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Impact of COVID-19 on the Agriculture Sector: Survey Analysis of Farmer Responses from Kerala and Tamil Nadu States in India

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Abstract: The global COVID-19 pandemic has hit the agriculture sector hard around the world. A study was conducted to assess the impact of the pandemic on cropping patterns, crop management, usage of chemical inputs and their organic alternatives, harvesting, and marketing avenues through a survey approach in the two states of Kerala and Tamil Nadu in India. A total of 250 farmers participated in the study, the data was analyzed by Chi-square test and Kruskal–Wallis test. The assessment of the impact of COVID-19 on some aspects was undertaken by dividing the study period into three phases. Though a smaller number of people were infected with COVID-19 in the initial phase of the pandemic compared to the later phases, farm operations and the procurement of inputs were significantly affected at this phase as there was a sudden disruption in transportation due to COVID-19-induced movement restrictions. During the entire study period, commodities such as rice, bananas, vegetables, coconuts, and flowers suffered maximum crop loss compared to pulses, groundnuts, cotton, and rubber. Among fertilizers, the maximum shortage was observed for chemical fertilizers (46%) and biofertilizers (30%) compared to cow dung (18%) and poultry manure (6%), indicating that farmers tended to use more local materials that could be easily procured and accessed compared to shop-based inputs. A rise in the cost of cultivation, scarcity of farm workforce, and difficulty in hiring farm machinery all have contributed to the loss of profit during the pandemic period. As a response to COVID-19, growers initiated post-harvest processing of commodities, and cropping systems remained the same during the period. The paper also discusses some remedial measures to be adopted by households in the future, to minimize the impacts of such pandemics in the agrarian sector.

Keywords: agriculture; COVID-19; impact study; Indian scenario; marketing; organic farming

1. Introduction

The global COVID-19 (Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)) pandemic has impacted all sectors including agriculture, business, employment, entertainment, education, economy, transport, social and religious gatherings, food security, and sports [1–8]. COVID-19's impacts on the agriculture sector differ from region to region, with the major issues being reported including labor and machinery shortages, limited access to crop fields and markets, poor access to agricultural inputs, services, and advisory services, supply chain disruptions, and perishability of the products due to limited access to

market and insufficient post-harvest handling [4,9–15]. Many studies reported manpower shortages affecting a spectrum of activities from seeding to post-harvest handling [8,13,16]. Additionally, lockdowns have significantly affected agriculture commodity movement and marketing of the products [14,17].

Within the agriculture sector, the impacts of COVID-19 vary with crops; the impact seems to be more on perishable commodities including vegetables and fruits compared to nonperishable products [8], such as rice, and this emphasizes the requirement for enhancing post-harvest processing or value addition of agricultural commodities [18]. Due to restrictions imposed on transport and movement due to lockdown, supply chain disruptions were apparent in many regions [19]. The impact of the pandemic was more pronounced for small-scale growers [3]. A study in Canada indicated that the online shopping opportunities for small producers and processors had minimized the impact on supply chain disruptions [20] and another study in the USA indicated a greater impact due to COVID-19 on the vulnerable communities of society [10]. Many products were sold at a low price, leading to loss of profit to growers [21]. Conversely, there was also a price rise for some commodities. For instance, in Thailand, the price of ginger was higher than the previous year (pre-COVID-19 levels) because of the hike in the world market demand and the belief that ginger could suppress COVID-19 infections [22]. COVID-19 restrictions affected the movement of farmworkers, affected the supply and demand of agricultural commodities, and led to the closure of food production units as well as financial pressures in the agricultural supply chain [3].

