

GENERAL REVIEW

Agri-food supply chain and disruptions due to COVID-19: effects and strategies

Saurabh Sid¹, Rahul S Mor¹, Anupama Panghal², Dinesh Kumar³, Vijay Kumar Gahlawat⁴

¹Department of Food Engineering, National Institute of Food Technology Entrepreneurship and Management, Kundli, Sonapat, India.

²Department of FBM & ED, National Institute of Food Technology Entrepreneurship and Management, Kundli, Sonapat, India.

³Department of Production & Industrial Engineering, National Institute of Technology, Jamshedpur, India.

⁴Department of Basic & Applied Science, National Institute of Food Technology Entrepreneurship and Management, Kundli, Sonapat, India.

How to cite: Sid, S., Mor, R.S., Panghal, A. et al. (2021), "Agri-food supply chain and disruptions due to COVID-19: effects and strategies", *Brazilian Journal of Operations & Production Management*, Vol. 18, No. 2, e20211148. <https://doi.org/10.14488/BJOPM.2021.031>

ABSTRACT

Goal: The novel coronavirus (COVID-19) pandemic has severely affected the global economies. It has a considerable effect on the agri-food economy and the linking food supply chains. The entire agri-food sector needs more attention because the concept of 'work from home' does not work here, and life cannot move even a single step without food. This paper offers a future agri-food sector perspective amid the COVID-19 pandemic.

Design / Methodology / Approach: This paper explores the short-term and long-term effects of the COVID-19 pandemic on agri-food supply chains (AFSCs) based on the available information. The regulatory mechanisms taken by different government agencies, NGOs, and the food industry to manage the demand & supply disruptions are also discussed.

Results: The detailed effect analysis of the COVID-19 on agri-food supply chains and remedial strategies are conducted for different interfaces of AFSC, viz. production, handling & storage, processing & packaging, distribution & marketing, consumption, etc.

Limitations of the investigation: Given the research area's novelty, it may take enormous time to fully assess the current pandemic (COVID-19) effect on agri-food and its allied sectors.

Practical implications: This paper would help the agri-food industry and the authorities assess the effect of COVID-19 on the agri-food sector.

Originality/Value: This paper significantly contributes to new research directions and views for the AFSC and disruptions due to the COVID-19 pandemic.

Keywords: COVID-19 Pandemic; Agri-Food Sector; Supply Chain Disruption; Food Supply Chain.

1. INTRODUCTION

Given the ongoing COVID-19 pandemic, a global wake-up call has helped India cope up at an early stage, but it necessitates continuing efforts to get back on the right track in almost all sectors. The authorities worldwide have restricted their international and local movements with strict nationwide lockdowns as a precautionary measure to this pandemic (Galanakis, 2020). Most of the nations, including India, are now recording a rising number of COVID-19 infected cases. In response, there is a strict nationwide movement lockout since March 23, 2020, in India to stop the spread of this deadly virus. The restrictions are adversely affecting all aspects of the Indian economy, especially the agri-food economy, which is 96 percent reliant

Financial support: None.

Conflict of interest: The authors have no conflict of interest to declare.

Corresponding author: dr.rahulmor@gmail.com

Received: 13 January 2021.

Approved: 26 March 2021.

Editor: Syed Abdul Rehman Khan.



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

on the private sector. Thus, the linking FSCs are also not immune to this slowdown (Reardon et al., 2020). A significant increase in demand for the commonly shelf-stable food commodities is observed due to a few exemptions in movement and the rumors leading to panic buying and stockpiling behavior of customers and hence, stock-out of these products (Kamble and Mor, 2021; Troskie, 2020). The loss of income to a significant section of Indian society is also favoring this attitude, and as a result, food prices are rising sharply. Government agencies and some NGOs work continuously to compensate for this loss and maintain a regular supply of these prime necessity products. India's government has released INR 1.7 lakh crores to the different states, seeking funds for the poor and migratory workers (Ranjith and Varma, 2020). Indian food economy, which is 85 percent dependent on micro, small, and medium-sized enterprises (MSMEs), the mega relief economic package of INR 20 lakh crore (about 10 percent of Indian GDP) is announced by the honorable prime minister of India dated May 12, 2020. This package supports the related agri-food farmers, laborers, cottage industries, and middle-class people. There is a massive risk for agricultural and food security because 92 percent of the food consumed is purchased from FSCs and is provided to the consumer through the private sector. There need proper FSC planning and management to avoid the food crisis due to COVID-19 (Reardon et al., 2020; Stauffer et al., 2018; Zurayk, 2020; Ivanov and Dolgui, 2020; Carberry and Padhee, 2020).

Thus, this paper unfolds the possible short-term and long-term effects of the COVID-19 pandemic on FSCs concerning a balance among the demand and supply based on data accessible to date. The demand-side assessment takes into action the abrupt shift in food procuring patterns & eating behavior and the public's panic purchasing attitude. The supply-side evaluation drafts the disturbance within and across border transportation, workforce shortage, etc. (Hobbs, 2020; Sharma et al., 2020). The negative aspect of this disaster is more dominant than positive, and possible remedial policies and strategies to achieve effectiveness in FSCs are discussed. The rest of the paper is organized as follows. Section 2 introduces AFSCs; section 3 presents the detailed effect analysis of COVID-19 on AFSCs and remedial strategies for each stage of AFSC. Section 4 concludes the paper's outcome, followed by the limitations and future research directions in the area.

