




# Economic Shock and Agri-Sector: Post-COVID-19 Scenario in India

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## Abstract

The COVID-19 pandemic had a devastating impact on the human health and global economy. The food and agriculture sectors have also felt these effects. In many countries, the measures taken to curb the spread of the virus were initiated to hinder the supply of agricultural products to markets and consumers inside and outside the borders. How this impacts the food safety, nutrition, and the livelihoods of farmers, fishermen, and others working in the food supply chain depends mainly on short-, medium-, and long-term policy responses. Epidemics pose severe challenges to the food system in the short term, but they also offer an opportunity to face challenges and accelerate the transformation of the food and agricultural sectors to increase resilience. The aim of the review was to highlight the valuable insight on the impact of COVID-19 on the Indian agricultural system and rural economy, as well as potential strategies for post-pandemic recovery.

**Keywords** Pandemic · Economic growth · Food safety · Migrant workers · Farmers

## Introduction

Wuhan (China) reported the first case of COVID-19 on 31 December 2019, a disease caused by a novel coronavirus (2019-nCoV), different from SARS-CoV and MERS-CoV [1]. Since then, there has been a surge in reports of confirmed cases of this new virus infection worldwide, and it has now become a major global health factor affecting the normal development of society and all its components. From the Spanish flu in 1918 to AIDS, there is always a risk of developing new infections [2]. Now, COVID-19 is an infectious disease that threatens and disturbs human health. Past pandemics in the world have shown that quarantine and panic affect human activities and economic

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growth and also have a huge impact on agricultural activities [3–5]. Agriculture is one of the most important areas of human development and is related to food security [6–8]. When pandemics occur, hunger and malnutrition also increase [9, 10]. As the disease progresses, the situation worsens, movement restrictions become stricter, labor shortages for harvesting, and it is difficult for farmers to bring their products to the market.

Millions of farmers in low-income countries are extremely vulnerable to food supply shocks, and from a climate change perspective, reducing this vulnerability remains difficult [11]. The limiting factors that curbed the spread of the COVID-19 pandemic have caused severe supply-side shocks in rural areas, including friction in the agricultural market in sub-Saharan Africa [12]. Under COVID-19 restrictions, large-scale field experiments will be used to study the impact of improved farm storage on household food security [11].

According to the SMS survey data, we found that during the COVID-19 restriction period (which coincides with the off-season of agriculture), the food insecurity of controlled households has increased. Through improved farm storage technology and trained families, food safety during the COVID-19 restriction period was relatively lower in India [11, 13]. This emphasizes the benefits of improving farm storage to reduce vulnerability to food supply shocks. These findings are related to larger and longer-term concerns about the trade-offs between climate change adaptation, public health, and food security [11].

By looking at the agriculture sector and pandemic, many questions come the way like how does the agriculture sector of India responds to the pandemic? How the Government has helped the 140 million farming households of India during the pandemic and what all measures were taken by the Government for them, and the long- and the short-term effects of the pandemic on the national economy of the developing countries including India [14–16].

Soon after the lockdown was announced, the Finance Minister of India announced a package of 1.7 trillion rupees under the scheme of “Pradhan Mantri Garib Kalyan Yojana”, mainly to protect vulnerable groups (including farmers) from the negative effects of the corona pandemic [17]. This scheme included providing rice/wheat to 800 million people, providing employment opportunities to the poor sections of society, and providing a cover of 0.5 million to different health workers employed under the “PM-KISAN” program [18, 19]. Under the same “PM-KISAN” program, INR 6000 in the farmer’s bank accounts was circulated as income support annually in three installments. As per the Finance Ministry, these benefits were given to 86.9 million farmers. The worker’s wage rates working under NREGS (Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) scheme) were also increased [20]. PM-CARES Fund was set up with the main objective of dealing with any kind of distress or an emergency posed by the COVID-19 pandemic [21, 22].

The Indian Council for Agricultural Research (ICAR) has issued guidelines for farmers to follow during the lockdown. The advisory mentions the practices and measures to follow during post-harvest storage and sales of agricultural products. Measures to grow and threshing various “Rabi” (winter sowing) crops were also included in the advisory [20, 23].

