: <https://i0.wp.com/compass.rauias.com/wp-content/uploads/2023/05/image-121.png>

The basic products (wheat, maize) and the valuable goods (fruits, veggies and fisheries) form both of the main categories of the food chain of value. The manufacturing of basic commodities is costly in terms of capital, and the lack of workers due to travel bans caused by the COVID-19 pandemic had a greater effect on their output. The COVID-19 pandemic has presented an opportunity to detect and fix obstacles in the movement of nourishment between towns, states, regions and nations, hence impacting every aspect involved in commodity distribution. For the purpose of moving goods, logistics in supply chain elements must undergo extensive testing and receive unique authorization. Port employees must be regarded as vital employees, and good healthcare and security precautions, such as examinations, protective clothing and socially detached exercises, must be prepared. Globally, markets become more stable as a result of these actions. It is the obligation of significant sponsors and international lending agencies to assist in shipping basic products for nations to implement these regulations. The availability of closing stock, production stock and domestic utilization of maize, as well as that of wheat, is illustrated in Figure 4 and Table 2 and is shown in Figure 5 and Table 3.

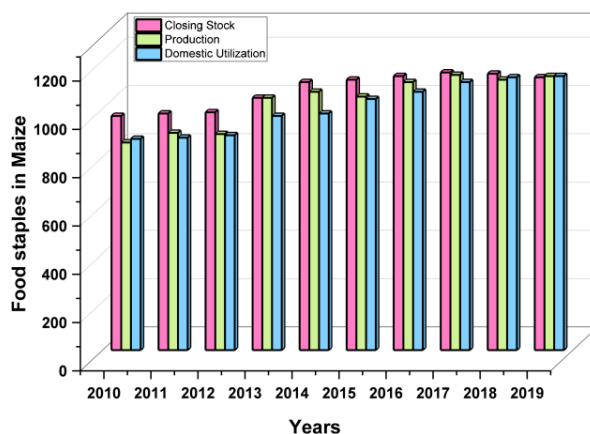


Figure 4 Availability of maize during different disaster durations.

Source: <https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcT9sON5a6XCpr1Tk5Zcw6XYzCAxGiUiJ3J7bIUubX9qQVYUneah>



Table 2 Numerical outcomes of maize consumption during the COVID-19 pandemic.

Years	Food staples in Maize		
	Closing Stock	Production	Domestic Utilization
2010	970	860	875
2011	980	900	880
2012	985	895	890
2013	1045	1045	970
2014	1110	1070	980
2015	1120	1050	1040
2016	1135	1110	1070
2017	1150	1140	1110
2018	1145	1120	1130
2019	1130	1135	1135

Source: <https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcT9sON5a6XCpr1Tk5Zcw6XYzCAxGiUiJ3J7bIUubX9qQVYUeah>

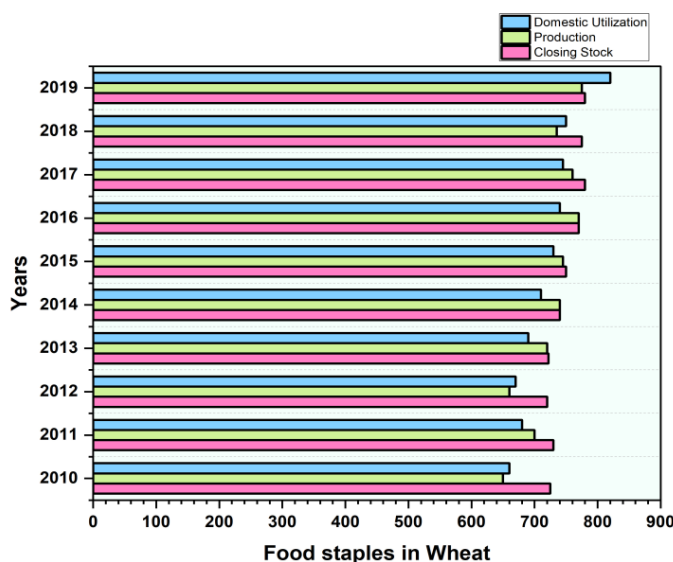


Figure 5 Availability of wheat during different disaster durations.

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Table 3 Numerical outcomes of wheat consumption.

Years	Food staples in Wheat		
	Closing Stock	Production	Domestic Utilization
2010	725	650	660
2011	730	700	680
2012	720	660	670
2013	722	720	690
2014	740	740	710
2015	750	745	730
2016	770	770	740
2017	780	760	745
2018	775	735	750
2019	780	775	820

Source: https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcSxTV0fl_s3CXUzvcqBUNBr8lCtYzs_up3zxnQ9BJTE9rkEulg6



The month after the COVID-19 shutdown, nourishment shipments at wholesalers decreased by a median of sixty-four percent, although the wholesale cost climbed approximately ten percent. Following the closure, a number of India's agricultural markets closed, while the volume of food that came into the markets nevertheless decreased operationally. This resulted in a decrease in volume, which involved two widespread and intense margin modifications. Although pricing resumed its downward trajectory, quantities eventually rebounded upon the start of the shutdown, with dissolved attaining rates comparable to those observed in the year 2019 during the COVID-19 pandemic, as shown in Figure 6.