2. AGRI-FOOD SUPPLY CHAINS

AFSC is the complex network of linking distribution channels from *'farm to the fork'*. Managing AFSC includes a structured way of controlling the product flow from the primary manufacturer to the end consumer (Bhatia and Janardhana, 2020; Mor et al., 2018; Khan and Yu, 2019). India finds itself when more brainstorming and restructuring are immediately needed to achieve greater efficiency in the AFSCs for meeting the unexpected rising demands of specific products. Forsido et al. (2020) quantifies five significant stages of the FSC, which need to be managed instantly, i.e., production, processing & packaging, handling & storage, distribution & marketing, and consumption. A dramatic change in the food processing sector is observed during this pandemic, including market modernization, shortened product shelf-life, technical advances, and consumer demand diversification. Companies participating and collaborating under such FSC practices have to deal with several threats that need to be managed aptly. The increasing concern about food nutrients, increased interest in their safe packaging, freshness, and demand for some specific food products, including immunity-boosting products, need more attention throughout the supply chain flow. Coherent measures are also required where markets can play a worthy role, and private capital funding can be stepped-up. Since the FSCs offer a connection between primary producers and end-consumers through mediators, an effective supply chain analysis along with the green practices in their management can resolve this substantial economic loss to FSCs (Yu et al., 2021; Khan et al., 2020). The different stages are elaborated in the following sections.

3. ANALYSIS AND REMEDIAL STRATEGIES

The detailed effect analysis of the COVID-19 on agri-food supply chains and remedial strategies is conducted and mentioned in the following sub-sections.

3.1 Production

The production of raw-produce is the first stage of FSCs, and the largest agri-rural workforce employer in the country appears to be less affected directly, but its indirect effects are worst. Although about 70 percent of the farm laborers are locally available, restricted movements and social distancing have increased the labor shortage at the production stage, leading to crop failure (Larue, 2020). The farmers involved in growing grapes in Pune's western city were forced to help student volunteers harvest their crops. Consequently, a prominent Indian farmer's group has demanded a relief package of INR 1.5 lakh crores for themselves from the concerned government agencies (Toppo, 2020). There seems a risk of COVID-19 eruption in rural areas due to the improper monitoring systems of returning laborers.

Additionally, these workforces will penetrate in casual rural non-farm employment (RN-FE) activities, which engage about 39 percent of rural women and is responsible for 61 percent of Indian rural income (Chand et al., 2017; D'Souza et al., 2020). Since RN-FE is linked directly or indirectly with the agri-food sector, this will also affect the AFSCs. Further, the Indian economy is composed of approx. 80 percent of non-grain food is fed mainly through perishable FSCs. Other indirect effects consist of decreasing demand and export instability of perishable products like milk, fish, chicken, vegetables, etc., due to the change in customers' food purchasing and eating behavior due to limited earnings.

Further, amid this crisis, the farmers are not getting agricultural inputs timely, and hence, they may find difficulties in preparing and conserving quality seeds for the next season. The concern regarding the availability of protective equipment and safety gloves is also hindering livestock animals' productivity. There is a need to circulate different low-cost harvesting technologies throughout the country with other farm machinery banks. Regular energy supply and information regarding farm machinery usage are also required to make the farmers aware of such machinery and technology. It will also help them cope with such situations in the future. A brief of short and long-term impacts, along with likely remedies, is shown in Table 1.

Table 1. Effects and remedial strategies: Production

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
Agri-products handiness and availability	· Imports and circulation	· Promotion of peri-urban Agri and RN-FE activities	· Farm production decline	· Development of local infrastructure
	· Delay in supply	· Safe and efficient distribution of agri-equipment, seeds, fertilizer, and pesticides	· A sharp rise in food commodity prices	· Efficient government policies to purchase and circulate food
	· Lethargic system	· Involvement of the private sector and local people in transportation	· Agri-inputs shortage	· Encouragement of agri-based entrepreneurial activities
		· Focus on agri-inputs import	· Food insecurity	· Incentives to small agribusiness
		· Increase in access points		· Proper saving and judicial investments
		· Provision of subsidy		
Agricultural extension	· Breakdown of extension services, such as	· Digital and remote communication	· Reduced field and farm production	· Development of web/app/GIS-based technology

Table 1. Continued...