Supply chain disruptions have also affected the consumption patterns of foodstuffs [23]. Significant reductions were observed in the income of temporary farm workers which impacted certain crop operations, especially the harvesting of crops [13]. For instance, in Nepal, growers faced difficulty in accessing crop production information during the lockdown period [9]. A study has reported supply chain disruptions with the maximum impact on the vulnerable section of the population [24]. A study in Japan indicated the growing potential of urban farming activities in combating the impact of COVID-19 [25]. The COVID-19 pandemic also indicated the need to have product diversification and linking marketing strategies to combat the impact of the pandemic [26]. However, in China, a minimum impact was witnessed on the agricultural sector during early 2020 [27].

In India, the first case of COVID-19 was reported in the state of Kerala, and subsequently a nationwide lockdown was declared on 24 March 2020, which continued until May 2020, disrupting people's movement all over the country [28]. In India, growers faced a farmworker shortage, leading to harvest delays, and the impact was more pronounced on smallholder farms than large farms [11,16]. Besides the impact on harvesting, the farmworker shortage was acute in some regions, which affected crop management, crop production, and post-harvest handling, leading to crop losses [18,29]. A study indicated the requirement for policy initiatives to manage water resources during a pandemic such as COVID-19 [30]. In some areas, COVID-19 has also led to reverse migration of the farm workforce affecting the planting of rice, leading to a yield loss of USD 674 million to 1.48 billion [11]. Rural households, including smallholders, were affected by the loss in migrant income, livelihood, and farm and non-farm incomes [31].

This paper presents the impact of COVID-19 on the agrarian sector of two states, Tamil Nadu and Kerala in India. The geographical proximity and similarity in crops and their management are the major reasons for selecting these states for studying the impact of COVID-19. The states of Kerala and Tamil Nadu are in the southern parts of India and in the latitudinal range of 8° N to 13° N. Kerala houses a population of 35.6 million (53% of the population is engaged in agriculture) and has an area of 3.8 million hectares [32]. The major crops of Kerala include rice, coconut, banana, tapioca, rubber, cashew, pepper, ginger, and turmeric [32]. The neighboring state of Tamil Nadu has a geographic area of 13 million hectares. The state houses a population of 67.9 million people, of which 70% are engaged in agricultural activities [33]. Compared to Kerala, Tamil Nadu accounts for a larger variety

of crops and the major crops include rice, jowar, ragi, bajra, maize, pulses, mango, banana, cotton, sugarcane, tea, coffee, and coconut.

The assessment of the impacts of COVID-19 on agriculture and farm households in the region, covering different aspects of cropping from seeding to consumption level, is a prerequisite in order to frame appropriate strategies for the future. The current study explored the impact of COVID-19 on the agriculture sector through undertaking a survey among farm households and discusses the probable solutions and strategic framework to combat such pandemics in the future.

2. Materials and Methods

2.1. Sampling and Data Collection

The impact of COVID-19 on the agriculture sector was studied through a survey of 250 farmers spread across 50 districts of Kerala (14 districts) and Tamil Nadu (36 districts), the study period was spread from January 2020 to December 2020. The data of this survey was collected from March to May 2021. Five farmers were randomly selected from each district with an area of more than 1 hectare using a prestructured interview schedule.

The impact of the pandemic on some of the aspects was assessed by dividing the study period into three phases, viz., Phase-1 (January to April 2020); Phase-2 (May to August 2020); and Phase-3 (September to December 2020). Phase-wise analysis was carried out as the impact of COVID-19 could vary over the entire period of the pandemic outbreak. During the study period, there was an increase in the number of patients over time. The beginning period can be classed as the preparatory phase, and the system tried to adjust with the pandemic over time. The important aspects analyzed during these three phases included farm labor and machinery shortages, shortages of seeds, fertilizer, and pesticides, transportation of the agricultural commodities, and access to credit and consultancy services.