The Reserve Bank of India (RBI) had also announced different ways to deal with the “burden of debt servicing” of the pandemic. Banking institutions suspended agricultural period and crop loans for 3 months (until 31 May 2020), and the interest rates of the high-paid borrowers’ crop loans were also reduced [24].

## Methods

From 1 February 2020 to 1 December 2020, literature was gathered using available online academic databases: PubMed, Science Direct, and Google Scholar. We focused our review on the impact of COVID-19 on the Indian agricultural system, employing MeSH (Medical Subject Headings) and non-MeSH to increase search sensitivity. In our search strategy, we used keywords such as “Indian Economy and SARS-CoV-2/ COVID-19,” “Labor, Farmers, and SARS-CoV-2/ COVID-19,” “Agriculture and SARS-CoV-2/ COVID-19,” “India’s Agricultural System and Pandemic Restrictions,” “Agricultural Sector and COVID-19 Crisis,” “Agricultural Policy and Post-COVID-19,” “Agricultural Crisis and India’s Economy,” and “Food Supply Chain, Immigrants and Coronavirus.” We also looked through the reference lists of the relevant articles to see if any studies were missing. There was no language or publishing time constraints. To facilitate the screening of publications from databases, all literature searches were downloaded into an EndNote library (version X9, Thomson Reuters, Philadelphia, PA).

## Immediate Challenges

Despite all these measures, the negative impact of the COVID-19 pandemic on the agricultural economy has attracted more and more attention due to continued restrictions on people’s traffic and vehicle traffic [25]. During the peak of the Indian “*Rabi*” season, when crops such as wheat, gram, lentils, and mustard (including rice fields in irrigated areas) have been harvested or are close to maturity [26]. This is also when the farm’s crops arrive at “*Mandis*” (markets) for reliable attainment by designated Government agencies. The supply and mobilization of fresh fruits, vegetables, and dairy products in the market were also disrupted, and thus, it did not meet the demand of growing urban and rural consumers. Due to the lockdown, several workers migrated towards their homes which also created an emergency situation [27–29]. The workers play a vital role during the harvesting and storage of products in the marketing centers, as well as for post-harvest handling. The Ministry of the Internal Affairs informed that a very important measure is to exclude blocked farmers, migrant workers, and harvesting- and planting-related machinery.

For the national Government, providing grains, vegetables, fruits, and other necessities both to the rural and urban areas consumers was the most critical challenge, as the supply chain and stakeholders were disrupted in the lockdown [30]. Respective Government agencies should monitor an effective transportation and distribution system to reach every vulnerable group of the country by maintaining established guidelines and social distancing norms [31].

As the blockade done due to COVID-19 coincides with the “*Rabi*” harvest season, the farmers completely relied on the Government to make sure proper crop harvesting was achieved without any interruptions. The waiving restriction on the intra- and interstate movement of farmers or laborers, as well as harvesting and related farm machines, was a right step taken by the Union Home Ministry [32, 33]. While ensuring the provision of workers for critical farm management, the Government system should prioritize its safety (protection from COVID-19) and welfare.

## Mitigation Measures

In any disaster or pandemic situation, the impoverished members are always the hardest hit. Approximately 85% of farmers in India are small/marginal farmers, and most of them are landless farmers. Therefore, welfare measures to control the damage caused by COVID-19 were undoubtedly complete and very helpful for implementation. Therefore, the focus of the Government should be to save the lives of all citizens. However, people engaged in agriculture and related activities, mainly those who lost income due to informal employment during the blockade, have other options like cash transfer, until the economy recovers [34, 35].

To maintain the demand for agricultural products, we should increase investment in key logistics. In addition, appropriate policies and incentives need to be adopted to encourage e-commerce, transportation companies, and start-ups. Small- and medium-sized enterprises that use raw materials from agriculture and related sectors also require special attention to ensure that the rural economy does not collapse [20].