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
scheme and activity	training, testing, demonstrating, etc.			
	· Restricted advertisement of advanced technologies	· Engagement of local model farmers for extension services	· Inability to operate machinery	· Upgradation of private extension systems
		· Revision of extension policies		· Strengthening of the disaster prevention department
		· Tax-waiver schemes on Agri machinery		
Workforce movement	· Labor shortage	· The safe and watchful labor movement	· Reduction in productivity of labor-intensive agri-firms	· Focused advertisement for small and handy agri-machineries
	· Risk of COVID-19 eruption due to labor migration	· The mandatory quarantine period for migrant labor	· Shrinking agribusiness and foreign exchange	· Promoting RN-FE activities to employ labor during off-days
	· Decline in exports	· Appropriate prevention measures during farm activities		· Establishment and promotion of contract farming
		· Living quarters establishment for emergencies		
		· Regular payment to labor		
Fuel and energy accessibility and affordability	· Fuel scarcity for Agri machinery	· Provision of fuel reservations at petrol pumps for Agri machinery	· Fuel scarcity for Agri machinery	· Ensuring sustainable energy supply
				· Promoting renewable energy operated farm machinery
Pastoral and daily wage workers movement	· Risk of COVID-19 pandemic outbreak	· Awareness campaigns, restricted movements, food/water facilities		· Provision of local employment
	· A starvation situation may come	· Providing the source of earning	· Stressed environment among public	
		· Government incentives		· Local infrastructure development
Local administration	· Resources diversion	· Proper tasks allotment to various stakeholders	· Fewer resources for agri-food businesses	· Budget allotment and engagement of govt. bodies

Table 1. Continued...

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
Service/support sector	· Coordination failure among different stakeholders	· Effective decision-making and communication systems at different levels	· Reduction in raw-produce	· Facilitating agricultural activities
				· Effective decision-making and communication systems
	· Budgeting for agri-food production	· Promotion of rural financing and planning of NGOs/Coop. activities	· Lack of fronts for raw-produce, bankrupting of financing bodies	· Focus on agri-food oriented banks/insurance agencies
	· Restricted movements of NGOs/Coop. societies	· Effective virtual communication	· Overburden and shrinkage of NGOs and Coop. societies	· Resource mobilization for NGOs and Coop. agencies
	· Issues with collaborative work approach of agri-food agencies & farmers	· Awareness among farmers, local administration, and collaborating bodies	· Lack of coordination	· Proper coordination among farmers and Agri agencies and
Wildlife incorporation	· Inapt wildlife control in the field	· Coordinated effort along with apt prevention measures	· Loss of crop a field	· Arrangements like wire and electric fencing
		· Usage of natural/homemade repellents	· Food insecurity	
Research and development activity	· Disrupted R&D activity	· Finding an alternative way to complete ongoing R&D activities	· Delay in technology development	· Promoting agri-food based research and technology development activities
	· Improper resource utilization and budget diversion	· Development of rapid response programs		

3.2 Handling and Storage

The research studies depict that the handling and storage share a significant portion as postharvest losses among the one-third of food wastage in FSCs globally (Food and Agriculture Organization, 2019; Yahia et al., 2019). The movement restrictions have further hampered the whole handling and storage operations, leading to the wastage of perishable foods. A massive loss of vegetables is now coming to notice, such as the harvested bell pepper and cucumbers are left to get rotten in Haryana. Further, Asia’s largest onion trade business in Maharashtra also found it challenging to handle the harvested onion in the absence of transportation across the country. Tons of vegetables and fruits are decaying in Delhi’s *Azadpur Mandi*, the country’s largest agri-food market (Abhishek et al., 2020). The losses in horticulture and floriculture for order cancellation also lead to an economic imbalance. Even a significant loss for low-perishable grains is observed in the absence of circulation and inappropriate storage

techniques. The food grains in warehouses are getting waste due to fungi development, damage by insects and pests, and food made available for eating/purchasing as happened in France and UK (Phillipson et al., 2020). Further, a needs to introduce low-cost techniques like evaporative coolers and crates in the system and hermetic bags for proper storage along with proper follow-ups of first-in, first-out rules (FIFO). And one should focus on solar operated cold storage throughout the nation to avoid such types of problems in the future (World Health Organization, 2020; UN News 2020; Belhadi et al., 2020). A brief tabulated form of the impacts and remedial actions on handling and storing AFSCs is enlisted in Table 2.

Table 2. Effects and remedial strategies: Handling and Storage

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
Inefficient storage technology loss	· Inappropriate storage infra	· Promotion of public-private partnerships for food storage infra	· Grain wastage due to inappropriate storage	· Promoting the Ethylene management of perishable foods
	· Lack of cold storage technology in remote areas	· The building of temporary warehouses	· Lack of cold storage technology in remote areas	· The building of community/large warehouse
	· High loss of perishable products	· Promoting low-cost handling & storage equipment	· High loss of perishable products	· Agri-food processing industries, institutes, etc. should come forward to setup postharvest storage and handling technology
Stockpiling issue	· Deterioration in food quality	· Promotion of solar operated cold storage technology and plants	· Deterioration in food quality	· Promoting private investments
		· Ensuring handiness and timely availability of food products		· High costly products
Losses due to workforce shortage	· Hampered harvesting · Handling issues	· Maintaining a quarantine period for migrant labor · Following appropriate prevention measures during farm activities	· Barriers to the seasonal labor movement	· Ensuring the safe and watchful movement during packing and storage of food products

Table 2. Continued...