Aspects that were assessed for the entire period of the study included profit loss from major crops, including rubber, cotton, cassava, tea, pulses, sugarcane, groundnut, fruits, flowers, vegetables, coconut, rice, and banana. Specific information was collected on the shortage of fertilizer inputs, viz., chemical fertilizers, biofertilizers, cow dung, poultry manure, and homemade organic formulations. Pesticide availability was assessed for insecticides, herbicides, fungicides, and organic formulations. Information on middlemen involvement, market fluctuations, post-harvest processing or value addition was also gathered. Besides the overall profit loss, information on the cost of cultivation, shortage of manpower, input costs, cropping system change, pest outbreaks, accessibility to food, access to credit facilities and markets, and anxiety level of growers were assessed.

Information on various aspects (as described above) was gathered by employing different questions. The questions included dichotomous answers (Yes or No) as well as Likert scale questions on a scale of 1 to 10. There were agree or disagree questions, questions on increase, decrease, and no change on the status of farming activities, and some open-ended questions. Dichotomous questions were asked on the status of cultivation, on the availability of a specific farm input (fertilizer or pesticide), and on the status of post-harvest processing. Likert scale questions were asked for on-farm labor shortage, shortages of seed, fertilizer, and pesticide, lack of demand of the produce, status of transportation, machinery shortage, access to credit and consultancy. The effect of COVID-19 was also assessed through questions on increase, decrease, and no change and such questions covered the involvement of middlemen, crop yield loss, input cost, anxiety level, and food accessibility. The aspects assessed through agree or disagree questions include market fluctuations, profit loss, labor and machinery shortages, cropping system changes, and pest outbreaks. Quantitative questions on yield loss and profit loss were also included.

2.2. Statistical Analysis

Chi-square analysis was performed on dichotomous questions, and pairwise comparison was performed by Fisher's Exact Test using "R companion package" at 0.05% signifi-

cance level. Kruskal–Wallis test was used to compare Likert scale questions, agree/disagree questions, and questions on the effect of change (increase, decrease, and no change), pairwise comparison was performed by Dunn test using library FSA, for the Kruskal–Wallis test, χ^2 was included with Kruskal–Wallis while reporting the results (e.g., Kruskal–Wallis χ^2). All the analyses were performed by employing the R statistical package [34].

3. Results and Discussion

3.1. Phase-Wise Analysis of the Impact of COVID-19

In the initial phase, the numbers of COVID-19 cases reported were only 496 and 2323 persons, in Kerala and Tamil Nadu, respectively (Figure 1). However, the numbers increased over time and reached 73,856 and 428,041 in Kerala and Tamil Nadu, respectively, at the end of Phase 2 (August 2020). A further increase was noticed during Phase 3, with 755,719 and 818,014 COVID-19 patients in Kerala and Tamil Nadu, respectively (Figure 1).