To eliminate urgent concerns regarding agricultural labor shortages, policies have adopted appropriate incentives through state-owned entities, Farmers' Producer Organizations (FPO), or Custom Hiring Centers (CHC) to make machinery easily accessible. In addition, ensuring the employment to the daily wage and landless workers, by paying a part of the farm labor (with farmers paying the balance wage amount) and thus reduce the monetary burden [15].

To answer, questions related to the announced Government measures resolve farmers' dissatisfaction and provide suggestions for farmers' operations; the Government must establish the availability of agricultural inputs, a dedicated toll-free hotline service/call center (local/language).

Agriculture in India is the mainstay of the country, and it has been observed in recent years that policies and plans vary from state to state. However, interrelated agricultural activities, agricultural support, or benefits from neighboring countries should not distort market conditions. There is evidence that giving up agricultural loans does not provide sufficient benefits for most small-scale and marginal farmers. Instead, the future credit of the borrower is influenced thus affecting the entire agricultural credit culture [36]. As the "Kharif" (wet/rainy) season approaches, institutional lending for crop loans should be expanded and promoted to stabilize (sufficient) credit flows to borrowing farmers. Agricultural inputs (seeds, fertilizers, pesticides, etc.) should be placed in advance for easy access. Private sector participants need to play an important role with the necessary policy support [15, 37].

The Agricultural Produce & Livestock Market Committee (APMC) has relaxed the regulations so that farmers can sell their agricultural products outside of the designated "Mandis," thereby ensuring that the burden on farmers is reduced. The State Government needs to adjust the mechanism through MSP (minimum support price) or other price support plans to smoothly purchase the farmers' valuable surplus [34, 36].

In the COVID-19 pandemic, most of the future budget allocations will be allocated to the health sector, because this is an unprecedented health crisis. But care should be taken that the primary sector should not invest so much that it can prevent irreversible damage to agronomy. The service and manufacturing services may hit a new low in the pandemic time due to economic crisis [38]. Therefore, it is very important to strengthen the agricultural sector to improve the economy of the country and also provide food, resilience, and security. At this emergency stage where climate change has also negatively impacted the

agriculture sector, investment including research and innovations will be very helpful and purposeful [39].

For a long time, people have advocated structural reforms such as land leases, contract agriculture, and private agricultural markets to strengthen investment in the agricultural sector and promote its growth. However, due to the lack of uniform enforcement of these laws by the State Government, the industry's potential has not been fully realized. These reforms require important political will. Appropriate state incentives by the Government can be used to address the decline in state enthusiasm and concerns about post-COVID-19 scenarios.

Due to the rapid population growth, India's food demand has also increased accordingly. However, the negative impacts of the Green Revolution, especially environmental trade-offs and major food fundamentalisms, were consequently realized. Therefore, there is a need to switch to a suitable model with a more diverse diet and stronger nutritional focus. The post-COVID situation presents its unique opportunity to re-apply existing food and agricultural policies to healthy people [40–42].

There are global concerns (not speculation) about restrictions on agricultural exports by a few global players. With a stable agri-exports strategy, India may take advantage of trade surpluses on commodities such as rice, meat, milk products, tea, honey, and horticulture products. The total value of India's agricultural exports in the 2018–2019 fiscal year was USD 38 billion. If the simplified policy is implemented, India's exports may increase further. The development of infrastructure and logistics to support exports requires investment and support from the private sector, which will be a long-term benefit for increasing farmers' income [43].

Many climate models predict that 2020 will be a favorable monsoon season (the Indian Meteorological Agency also officially announced) as the El Niño phenomenon affecting rainfall in India is not evident. This is indeed positive news in the COVID scenario, assuming agriculture practice can be largely intact [23].

Fortunately, the Indian Government is currently focusing on nutrition (besides food), safety, and increasing farmers' income (rather than increasing agricultural productivity). Appropriate plans and incentives to change consumer behavior are already on the agenda. For all of these things to happen, the current state of policy incentives that favor the two main staple foods, wheat, and rice needs to be changed. In the post-COVID-19 scenario, agricultural policy design should include these basic elements of the transformation of India's food system [30].