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
		<ul style="list-style-type: none"> · Plan for emergency-living quarters 		
Transport restriction losses	<ul style="list-style-type: none"> · Most prominent effect on perishable agri-food products 	<ul style="list-style-type: none"> · Promoting food processing activities to avoid wastages 	<ul style="list-style-type: none"> · Most prominent effect on perishable Agri products 	<ul style="list-style-type: none"> · Promoting food processing activities to avoid wastages
Order cancellation loss	<ul style="list-style-type: none"> · Reduced customer demand leads to shuffling of handling and storage systems · Workers lay off 	<ul style="list-style-type: none"> · Local consumption of perishable food · Promoting locally available food products · Payment to workers for running their livelihood 	<ul style="list-style-type: none"> · Unemployment, and · Social, economic, political, psychological imbalance in society 	<ul style="list-style-type: none"> · A safe movement to the market should be promoted. · Promoting the entrepreneurial activities at a small scale and policymaking
Food safety	<ul style="list-style-type: none"> · Prominent concern about food safety for non-vegetarian products · Issues with the cross-contamination of fruits and vegetables 	<ul style="list-style-type: none"> · Need to strengthen food safety standards · Promotion of hygiene and safety while handling foods · Awareness campaigns for customers by the agri-food sector and govt. agencies 	<ul style="list-style-type: none"> · Prominent concern about food safety for non-vegetarian products · Issues with the cross-contamination of fruits and vegetables 	<ul style="list-style-type: none"> · Rigorous research on food safety is needed for managing wet market and non-vegetarian food products · Awareness campaigns for customers by the agri-food sector and govt. agencies

3.3 Processing and Packaging

Food processing and packaging, the vital linkages between two pillars of a nation's economy (agriculture and industry), are experiencing both positive and negative impacts due to COVID-19. The demand for shelf-stable food products such as instant noodles, flour, edible oils, cookies, snacks, etc., has gone up exponentially because of these products' hoarding for survival during the crisis. Given limited relaxations to processed food manufacturers, the MNCs like ITC, Britannia, Parle, Nestle, and PepsiCo serves as a means of livelihood for about 1.3 billion people. However, in the coming future, all agri-food processing industries might get virtually stopped due to a deficiency of raw materials, packaging resources, and mobilized labor (Forsido et al., 2020). There is a need to remove the hurdle of different stages of FSCs and take advantage of this opportunity for uplifting the production and circulation of shelf-stable food products. This will further balance the food insecurity, economic crisis, and employment opportunities. However, some other allied sectors in food processing, including

midstream MSMEs, are still under threat and are more susceptible to labor shortages. Disruption in the workforce availability and risk of viral infection has also disturbed the whole downstream dairy processing and circulation networks. The egg, fish, meat, and chicken processing sector is under massive loss due to the claim of the zoonotic nature of COVID-19. Approximately a loss of INR 22.5 million is observed because of rumors regarding the poultry and meat industries. An INR 100 per bird was released through an official memorandum to support such farmers (Food and Agriculture Organization, 2020). Some other influences on processing and packaging are enlisted in Table 3.

Table 3. Effects and remedial strategies: Processing and Packaging

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
Shelf-stable products	<ul style="list-style-type: none"> · The major positive impact of COVID-19 is the increased demand for shelf-stable products 	<ul style="list-style-type: none"> · Increased production capacity and strengthening the supply chains along with utmost safety is of primary importance for shelf-stable products currently 	<ul style="list-style-type: none"> · Given the high demand, there may be a lack of raw produce and packaging material 	<ul style="list-style-type: none"> · Food safety training of workers
		<ul style="list-style-type: none"> · Establishing SMEs in different parts of the country to ensure a regular supply of raw produce 		
Dairy industry	<ul style="list-style-type: none"> · Decreased demand for milk byproducts 	<ul style="list-style-type: none"> · Promotion of dairy processing, especially raw-milk products 	<ul style="list-style-type: none"> · Lack of demand will affect the farmers indulged in raw-milk production 	<ul style="list-style-type: none"> · Processing of surplus milk into other products having longer shelf-life
	<ul style="list-style-type: none"> · Trust issues with perishable dairy byproducts due to infection fear 	<ul style="list-style-type: none"> · Rumors should be avoided 	<ul style="list-style-type: none"> · Price hike issues due to reduced production 	<ul style="list-style-type: none"> · Promoting safe storage and distribution systems
	<ul style="list-style-type: none"> · Restricted sale of milk despite increased demand for raw milk 	<ul style="list-style-type: none"> · Increased consumption of dairy byproducts 	<ul style="list-style-type: none"> · Increase concern about food and nutrition insecurity 	<ul style="list-style-type: none"> · Promoting the rebait and subsidy schemes
	<ul style="list-style-type: none"> · Restriction of milk processing up to the semi-processed products 			<ul style="list-style-type: none"> · Diversification of food products
	<ul style="list-style-type: none"> · Problems linked with product storage and distribution 			<ul style="list-style-type: none"> · Strict guidelines from the competent authority for dairy products
Meat and Fish processing industry	<ul style="list-style-type: none"> · Low demand due to infection fear 	<ul style="list-style-type: none"> · Allied businesses should opt for safe supply and processing practices 	<ul style="list-style-type: none"> · The collapsing of allied businesses viz. fish, poultry, meat, etc. 	<ul style="list-style-type: none"> · Promotion of food processing to make it available through years and safe for consumption.
	<ul style="list-style-type: none"> · Vanishing of non-vegetarian products from the market 	<ul style="list-style-type: none"> · Search for additional options like food processing 	<ul style="list-style-type: none"> · Unemployment 	<ul style="list-style-type: none"> · Need for market diversification and govt. incentive schemes
	<ul style="list-style-type: none"> · Reduction in supply to hotels, restaurants, small shops, etc. 	<ul style="list-style-type: none"> · Focus on the safe delivery of processed products 	<ul style="list-style-type: none"> · Increased social and economic pressure 	