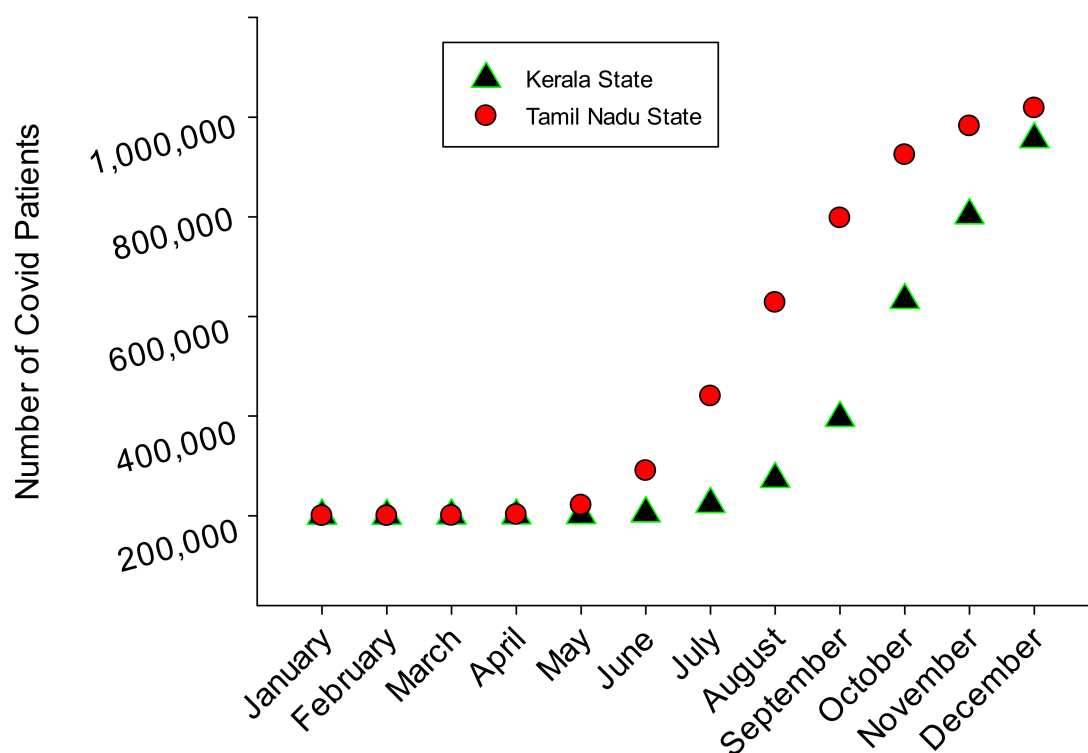


Figure 1. Number of cumulative COVID-19-positive cases in Kerala and Tamil Nadu states of India in the year 2020 (available online: <https://www.covid19india.org> (accessed on 28 December 2021)) [35].

The phase-wise status of some of the agricultural activities as affected by the pandemic is presented in Table 1. Farm labor shortage, fertilizer shortage, and machinery shortage were less pronounced during Phase 3 (third phase) of the pandemic in the year 2020 (Table 1), although the number of COVID-19 cases was much higher in the third phase (Figure 1). Pesticide shortage was pronounced in the second phase of the pandemic (Table 1). Similarly, access to consultancy and extension activities and credit were more affected during Phase 1 compared to Phase 3 (Table 1). Demand for produce and transportation were also affected in the Phase 1 period, but this eased during Phase 3, although substantial portion of the population was affected during the last phase (Phase 3) compared to the previous phases (Table 1). Access to credit and agricultural consultancy services was affected to the maximum level during Phase 1 and Phase 2 compared to Phase 3 (Table 1).

Table 1. Assessment of the impact of COVID-19 on agricultural inputs and activities during three phases *.

Activity	Phase-1 *	Phase-2 *	Phase-3 *
Farm labor shortage	8.7a **	8.7a	5.8b
Seed shortage	5.36ab	5.8a	4.9b
Fertilizer shortage	6.1b	6.7a	4.6c
Pesticide shortage	4.9b	7.6a	4.7b
Lack of demand of produce	8.13a	7.96a	6.7b
Transporting produce was affected	8.2a	8.5a	5.9b
Machinery shortage	4.3a	4.6a	3.7b
Access to credit	7.6a	7.5a	5.2b
Access to consultancy	8.6a	8.2a	5.5b

Notes: * January to April 2020 (Phase-1), May to August 2020 (Phase-2), and September to December 2020 (Phase-3). ** Kruskal–Wallis test was used to compare the phase-wise impact and different letters indicate significant difference between the phases.

The results of the phase-wise analysis bring forth a few important points. First, though the number of affected people in the initial phase of the pandemic was very low, farm operations and procurement of inputs were affected at the maximum level during Phase 1, as there was a sudden disruption in transportation, leading to restrictions on the movement of people. Input availability was significantly reduced as there were movement restrictions and closures of shops at the initial phase due to lockdown. However, over time, the system seems to have adjusted with the pandemic, with an easing of the difficulties faced by the growers in the initial phases, though the number of COVID-19 patient cases was yet on the increase. This clearly indicates the importance of proper strategies at the beginning of a pandemic, as the impact can be at its maximum in the initial phases.