## **Impact of COVID-19 on India's Agriculture, Food Security, and Livelihoods**

India has taken early measures to limit the spread of COVID-19 and imposed a 21-day national lockdown on 2.1 billion people from 25 March 2020. Compared with other countries, the novel coronavirus is spread widely in India. So far, the reported incidence of infectious diseases has been very low, with 5,274 cases and 149 deaths as of 8 April 2020. However, with the rapid increase in COVID-19 cases, people are very worried about the potential spread and impact of this disease. India needs to prepare for a possible surge. The test needs to be greatly expanded. The Government believes that the pattern of the COVID-19 epidemic is similar to the 2009 H1N1 influenza pandemic

[9], implying that the spread is unlikely to be uniform. After the 21-day period expires, the Government plans to maintain a complete lockdown in the “hotspot” areas only and relax elsewhere [14].

These measures may help limit the health crisis, but like other countries, all economic activities except basic services were completely interrupted, coupled with the huge number of unemployment and severe food insecurity, resulting in economic crisis and mental anguish.

In India, among the 465 million workers nationwide in 2017–2018, approximately 91% (422 million) were informal workers. Due to the lack of fixed wages and income, these farmers, immigrants, and other informal workers were hit hardest during the blockade which directly impacts agriculture, supply chains, food and nutrition security, and potential livelihood [34].

## Agriculture and Supply Chains

COVID-19 has disrupted certain activities in agriculture and the supply chain. Initial reports indicate that harvesting activities have been suspended due to a lack of migrant workers, particularly in northwest India, where wheat and beans were being harvested. Transportation and other issues caused significant disruption in the supply chain. Wheat, vegetables, and other crops are becoming more affordable, but consumers are often forced to pay more. According to media reports, the closure of hotels, restaurants, candy shops, and coffee shops has depressed milk sales. On the other hand, erroneous information that chickens are carriers of COVID-19, especially on social media, has caused serious damage to the poultry industry [44].

To maintain the normal operation of the agricultural sector and supply chain, the following measures should be taken:

1. The Government has issued blockade rules banning farm operations and supply chains. However, implementation issues that led to labor shortages and low prices should be fixed.
2. Maintaining the functioning of the supply chain is essential for food security. It should be noted that the death toll of 2 to 3 million people from the Bengal famine (1943) was not due to food shortages but due to the food supply interruptions.
3. To maximize the protection from the coronavirus, farm populations should be tested and practice social distancing to the greatest extent possible.
4. Farmers must still have access to the markets. This could be a mix of the private market and Government procurement.
5. Due to the urgent need for input supply and market access, issues related to the pandemic, small poultry, and dairy farmers need more targeted assistance.
6. Farmers and agricultural workers should be included in the Government’s support package and social protection plan to deal with the crisis.
7. With the strengthening of the blockade measures, the demand for food delivery and e-commerce is increasing. This trend should be encouraged and promoted.
8. The Government should promote trade by avoiding export bans and import restrictions.

## Agricultural Trade Relations

In the past, there have been re-evaluations of how international relations are to be conducted in the aftermath of major economic disruptions. In the aftermath of the First World War, for example, the economic arm of the League of Nations produced a significant degree of international cooperation, resulting in the 1927 World Economic Conference, which also included non-members, viz., the USA. The countries involved in the conference decided that it was time to terminate tariffs (League of Nations, 1927). However, with the passage of the Smoot-Hawley Tariff Act in the USA in June 1930, countries switched from relatively free international trading systems to a high degree of protectionism in the wake of the economic fallout from 1929 stock market crash. Canada was the first nation to retaliate in May 1930, long before Smoot-Hawley was signed into law [45]. Many other nations followed suit, raising tariffs and trade barriers against each other and the USA.

## Use Social Safety Nets as a Bridge Between Health and Economic Shocks

The lockdown ruined almost all economic activities. The employment and income of informal workers employed in the urban areas were lost. The Centre for Monitoring Indian Economy estimates that the unemployment rate surged from 8.4% in mid-March to 23% in the first week of April. As of 5 April 2020, the unemployment rate in urban areas soared to 30.9%. This closure has caused great suffering to informal workers living unstable lives [34].