3.4 Distribution and Marketing

Distribution and marketing, agents to align the demand & supply, will be a hard hit due to many ups and downs in AFSCs, and several players in AFSCs have withdrawn from the food trade as a result of the pressure on logistics services. This kind of disturbance in the downstream MSMEs leads to a shortage of food, increased demand and price, and increased unemployment (Farias and Gomes, 2020; Singh et al., 2021). Usually, the supplier plans for an anticipated rise in customer demand on special occasions, but, unfortunately, the rapid and unpredictable increase in demand across critical categories have produced short-run outflows for the whole food distribution network designed for just-in-time development and delivery systems (Mussell et al., 2020). On the other hand, concerning the supply-side, there comes a hurdle in the food supply and trade slowdown. The producers of coffee are unable to sell it in the state of Karnataka, India's largest coffee-producing province, owing to the blockade in the supply chain, and tons of processed coffee worth USD 52 million is stacked up in warehouses. Hence, there is a need to find more efficient distribution options for small FSCs so that farmers can deliver their food quickly (Todorovic et al., 2018). However, a few such innovations are already in practice, such as Kerala's state is using mobile vegetable trucks to provide doorstep delivery of fruits and vegetables. But, this is a temporary base solution for short-run problems. Some other issues with probable remedies regarding distribution and marketing in FSCs are mentioned in Table 4.

Table 4. Effects and remedial strategies: Distribution and Marketing

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
Demand-side aspects	· Increased food prices	· Restriction on hoarding	· Accessibility of food to needy people	· Restriction on hoarding
		· Creating awareness regarding the availability of sufficient stock	· Food insecurity	· Proper sanitation at each level of AFSCs
		· Monitoring the price		· Apt distribution of food items
	· Recession in the restaurant and café businesses	· Rebate/exemption in taxes	· Recession in the restaurant and café businesses	· Rebate/exemption in taxes
		· Promoting online delivery systems		· Promoting online delivery systems
	· Income loss and increased unemployment	· Strategies to get people engaged in other roles like food distribution	· Income loss and increased unemployment	· Focus on more food production
	· Shortage of food leading to the crisis	· Search for alternate market		· Promoting the SMEs
	· Lack of export · Foreign currency loss	· Focus on import and export policies	· Lack of export · Foreign currency loss	· Integration of the private sector
				· Trade and market diversification
	· Reduced demand for specific food items	· Need for creating awareness	· Reduced demand for specific food items	· Need for creating awareness
	· Can also be focused on export	· Can also be focused on export		

Table 4. Continued...

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
Supply-side aspects	· Trade slows down due to restricted movement	· Expansion of market to remote areas	· Food shortage.	· NGOs and cooperatives can play a crucial role.
	· Problems associated with the supply of agri-food products due to import issues	· Collaboration among different government bodies and R&D centers · Redesigning of import/export policies	· Problems associated with the supply of agri-food products due to import issues · Food shortage	· Focus on the import of essential commodities · Redesigning the import/export policies
	· Shortage of food in urban areas due to movement restrictions	· Strengthening the already working agencies and cooperatives	· Risk of increasing infection leads to food shortage	· Ensuring safe and continuous movement for public
	· Psychological problems	· Focusing on employment		· Redesigning the marketing and food distribution systems · Specialized food transporters
	· Reduced supply of food and adulteration leading to food price hiking	· Designing the policies for food storage and distribution · Regular checks on adulterations	· Accessibility of food to needy people · Food insecurity	· Efficient distribution of food items · maintaining sanitation at each level through the supply chains
	· Reduced supply of specific food items	· Awareness campaigns · Focus on stable transportation	· Reduced supply of particular food items	· Awareness campaigns · Focus on stable transportation

