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Assessing the Impact of the COVID-19 Lockdown on Indian Agriculture and Identifying Sustainable Resource Thresholds for Smallholder Farmers

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Abstract

The COVID-19 pandemic prompted the Government of India to institute a stringent nationwide 'lockdown' that severely restricted the movement of people and goods. The lockdown had a strong impact on agricultural harvesting and marketing, which varied across different categories of farmers. Here we find that in the states of Punjab and Telangana, farmers with more than two hectares of landholding were more resilient, while smaller farmers were more susceptible to lockdown induced disruptions–the most problematic being labor shortages. While the large farmers mitigated labor scarcity through the use of harvest machinery, small farmers, constricted by insufficient capital, enlisted the labor of household members to undertake necessary farming activities. The findings of the study suggest that future policies should focus on ensuring easier access to labor, credit and marketing facilities for small and marginal farmers. Such initiatives will require an active contribution by the government.

Keywords: COVID-19, Lockdown, Agricultural marketing, Telangana, Punjab

JEL Classification: Q11, Q13, Q18

Introduction

The impact of the COVID-19 pandemic is manifold, not least because worldwide, governments have implemented a range of policies that strictly limited the movement of people and goods, often referred to as "lockdowns." While these policies have slowed the spread of the virus, they also caused major disruptions to economic sectors that are crucial to global sustainability. Lockdowns disproportionately impact economic activities that require the movement or congregation of large numbers of people, such as the gathering of laborers in locations where seasonal work is available. Reducing these movements threatens all such work, which can exacerbate inequalities in the global economy and reduce sustainability. Agriculture is a major case in point, especially in places where harvesting and marketing activities are dependent on mobile labor.

The agriculture sector is an essential component of the economy in India, where it provides food security to the world's second most populous country. Agriculture is a crucial means of support as it employs 44.2% of the country's workforce, most of which is located in rural areas (NSSO, 2019). The critical role of agriculture extends beyond generating food security and livelihoods; it also ensures the equitable development of rural and urban parts of India and helps counteract inequities between India and the Global North (Pingali *et al*, 2019).

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Indian agriculture primarily occurs during two seasons–the winter (rabi) crop and the summer (kharif) crop (Devendra and Thomas, 2002). In the northern parts of the country, rainfall in both seasons supports growing in both seasons, while in the southern parts of the country, rainfall during the Indian Summer Monsoon supports growing in the kharif season. Rainfall in both regions is supplemented by water storage and bore wells, and the north is also marked by extensive canal systems (Green *et al*, 2020). Here we consider the impact of the lockdown on the farmers in the states of Telangana (southern India) and Punjab (northern India).

The lockdown coincided with the harvest period for winter-grown paddy, maize, pigeonpea and cotton in Telangana (Kamraju *et al*, 2017), and the wheat crop in Punjab, a site of India's Green Revolution (Dhillon *et al*, 2010; Nair and Singh, 2016). Telangana is a relatively new state, carved from Andhra Pradesh in 2014. About 38% of its land is available for agriculture, with a cropping intensity of 125% (GoT, 2017). Agriculture contributes 13% to Telangana's income, and nearly 56% of the state's population is dependent on it. About 56 % of the net cropped area is irrigated (Kamraju *et al*, 2017). The agriculture sector in Punjab is quite different. The state has played an unparalleled role in the growth and development of India since the advent of the Green Revolution in the mid-1960s. About 83% of the geographical area in the state is cultivated and agriculture contributes about 28% to the state gross value added. Punjab occupies merely 1.52% of the total geographical area of the country, but it is the largest producer of food grains (wheat and paddy rice); its share in the central pool of food grains is the highest in the country with a contribution of 25% of rice and 35% of wheat, and the cropping intensity is more than 190% (GoP, 2020).

Harvesting and marketing agricultural produce are more labor intensive than planting or growing of rabi crops, and both of these agricultural activities rely heavily on seasonal labor availability. Mobile labor–a workforce beyond the smallholder that does not permanently reside in the village adjacent to the cropped area–plays a critical role in both regions. In Telangana, workers from adjacent villages travel according to demand for their work in agriculture. These farm laborers often come either from landless families or are those cultivating their own small plots of land. Wages vary widely from region to region, from crop to crop, and from one farm activity to another (Naidu *et al*, 2018). Landless mobile laborers are dependent on daily wages for their livelihood. Punjab has an increased reliance on highly mechanized agriculture, but labor continues to play a crucial role. Agriculture and allied activities employ 26% of the labor force in Punjab (GoP, 2020). In addition to the labor provided by local agricultural labor households and the own labor of small landholders, Punjab's agriculture is mainly dependent on mobile labor, mostly from the states of Bihar and Uttar Pradesh (Mehra and Singh, 2014). This movement is usually cyclical as the labor generally moves according to season – harvesting and sowing – and goes back to native villages (Kaur *et al*, 2011).