The best way to address this urgent need is to use an extensive social safety net to stabilize life with food and cash. The Indian Government responded quickly to the crisis and announced a USD 22.5 billion rescue plan on 26 March 2020, which included the transfer of food and cash. Some State Governments also announced their support plans.

The Central Government's relief plan was called "Pradhan Mantri Garib Kalyan Yojana." The Prime Minister's plan for the well-being of the poor aims to provide safety to people who have been hit hard by the COVID-19 lockdown network. However, this is not enough compared to the magnitude of the problem. Nobel laureates in economics, Prof. Esther Duflo and Prof. Abhijit Banerji, said that the "Government should make the social resettlement plan bolder" [17].

The Indian Government has quickly responded to the crisis and announced a USD 22 billion relief package, which includes food and cash transfers. Several State Governments have announced their support packages. The USD 22 billion expenditure is only 0.85% of India's GDP. This is much lower than the package passed in the USA, Europe, and some Asian countries. India should consider spending at least 4 to 5% of GDP. Even if the budget deficit increases temporarily, the Central and State Governments must spend more [43].

In addition to the Government package, below are some additional actions needed:

- Food safety and nutrition: Government warehouses with 71 million tons of rice and wheat are overflowing [30, 46]. For the avoidance of exclusion errors, it is better to offer universal distribution coverage in the next few months. Nutrition programs such as Integrated Child Development Services (ICDS), mid-day meals, and rural child-care centers ("Anganwadis") should continue to function as essential services and pro-



vide recipients with rations and meals at home. To enhance nutrition for children and women, eggs can be added. Innovative programs have been started by several State Governments to assist informal workers and the poor. For example, at the doorsteps of households, the Kerala Government is providing meals with diversified diets [11, 30, 47, 48].

- Cash transfers: Unemployed informal workers need funding for cash income. Through the “Jan Dhan” financial inclusion program, the Government has provided INR 500 (USD 6.60) per month to the bank accounts of 200 million women, but this is also inadequate. For the next 3 months, we need to have a minimum of INR 3000 (USD 40) per month in cash transfers [17].
- Migrant workers: There are some 40–50 million seasonal migrant workers in India. In recent days, global media have broadcast images of hundreds of thousands of migrant workers from several states traveling miles and miles on highways; some have traveled more than 1,000 km to return to their home villages. Both cash transfers and nutritious food should be provided [18, 27, 49–51].

COVID-19 India’s unprecedented challenge; due to the large population, non-regular employees, the blockade, and other companies’ distance survey results. The Central and State Governments have accepted the challenge and responded harshly, but this response should only be the beginning. India must be prepared to scale it up as events unfold, easing the economic impacts through even greater public program support and policies that keep markets functioning [30, 52–56].

## Conclusion

Along with the spread of COVID-19, the Indian Government enforced a 21-day national lockdown and then maintained a full lockdown at hotspots to limit the spread of the virus transmission. These precautions taken by the Indian Government could help limit the health crisis, but the complete lockdown has plunged the Indian economy into recession. India’s economic shock could be even more serious for two reasons. First, the economy slowed before COVID-19, exacerbating existing unemployment, low incomes, rural hardship, malnutrition, and general inequality. Second, India’s large informal sector is particularly vulnerable.

Key features of India’s COVID-19 containment are complete disruption of supply chains, disruption of food procurement by government agencies, shortage of workers collecting crops from farms and merchants harvesting “Rabi” crops, shortage of truck drivers and blockades in the transport of commodities, limited availability of APMC “Mandis” operations, and closure of retail markets. The crisis triggered by the pandemic has severely affected India’s agricultural system. If we do not understand the impact of COVID-19 on the agricultural system, we will not be able to respond to the food security crisis. In India, mobility restrictions, transportation issues, and reverse labor migration have disrupted the domestic supply chain and ultimately pushed up the wholesale and retail prices of basic commodities such as soybeans, flour, milk, and vegetables. Buffering edible grains and crop discretion over previous crops limits the short-term impact, but if three-quarters of consumers report rising prices for basic commodities, that is not enough.