3.2. Specific Impact on Products and Activities

Of the 250 respondents, 95% cultivated during the lockdown period and a significant difference was not observed between the districts ($\chi^2 = 47$, $df = 49$, p -value = 0.55). However, 94% of the respondents reported that their farming activities and crop management were affected due to COVID-19, though the difference was not observed across the districts surveyed ($\chi^2 = 59$, $df = 49$, p -value = 0.17). During the entire study period, the crops rice, bananas, vegetables, coconuts, and flowers suffered maximum crop losses (Figure 2). However, crop loss was minimum for pulses, groundnuts, cotton, and rubber as these are storable commodities (Figure 2). Although the specific contribution of different activities on crop yield loss was not computed, the shortage of farm labor, machinery, and inputs, as well as a lack of demand for the harvested produce might have contributed to crop loss (Table 1). Among the fertilizers, the maximum shortage was observed for chemical fertilizers (46%), followed by biofertilizers (30%); among the organic materials, the maximum shortage was for cow dung (18%), and this was followed by poultry manure (6%) (Figure 2), indicating the local materials that could be procured were accessible to growers compared to the shop-based inputs. Among the pesticides, growers faced a maximum shortage of insecticides (52%), followed by herbicides (25%); shortage of fungicides (14%) and organic formulations (10%) were at the lowest (Figure 2).

During the entire study period, among the growers, 47%, 39% and 16% of the respondents reported a lack of middlemen involvement and an increase and decrease in middlemen involvement, respectively (Kruskal–Wallis $\chi^2 = 36$, $df = 2$, ≤ 0.05). In total, 70% of the population was affected by the market fluctuations (Kruskal–Wallis $\chi^2 = 48$, $df = 1$, p -value ≤ 0.05) and 80% suffered profit loss for their products compared to normal time (Kruskal–Wallis $\chi^2 = 62$, $df = 1$, p -value ≤ 0.05). As a response to COVID-19, during the pandemic period, growers carried out some post-harvest processing or value addition; all the growers in Kerala and 32% of growers in Tamil Nadu conducted post-harvest processing ($\chi^2 = 32$, $df = 1$, p -value ≤ 0.05).