3.5 Consumption

India's AFSCs concerning procured food market and consumption are enormous, and the urban people consume approximately 60 percent of India's food. All food eaten in these areas is purchased because nearly all the urban residents are net food buyers. However, out of the rest 40 percent of food, about 80 percent is purchased (Reardon et al., 2020). This much large share of purchased food, in overall food intake, decreases day by day due to the declining earning and food consumption patterns. About 85 and 53 percent of the workforce do not have paid jobs in rural and urban areas, respectively, and 46 percent of the salaried job staff do not get any paid leave. Over 70 percent of employees work without legal agreements. Overall, nearly 90 percent of all families in India would encounter a significant drop in income in the coming months (Abhishek et al., 2020). As a result, the restaurants are getting closed, and food & nutritional insecurity is increasing day by day. Further, a shift in purchasing and consumption patterns from local markets to supermarkets is now a rising question for society. Short FSCs and local produce may be a possible solution to these questions (Cappelli and Cini, 2020; Mayurnikova et al., 2020). Additionally, the call for green agriculture products should be encouraged. It further helps in developing the green agricultural product supply chain which strengthens the relation between agricultural product suppliers and urban residents (Yu and Khan, 2021). However, worth noting point for such pandemic situations, poor people are getting rice, pulses, cooking gas, etc., free for a minimum of three months under *Pradhan Mantri Garib Kalyan Yojana (PMGKY, India)*. Amid COVID-19, the defense food research laboratory (DFRL) is working around the clock for feeding nutritious meals, particularly to healthcare professionals across India. The Karnataka government is effectively providing 1 million meals to the starving poor people in Bengaluru with the aid of a food delivery app developed by young engineers. Private firms such as SRK and Wipro have funded about 60,000 servings per day in the government canteens to feed the needy (Food and Agriculture Organization, 2020), and there are numerous other examples in this line. There requires concise attention regarding the impacts and policies for getting out of this pandemic's unwanted situation, as mentioned in Table 5.

Table 5. Effects and remedial strategies: Consumption

Factors	Short-term impact	Remedial strategies	Long-term impact	Remedial strategies
Closed restaurants	<ul style="list-style-type: none"> · Food availability issues 	<ul style="list-style-type: none"> · Ensuring food safety throughout AFSC · Regular monitoring of workers 	<ul style="list-style-type: none"> · Permanent closure of many restaurants 	<ul style="list-style-type: none"> · Support from government agencies · Searching for alternate options
Food consumption pattern	<ul style="list-style-type: none"> · A remarkable shift in food consumption patterns 	<ul style="list-style-type: none"> · Food businesses should try to capture the new pattern 	<ul style="list-style-type: none"> · A significant shift in food consumption patterns 	<ul style="list-style-type: none"> · Focus on new & customized food products · Food businesses should try to capture the new pattern
Food and nutrition insecurity	<ul style="list-style-type: none"> · Extensive effect on weaker sections of the community 	<ul style="list-style-type: none"> · Creation of emergency shelter · Need for resources mobilization 	<ul style="list-style-type: none"> · Extensive effect on weaker sections of the community · The enhanced dependency of the public to seek support from govt. bodies 	<ul style="list-style-type: none"> · Creating employment opportunities · Strengthening small scale businesses, particularly in agri-food processing
Effect on the customer	<ul style="list-style-type: none"> · Income-loss leading to the reduced purchasing power of public 	<ul style="list-style-type: none"> · Cash flow for the smooth functioning of agri-food markets · Safe and continuous delivery of food products throughout AFSCs 	<ul style="list-style-type: none"> · Income-loss leading to the reduced purchasing power of public 	<ul style="list-style-type: none"> · Cash flow for the smooth functioning of agri-food markets · Safe and continuous delivery of food products throughout AFSCs Creating employment options
Increase in price	<ul style="list-style-type: none"> · Price hicks due to restricting movements and storage issues 	<ul style="list-style-type: none"> · Disturbance in AFSCs needs effective management · Proper monitoring of the wholesale and retail market · Strengthening the doorstep delivery systems 	<ul style="list-style-type: none"> · Scarcity of food due to lagging systems 	<ul style="list-style-type: none"> · Disturbance in AFSCs needs effective management · Promotion and funding to local agri-food processing units
Psychological effect	<ul style="list-style-type: none"> · Reduced consumption of high-value food products · Risk of consumers and producers · Lack of inspiration · Fear of quarantine 	<ul style="list-style-type: none"> · Motivating the producers and farmers · Awareness campaigns 	<ul style="list-style-type: none"> · Reduced consumption of high-value foods · Risk of consumers and producers 	<ul style="list-style-type: none"> · Eradicating confusion about the virus and brake on rumors · The public mind-set need to shift to other issues

4. CONCLUSIONS

The AFSCs and the private sector's fusion has set India as one of the fastest rising agri-food economies globally. Given the aforesaid features of Indian FSCs and the nationwide

lockdown, it is concluded that the COVID-19 pandemic has its long-term effects on the Indian agri-food sector. This paper addresses the demand and supply side of Indian AFSCs and probable short-term and long-term impacts and remedial strategies. The government authorities and NGOs are trying hard to handle this uninvited guest and getting AFSCs back again on the right track. Despite the current pandemic, studies suggest that there will be no acute food deficit in the market for the coming few months. However, there may come a stage of the recession just after this disaster due to disturbances in different farmer end activities, industrial processing, and the linking AFSCs. Therefore, the entire agri-food sector needs unprecedented strategies and policies because the concept of 'work from home' is not applicable here, and life cannot move even a single step without food.