The Indian agricultural system deserves a new deal in the post-COVID scenario. The pandemic has highlighted major differences in the way agricultural policies are implemented over



the decades. It effectively reversed the importance of self-reliance for food production and the pitfalls of the free trade system. In India, small-scale farmers are not rooted in large agricultural enterprises or corporate farms but are related to the issue of agricultural transformation and the role of the state in agricultural policy. After locking, these suspicions must be forced into the policy table. This prospect depends on whether the political economy of decision-making is favorable. Certainly, the expectation that the orthodoxy of economic theory will easily give way to a more idiosyncratic understanding of our economy and society is a very high requirement. At the other end of the blockade is a struggle that has not yet been carried out. The ending of the lockdown is not going to stop the issues. Instead, the issues will be exacerbated at the beginning of the new agricultural sowing season. There is a great need for Government help and activeness to implement each and every laws in the sector and also to assist in the agricultural inputs. The absence of any aid would only intensify the agricultural crisis. The need for an hour is to optimize agricultural possibilities, which in difficult times have shown their utility and resilience.

For a long time, it has been advocated to promote investment and growth in the agricultural sector through structural reforms such as contract agriculture, land leasing, and private agricultural markets. However, the provincial government has not uniformly enforced these laws and has not fully realized the potential of the agricultural sector. These reforms require strong political will.

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## References

1. Zhao S, Lin Q, Ran J, Musa SS, Yang G, Wang W, Lou Y, Gao D, Yang L, He D (2020) Preliminary estimation of the basic reproduction number of novel coronavirus (2019-nCoV) in China, from 2019 to 2020: a data-driven analysis in the early phase of the outbreak. *Int J Infect Dis* 92:214–217
2. Frank MacFarlane Burnet S, Burnet FM, Burnet M, White DO (1972) Natural history of infectious disease. CUP Archive
3. Arndt C, Lewis JD (2001) The HIV/AIDS pandemic in South Africa: sectoral impacts and unemployment. *Journal of International Development: The Journal of the Development Studies Association* 13(4):427–449
4. Leroy EM, Rouquet P, Formenty P, Souquière S, Kilbourne A, Froment JM, Bermejo M, Smit S, Karesh W, Swanepoel R (2004) Multiple Ebola virus transmission events and rapid decline of central African wildlife. *Science* 303(5656):387–390
5. Hanashima M, Ki T (2012) Urbanization, industrialization, and mortality in modern Japan: a spatio-temporal perspective. *Ann GIS* 18(1):57–70
6. Abdelhedi IT, Zouari SZ (2020) Agriculture and food security in North Africa: a theoretical and empirical approach. *J Knowl Econ* 11(1):193–210