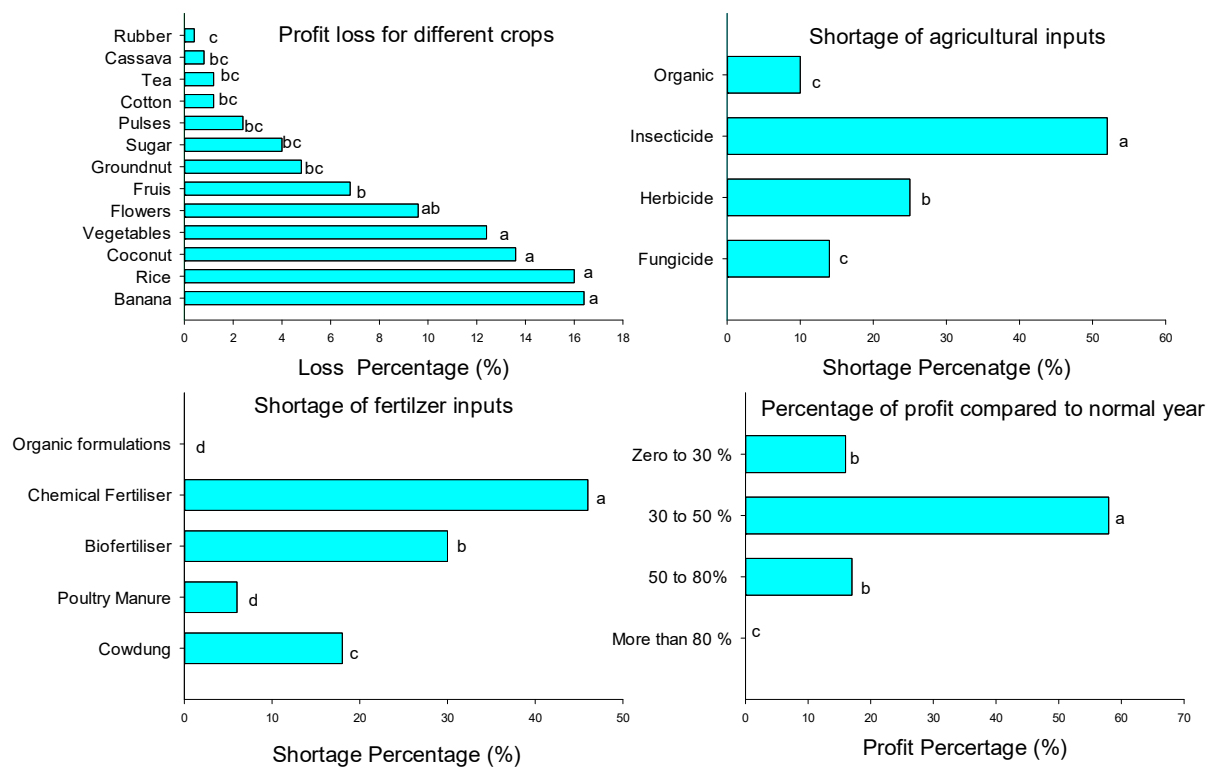


Figure 2. Impact of COVID-19 on profit loss, availability of various agricultural inputs, shortage of fertilizer inputs, and on profit received by growers during the year 2020 compared to the normal year. Different letters indicate a significant difference between the treatments.

The crops that suffered maximum crop loss were mostly perishable commodities, including bananas, vegetables, fruits, and flowers, compared to non-perishable commodities such as rubber, pulses, groundnut, and cotton, which suffered less loss as they could be stored. In addition, as a response to COVID-19, growers attempted post-harvest processing and value addition. A review analysis on COVID-19's impact on the food supply chain also indicated that appropriate marketing strategies could tackle the perishability and wastage of commodities during the pandemic period [3]. The results of this study indicate the necessity for enhancing post-harvest processing facilities and marketing facilities as this could reduce the loss of valuable agricultural commodities, as they are perishable in nature.

3.3. Direct Impact on Crop Cultivation

During the lockdown, only 20% of the growers suffered crop yield loss (lowest among the responses), change was not observed for 48% of the respondents and was significantly higher than those who reported an increase in crop yield (32%) (Kruskal–Wallis $\chi^2 = 22$, $df = 2$, $p\text{-value} \leq 0.05$). The follow-up question indicated that the increase in crop yield was primarily because growers could devote more time in the crop fields as there was a lockdown. Among the growers, none of the growers received profit more than 80% of that received in a normal year (Figure 2). Half of the respondents observed a cropping system change compared to the normal period (Kruskal–Wallis $\chi^2 = 0.20$, $df = 1$, $p\text{-value} = 0.6582$) as a quick response to COVID-19 and 82% of the respondents did not experience any pest outbreaks (Kruskal–Wallis $\chi^2 = 67$, $df = 1$, $p\text{-value} \leq 0.05$); this indicates that a change in cropping or a resurgence of pests have not contributed to crop yield loss. On the other hand, cost of cultivation was increased due to shortage of manpower and machinery, 83% of growers experienced a shortage of labor (Kruskal–Wallis $\chi^2 = 71$, $df = 1$, $p\text{-value} \leq 0.05$) and 68% of the respondents faced difficulty in hiring machinery (Kruskal–Wallis $\chi^2 = 34$, $df = 1$, $p\text{-value} \leq 0.05$). Moreover, 44% of the respondents felt an increase in input costs, while 38% experienced no change, and 18% reported a reduction in input costs (Kruskal–

Wallis $\chi^2 = 81$, $df = 2$, $p\text{-value} \leq 0.05$). The follow-up questions indicated that the decrease in input cost was for the locally available organic materials. Additionally, 68% of the respondents indicated that they could access the credit facilities through the institutions (Kruskal–Wallis $\chi^2 = 41$, $df = 1$, $p\text{-value} \leq 0.05$).