4.1 Limitations and future scope

The paper offers a perspective of the future AFSCs, viewing the current scenario and information available to date. Although this is a novel area, it may take enormous time to fully assess the current pandemic (COVID-19) effect on agri-food and its allied sectors. Numerous technological innovations will likely occur in the coming years. Future research, innovations, policies, machinery, etc., would help farmers better cope with such pandemic and offer an efficient AFSCs while also making the agri-food sector more productive and more attractive for the coming generations. Thus, there seems to be an infinite scope of research associated with the agri-food sector and making this a business of interest and full of profit through technological innovations.

ACKNOWLEDGEMENTS

The authors are thankful to the National Institute of Food Technology Entrepreneurship and Management, Kundli, Sonapat (Haryana), India, for providing the infrastructural and other supports to conduct this research work smoothly.

REFERENCES

- Abhishek, Bhamoriya, V., Gupta, P. et al. (2020), "India's Food System in the Time of Covid-19", *Economic and Political Weekly*, Vol. 15, pp. 12-4.
- Belhadi, A., Kamble, S.S., Khan, S.A.R. et al. (2020), "Infectious Waste Management Strategy during COVID-19 Pandemic in Africa: an Integrated Decision-Making Framework for Selecting Sustainable Technologies", *Environmental Management*, Vol. 66, No. 6, pp. 1085-104.
- Bhatia, M. and Janardhana, G.M. (2020), "Agriculture supply chain management - an operational perspective", *Brazilian Journal of Operations & Production Management*, Vol. 17, No. 4, pp. e2020978. <http://dx.doi.org/10.14488/BJOPM.2020.043>.
- Cappelli, A. and Cini, E. (2020), "Will the COVID-19 pandemic make us reconsider the relevance of short food supply chains and local productions", *Trends in Food Science & Technology*, Vol. 99, pp. 566-7.
- Carberry, A. and Padhee, A.K. (2020), "Containing COVID-19 impacts on Indian agriculture, available at: <https://www.icrisat.org/containing-covid19-impacts-on-indian-agriculture/> (accessed 12 May 2020).
- Chand, R., Srivastava, S.K. and Singh, J. (2017), "Changes in rural economy of India, 1971 to 2012 lessons for job-led growth", *Economic and Political Weekly*, Vol. 52, pp. 64-71.
- D'Souza, A., Mishra, A.K. and Hirsch, S. (2020), "Enhancing food security through diet quality: the role of non-farm work in rural India", *Agricultural Economics (United Kingdom)*, Vol. 51, No. 1, pp. 95-110.
- Farias, D.P. and Gomes, M.G.S. (2020), "COVID-19 outbreak: What should be done to avoid food shortages?", *Trends in Food Science & Technology*, Vol. 102, pp. 291-2. <http://dx.doi.org/10.1016/j.tifs.2020.06.007>.
- Food and Agriculture Organization (2019), "Food loss and food waste", available at: <http://www.fao.org/food-loss-and-food-waste/en> (accessed 8 May 2020).
- Food and Agriculture Organization (2020), "Local food systems and COVID-19: a glimpse on India's responses", available at: <http://www.fao.org/in-action/food-for-cities-programme/news/detail/en/c/1272232> (accessed 12 May 2020).