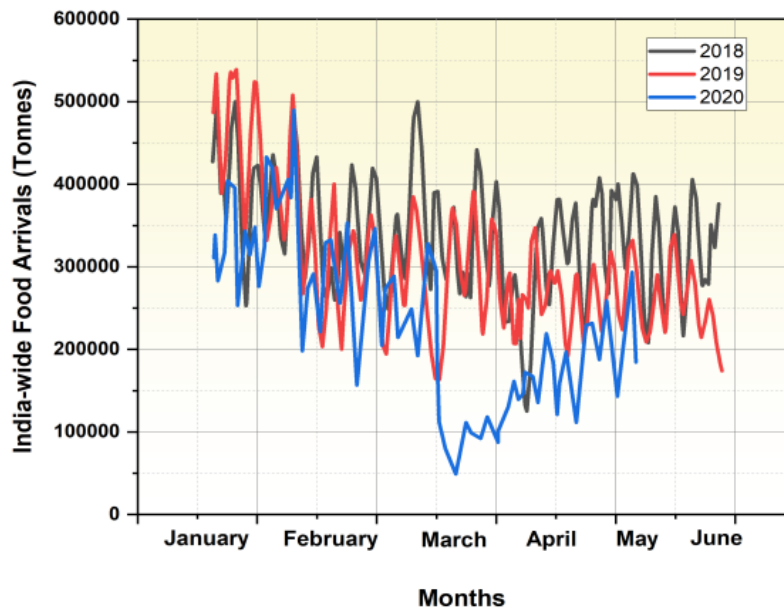


Figure 6 Food volumes across India during the COVID-19 lockdown.

Source: https://pedl.cepr.org/sites/default/files/C19%206661%20Figure%201_0.png

4. Final considerations

For food safety and sustainability to be maintained during catastrophes, FSC systems must be resilient and adaptable. This is true in light of the COVID-19 pandemic. This idea entails recognizing the weaknesses shown in times of crisis and putting adaptation plans in place to guarantee a steady supply of nourishment between farmers and customers. Through the use of strategies such as integrating technologies, source diversity and efficient logistics preparation, the parties involved can reduce interruptions and create a resilient FSC that can survive unanticipated obstacles. The idea highlights the need for all-encompassing, cooperative and welcoming strategies to develop resilience in FSCs, ensuring that they are capable of managing the intricacies of calamities and ensuring that food is available and accessible to everyone.

4.1. Limitations

- It is necessary to commit large sums of money and other assets to the implementation of adaptive and resilience-building strategies. Due to the possible absence of assets, small-scale agriculturalists, manufacturers and wholesalers might be less prone to the effects of catastrophes than larger organizations are.
- The absence of strong services, such as effective mechanisms, warehouses, and railways, can make it difficult for the FSC to operate smoothly and following catastrophes in many areas, particularly in emerging economies. The problems associated with nutrition can be worsened by insufficient facilities, which can contribute to losses after harvesting as well as product waste.
- A food-related production chain's ability to create and execute complete adaptability and resilience measures could be hampered by uneven or insufficient laws as well as policies. The task of creating robust agriculture can be slowed down by imprecise or rigid regulations that impede the implementation of cutting-edge techniques and technology.
- The numerous social and diplomatic elements that impact international agricultural sectors might impede attempts to strengthen the resilience of food distribution networks. Nutritional availability and affordability can be impacted by changing market rates, trade barriers and competitive monopoly status in populations that are more susceptible to catastrophic catastrophes.

4.2. Future scope

- The next phase should place a strong emphasis on agricultural diversity via the planting of a range of agricultural products, the creation of many routes for shipping, or the creation of other sources. By reducing dependence on particular areas or vendors, diversity can lessen the effects of localized calamities and increase resiliency generally.
- Sustainable procedures, such as the use of recyclable packaging, cost-effective delivery and ecologically sound agricultural methods, will be prioritized more in FSCs in coming years. By putting environmentally conscious procedures into place, the ecological impact of FSC can decrease, and its resilience to unfavorable occurrences can increase.
- It is anticipated that governing bodies and world bodies will concentrate on enacting legislation that will fortify the legal system, encourage collaboration across borders and improve risk mitigation techniques. Reliable FSCs will require robust regulations that emphasize catastrophe planning, offer aid to impacted parties and enable effective cooperation among different interested parties.
- More cooperation between all parties involved, governments, suppliers, retailers, manufacturers and consumers is anticipated in the years to come. Working together with the FSC can promote the exchange of data, the sharing of expertise and cooperation to solve these issues. Collaboration across borders and collaboration among the public and private sectors are essential in creating comprehensive strategies to improve the capacity for adaptation in the face of catastrophes.

Ethical Considerations

Not Applicable.

Conflict of Interest

The authors declare no conflict of interest.

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