Accessibility to food was decreased for 36%, and 41% of people reported no change in food availability, but only 23% reported an increase in food availability, and that was the least among the respondents (Kruskal–Wallis $\chi^2 = 12$, $df = 2$, $p\text{-value} \leq 0.05$). A total of 79% of the growers experienced an increase in anxiety level and 38% experienced no change in their anxiety level; however, 18% experienced a reduction in anxiety level (Kruskal–Wallis $\chi^2 = 101$, $df = 2$, $p\text{-value} \leq 0.05$). Some of the respondents replied to the supplementary question that the reduction in anxiety level was due to their financial security and the less-perishable commodities they cultivate, such as rubber or cotton.

The study indicates that inadequate availability of farm inputs and difficulties to access the market have constrained the growers. This indicates the necessity to reframe, strengthen, and monitor the supply chain of agricultural inputs right from the beginning phase of such a pandemic or any such catastrophe. Farmers' consortiums can play a major role in procuring and delivering such inputs effectively, minimizing transaction costs, and enhancing bargaining power [36]. The extension system must be strengthened through appropriate policy initiatives to safeguard the uncertainties by providing realistic market intelligence through integrating technologies and evolving decision support systems [37]. A noteworthy point of information is that organic inputs were not in shortage and this could supplement many inorganic inputs. The farmer consultancy and extension services should integrate available organic options, and research needs to be strengthened to develop packages integrating such locally available materials, also considering the environmental benefits of such commodities.

Furthermore, there need to be targeted approaches during such pandemics with due emphasis on training and funding priorities either as subsidy for the vulnerable community through initiating welfare schemes. Perishable commodities faced more losses, indicating the need to have a structured processing facility and network of marketing facilities. Farmers themselves adopted post-harvest techniques to handle the calamity, and the study indicated that profit loss can be minimized through opening avenues for post-harvest handling. The study demands the necessity for structured market interventions to overcome pandemic situations in the future to minimize the impact on the farming sector and the farm households, the majority of whom belong to small and marginal categories.

4. Conclusions

The study indicated that the impacts of pandemics such as COVID-19 on the farming sector and farm households can be at their highest at the beginning phase of the pandemic. Farm labor shortages, input shortages, machinery shortages, poor access to credit and consultancy, and movement restrictions were pronounced during the initial phase of the lockdown, indicating that there needs to be better preparedness in the initial phase to safeguard the sector from major setbacks. During the pandemic, inputs that were supplied through shops faced a shortage especially at the beginning of COVID-19 compared to locally available organic materials, indicating the need to ensure the adequate storage of inputs anticipating such a pandemic. In other words, steps are needed at the beginning phase in the event of information on the pandemic outbreak. Perishable crops viz., rice, bananas, vegetables, coconuts, and flowers suffered maximum crop loss compared to pulses, groundnuts, cotton, and rubber, which could all be stored after harvest. The loss of perishable commodities can be minimized by enhancing structured processing facilities and marketing facilities. Farmers themselves adopted post-harvest techniques to handle the calamity and the study indicates that profit loss can be minimized through opening avenues for post-harvest handling. The rise in cost of cultivation, scarcity of labor force and difficulty in hiring farm machinery have all contributed to profit loss during the pandemic period. The findings that emerge from the study are more important from future policy

and intervention perspectives, as the agriculture sector is otherwise beset with serious challenges affecting marketing and post-harvest storage systems. This calls for increased action by the national and state governments to strengthen the rural agricultural marketing systems, warehousing, and post-harvest management infrastructure.

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