- Forsido, S.F., Mitiku, F., Lemessa, F. et al. (2020). Covid-19 probable impacts on Ethiopian agriculture and potential mitigation and adaptation measures: no food-no health-no life. *Jimma, Ethiopia*, 1–79. available at: https://www.ju.edu.et/sites/default/files/Covid19%20impact%20on%20Eth%20Agri%20and%20mitigation%2023.04.20_final.pdf (accessed 5 May 2020).
- Galanakis, C.M. (2020), "The Food Systems in the Era of the Coronavirus (COVID-19) Pandemic Crisis", *Foods*, Vol. 9, No. 523, pp. 1-10.
- Hobbs, J.E. (2020), "Food supply chains during the COVID-19 pandemic", *Canadian Journal of Agricultural Economics*. <http://dx.doi.org/10.1111/cjag.12237>.
- Ivanov, D. and Dolgui, A. (2020), "Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak", *International Journal of Production Research*, Vol. 58, No. 10, pp. 2904-15.
- Kamble, S.S. and Mor, R.S. (2021), "Food supply chains and COVID-19: a way forward", *Agronomy Journal*, pp. 1-3. <http://dx.doi.org/10.1002/agj2.20515>.
- Khan, S.A.R. and Yu, Z. (2019), *Strategic Supply Chain Management* (pp. 1-290), Springer Nature Switzerland AG.
- Khan, S.A.R., Yu, Z., Golpīra, H. et al. (2020), "A state-of-the-art review and meta-analysis on sustainable supply chain management: future research directions", *Journal of Cleaner Production*. <http://dx.doi.org/10.1016/j.jclepro.2020.123357>.
- Larue, B. (2020), "Labour issues and COVID-19", *Canadian Journal of Agricultural Economics*. Vol. 68, No. 2, pp. 231-237. <http://dx.doi.org/10.1111/cjag.12233>.
- Mayurnikova, L.A., Koksharov, A.A. and Krapiva, T.V. (2020), "Food safety practices in catering during the coronavirus COVID-19 pandemic", *Foods and Raw Materials*, Vol. 8, No. 2, pp. 197-203.
- Mor, R.S., Bhardwaj, A. and Singh, S. (2018). "A structured literature review of the Supply Chain practices in Food Processing Industry", *Proceedings of the International Conference on Industrial Engineering and Operations Management Bandung, Indonesia*, pp. 588-599.
- Mussell, A., Bilyea, T. and Hedley, D. (2020). Agri-Food Supply Chains and Covid-19: balancing resilience and vulnerability. *Agri-Food Economic Systems*, 1–6. available at: www.agrifoodecon.ca (accessed 11 May 2020).
- Phillipson, J., Gorton, M., Turner, R. et al. (2020), "The COVID-19 pandemic and its implications for rural economies", *Sustainability*, Vol. 12, No. 3973, pp. 1-9.
- Ranjith, P.V. and Varma, A.J. (2020), "COVID 19-Indian scenario, challenges and possible revival strategies", *Purakala*, Vol. 31, No. 4, pp. 1834-42.
- Reardon, T., Mishra, A., Nuthalapati, C.S.R. et al. (2020), "COVID-19's disruption of India's transformed food supply chains", *Economic and Political Weekly*, Vol. 55, No. 18, pp. 1-4.
- Sharma, R., Shishodia, A., Kamble, S., et al. (2020). Agriculture supply chain risks and COVID-19: mitigation strategies and implications for the practitioners. *International Journal of Logistics Research and Applications*, 1-27, <https://doi.org/10.1080/13675567.2020.1830049>.
- Singh, S., Kumar, R., Panchal, R. et al. (2021), "Impact of COVID-19 on logistics systems and disruptions in food supply chain", *International Journal of Production Research*, Vol. 59, No. 7, pp. 1-16. <http://dx.doi.org/10.1080/00207543.2020.1792000>.
- Stauffer, J.M., Pedraza-Martinez, A.J., Yan, L.L. et al. (2018), "Asset supply networks in humanitarian operations: a combined empirical-simulation approach", *Journal of Operations Management*, Vol. 63, No. 1, pp. 44-58.
- Todorovic, V., Maslaric, M., Bojic, S. et al. (2018), "Solutions for more sustainable distribution in the short food supply chains", *Sustainability*, Vol. 10, No. 3481, pp. 1-27.
- Toppo, A. (2020). "Covid-19: Bharatiya Kisan Union Demands Rs. 1.5-lakh Crore Relief Package for Farm Sector", available at: <https://krishijagan.com/agriculture-world/covid-19-bharatiya-kisan-union-demands-rs-15-lakh-crore-relief-package-for-farm-sector> (accessed 6 May 2020).
- Troskie, D.P. (2020), "Impact of COVID-19 on Agriculture and Food in the Western CAPE Working Document (Version-2)", available at: <https://www.hortgro.co.za/wp-content/uploads/docs/2020/03/agricultural-scenariosc.pdf> (accessed 4 May 2020).

- UN News, (2020), "COVID-19: The global food supply chain is holding up, for now", available at: <https://news.un.org/en/story/2020/04/1061032> (accessed 3 April 2020).
- World Health Organization, (2020). "Coronavirus disease (COVID-19) situation report-108", available at: https://www.who.int/docs/default-source/coronaviruse/situationreports/20200507covid-19-sitrep-108.pdf?sfvrsn=44cc8ed8_2 (accessed 7 May 2020).
- Yahia, E.M., Fonseca, J.M. and Kitinoja, L. (2019). "Postharvest Losses and Waste", in E.M. Yahia (Ed.), *Postharvest Technology of Perishable Horticultural Commodities* (pp. 43-69). Woodhead Publishing. <https://doi.org/10.1016/B978-0-12-813276-0.00002-X>.
- Yu, Z. and Khan, S. A. R. (2021). "Evolutionary game analysis of green agricultural product supply chain financing system: COVID-19 pandemic", *International Journal of Logistics Research and Applications*, 1-21. <https://doi.org/10.1080/13675567.2021.1879752>.
- Yu, Z., Razzaq, A., Rehman, A. et al. (2021), "Disruption in global supply chain and socio-economic shocks: a lesson from COVID-19 for sustainable production and consumption". *Operations Management Research*, <https://doi.org/10.1007/s12063-021-00179-y>.
- Zurayk, R. (2020), "Pandemic and food security", *Journal of Agriculture, Food Systems, and Community Development*, Vol. 9, No. 3, pp. 1-5.

Author contributions: Saurabh Sid studied the literature and drafted this manuscript; Rahul S Mor monitored and directed the manuscript preparation; Anupama Panghal, Dinesh Kumar, Vijay Kumar Gahlawat supervised the revisions and content. The final edited manuscript was approved by all authors.