7. Kogo BK, Kumar L, Koech R (2020) Climate change and variability in Kenya: a review of impacts on agriculture and food security. *Environment, Development and Sustainability*:1–21
8. Denova-Gutiérrez E, Lopez-Gatell H, Alomia-Zegarra JL, López-Ridaura R, Zaragoza-Jimenez CA, Dyer-Leal DD, Cortés-Alcala R, Villa-Reyes T, Gutiérrez-Vargas R, Rodríguez-González K (2020) The association of obesity, type 2 Diabetes, and hypertension with severe coronavirus disease 2019 on admission among Mexican patients. *Obesity* 28(10):1826–1832
9. Sar T, Aernan P, Houmsou R (2010) H1N1 influenza epidemic: public health implications for Nigeria. *Int J Virol* 6(1):1–6
10. Burgui D (2020) Coronavirus: How action against hunger is responding to the pandemic. Available in: <https://www.actionagainsthunger.org/story/coronavirus-how-action-against-hunger-respondingpandemic>
11. Huss M, Brander M, Kassie M, Ehlert U, Bernauer T (2021) Improved storage mitigates vulnerability to food-supply shocks in smallholder agriculture during the COVID-19 pandemic. *Glob Food Secur* 28:100468
12. Adam C, Henstridge M, Lee S (2020) After the lockdown: macroeconomic adjustment to the COVID-19 pandemic in sub-Saharan Africa. *Oxford Review of Economic Policy* 36 (Supplement\_1):S338–S358
13. Balogun CE (2020) Mitigating the impact of COVID-19 on rural farm families in Nigeria through innovative information transfer. *Development* 10(2)
14. Kumar P, Singh S, Pandey A, Singh RK, Srivastava PK, Kumar M, Dubey SK, Sah U, Nandan R, Singh SK (2021) Multi-level impacts of the COVID-19 lockdown on agricultural systems in India: the case of Uttar Pradesh. *Agric Syst* 187:103027
15. Arumugam DU, Kanagavalli DG (2020) COVID-19: Impact of agriculture in India. *Aegaeum Journal* 8(5)
16. Sahoo JP, Samal KC, Behera D (2020) A blueprint to boost Indian agriculture in the era of Covid-19 pandemic. *Biotica Research Today* 2(8):780–782
17. Agrawal H, Menon S, Misra P, Sippy T, Srinivasan S, Tandel V, Vedavalli P (2020) PM Garib Kalyan Yojana: coverage, identification and implementation. Working paper, IDFC Institute
18. Farooqui MBMH, Pandey S (2020) Social security for informal workers in India.
19. Majumdar B Covid-19 Pandemic in India: a geo-environmental analysis. *Environmental Sustainability in the 21st century: Emerging issues and the way forward*:159
20. Trivedi S, Negi S, Anand N (2020) Impact of COVID-19 on agriculture supply chain in India and the proposed solutions. *International Journal of Sustainable Agricultural Management and Informatics* 6(4):359–380
21. Debnath R, Bardhan R (2020) India nudges to contain COVID-19 pandemic: a reactive public policy analysis using machine-learning based topic modelling. *PLoS ONE* 15(9):e0238972
22. Hari H, Shree N, Basak D (2020) Impact of Covid-19 on Agriculture in India. *J Econ Policy Anal* 1(1):82–94
23. Maheshwari K Impact of Covid-19 on agriculture sector in India. *International Journal of Trade & Commerce-IIARTC*
24. Shirpi M, Thirumoorthi P Operational, logistics and marketing problems for farmers of perishable agricultural products in Salem district due to Covid-19 crisis.

25. Kumar P, Hama S, Omidvarborna H, Sharma A, Sahani J, Abhijith K, Debele SE, Zavala-Reyes JC, Barwise Y, Tiwari A (2020) Temporary reduction in fine particulate matter due to ‘anthropogenic emissions switch-off’ during COVID-19 lockdown in Indian cities. *Sustain Cities Soc* 62:102382
26. Mukherjee N (2002) *Alternative perspectives on livelihood, agriculture and air pollution*, vol 1. Concept Publishing Company
27. Ranjan R, Bisht M (2020) Novel coronavirus and Indian overseas labour migrants: Updates from Gulf Cooperation Council Countries. *Roots Routes* 9:1–4
28. Dubey S, Biswas P, Ghosh R, Chatterjee S, Dubey MJ, Chatterjee S, Lahiri D, Lavie CJ (2020) Psychosocial impact of COVID-19. *Diabetes Metab Syndr Clin Res Rev* 14(5):779–788
29. Sengupta S, Jha MK (2020) Social policy, COVID-19 and impoverished migrants: challenges and prospects in locked down India. *Int J Commun Social Dev* 2(2):152–172
30. Aday S, Aday MS (2020) Impact of COVID-19 on the food supply chain. *Food Qual Saf* 4(4):167–180
31. Serpil A, Aday MS Impacts of COVID-19 on Food Supply Chain
32. Chattopadhyay S, De UK, Saha B, Kumar A, Ramachandran M, Mohanan P, Singh R, Saha A, Carreiras M, Mazigo A (2020) *Journal of Development Policy Review (JDPR): Vol. 1 Issues. 1 and 2 (2020): Special issue-the COVID-19 pandemic and India. IndraStra Global e-Journal Hosting Services*
33. Ramakumar R (2020) Agriculture and the Covid-19 pandemic: an analysis with special reference to India. *Review of Agrarian Studies* 10 (2369-2020-1856)
34. Dev SM, Sengupta R (2020) Covid-19: Impact on the Indian economy. *Indira Gandhi Institute of Development Research. Mumbai, India*
35. Shadmi E, Chen Y, Dourado I, Faran-Perach I, Furler J, Hangoma P, Hanvoravongchai P, Obando C, Petrosyan V, Rao KD (2020) Health equity and COVID-19: global perspectives. *Int J Equity Health* 19(1):1–16
36. Sharma R, Shishodia A, Kamble S, Gunasekaran A, Belhadi A (2020) Agriculture supply chain risks and COVID-19: mitigation strategies and implications for the practitioners. *International Journal of Logistics Research and Applications* 1-27
37. Siche R (2020) What is the impact of COVID-19 disease on agriculture? *Scientia Agropecuaria* 11(1):3–6
38. Sabatello M, Burke TB, McDonald KE, Appelbaum PS (2020) Disability, ethics, and health care in the COVID-19 pandemic. *Am J Public Health* 110(10):1523–1527
39. Kurukulasuriya P, Rosenthal S (2013) Climate change and agriculture: a review of impacts and adaptations.
40. Gray RS (2020) Agriculture, transportation, and the COVID-19 crisis. *Canadian Journal of Agricultural Economics/Revue canadienne d’agroéconomie* 68(2):239–243
41. Altieri MA, Nicholls CI (2020) Agroecology and the emergence of a post COVID-19 agriculture. *Agric Hum Values* 37(3):525–526
42. Cecchin A, Salomone R, Deutz P, Raggi A, Cutaia L (2021) What is in a name? The Rising Star of the Circular Economy as a Resource-Related Concept for Sustainable Development. *Circular Economy and Sustainability*:1-15
43. Tale N, Pawar P (2020) CHAPTER-8 The growth and consequences of COVID-19 in India. *Impact of Covid-19 on Education, Agriculture, Science and Technology* 58
44. Rawal V, Kumar M, Verma A, Pais J (2020) COVID-19 lockdown: impact on agriculture and rural economy. *Society for Social and Economic Research*
45. Kerr WA (2020) The COVID-19 pandemic and agriculture: short-and long-run implications for international trade relations. *Canadian Journal of Agricultural Economics/Revue canadienne d’agroéconomie* 68(2):225–229
46. Mawar R, Manjunatha B, Kumar S (2021) Commercialization, diffusion and adoption of bioformulations for sustainable disease management in Indian Arid Agriculture: Prospects and Challenges. *Circ Econ Sustain*:1–19
47. Cifuentes-Faura J (2021) Circular economy and sustainability as a basis for economic recovery post-COVID-19. *Circ Econ Sustain*:1–7
48. Liaros S (2021) Circular food futures: what will they look like? *Circ Econ Sustain*:1–14
49. Possas C, Marques ET, Risi JB, Homma A (2021) COVID-19 and future disease X in circular economy transition: redesigning pandemic preparedness to prevent a global disaster. *Circ Econ Sustain*:1–16
50. Nuthalapati CS, Nuthalapati C (2021) Has Open innovation taken root in India? Evidence from start-ups working in food value chains. *Circular Economy and Sustainability*:1–24
51. D’Amato D (2021) Sustainability narratives as transformative solution pathways: zooming in on the circular economy. *Circ Econ Sustain*:1–12
52. Keswani C (2020) *Bioeconomy for Sustainable Development*. Springer-Nature, Singapore. 392 pages, ISBN- 978-981-13-9430-0

53. Keswani C (2021) Agri-based bioeconomy: reintegrating trans-disciplinary research and sustainable development goals. CRC Press, Boca Raton, Florida, USA 384 pages, ISBN- 9780367471002
54. Keswani C, Dilnashin H, Birla H, Singh S (2019) Re-addressing the commercialization and regulatory hurdles for biopesticides in India. *Rhizosphere* 11(100155):10.1016
55. Nikolaou IE, Jones N, Stefanakis A (2021) Circular economy and sustainability: the past, the present and the future directions. *Circ Econ Sustain*:1–20
56. Halog A, Anieke S (2021) A review of circular economy studies in developed countries and its potential adoption in developing countries. *Circular Economy and Sustainability*:1-22