India's lockdown was announced on 24 March, shutting down many economic activities across the country. However, a few states like Punjab, Telangana, Kerala, Tamil Nadu and Rajasthan effected some forms of movement restrictions before the national lockdown (Narayanan, 2020). At this time, the crops of the winter growing season were ready for harvest, but the lockdown prevented the movement of migrant laborers and suspended transportation networks, thereby threatening the availability of labor for harvesting and reducing the agricultural system's capacity to bring produce to market (Ray and Subramanian, 2020). Given that the lockdown coincided with the harvesting period of the rabi season, we expected that harvesting and subsequent marketing of crops were likely to face immediate deleterious impacts. The 'complete shutdown' imposed in the state of Punjab occurred when the wheat crop was nearly ready to be harvested. Though movement and availability of farm inputs like seeds and fertilizers were not an issue at this stage, apprehensions regarding impediments to the harvesting and marketing of wheat crop became commonplace. The movement of final produce to mandis (markets) for routine seasonal procurement by the government generally commences from the beginning of April. Therefore, it quickly became clear that India's lockdown posed a particular danger to the agricultural sector. Considering that poverty in the country is concentrated among marginal and small famers, the dangers posed by ramifications of the lockdown were amplified, since the agriculture sector in India is dominated by smallholders who have limited access to land and capital (GoI, 2019; Dev, 2012; Kumar *et al*, 2019).

In Telangana, the lockdown was expected to reduce

the availability of machinery and increase the cost of hiring mobile laborers. In Punjab, it was expected to bring about an outright shortage of both mobile and local labor, machinery and transport; thereby leading to increases in wages, and hiring charges of machinery. In both regions, it was expected that the lockdown would also affect the costs of seeds and fertilizers, and other farm inputs and services in the forthcoming kharif season.

The lockdown was also expected to stymie marketing. In India, under the public procurement system, the agricultural produce is procured by government agencies at a Minimum Support Price (MSP). The MSP of a commodity refers to the price at which government procures the commodity from producers in order to maintain the buffer stock, which feeds the public distribution system for food security in the country. Further, the MSP ensures remunerative prices to the farmers for their produce and thus, incentivizes better production (Jain, 2019). Under this system, farmers arrive at the paddy procurement centers (PPC) with their Identity Document, which is required for registration, and they request an advance token. P-PAS facilitates the Society/ Agency preparing the schedule of purchase for each farmer for hassle free transactions at the PPC. A maximum limit is fixed for a single purchase from a farmer and daily purchase of the PPC. In Punjab, the produce is typically sold through commission agents, also known as Arhtiyas, who receive the payments for the produce sold which is then transferred to the farmers. By contrast, in Telangana, farmers sell directly to the government through the procurement process and receive payment within 45 days. It is noteworthy that almost all small farmers are dependent upon these agents in Punjab, as they also act as moneylenders providing credit. The farmers undertake collateral free borrowing from them, which is often attached to prospective produce to be sold, to be returned at the time of sale. The payments for the sold produce, received by these agents from the government for the sale of produce is passed on to the smaller farmers after the deduction of outstanding credit (Singh and Bhogal, 2015).

The lockdown was expected to constrain sale of produce since many mandis that catered to bulk produce were shut during the initial weeks of national lockdown (Narayanan, 2020). A few state governments, including Punjab and Telangana, took early measures and issued clarifications to include agriculture in the list of essential services, and make arrangements for smooth sale of agricultural produce (Narayanan and Saha, 2021). Nonetheless, the movements of officials responsible for procuring crops, and also the labor in the mandis that facilitate the cleaning, sewing, packing, loading and unloading of produce faced challenges (Ceballos *et al*, 2020). Furthermore, the lockdown was likely to impede the movement of the produce itself, thereby potentially delaying payments to farmers. The ramifications of lockdown were expected to be particularly grave for resource-poor smaller farm households that form more than 85% of the total farm households in the country. It is pertinent to note that smallholder farmers are reliant upon regular cash flow dependent on timely sale of produce, so the distress that was feared resultant of the ramifications of the lockdown was acute.

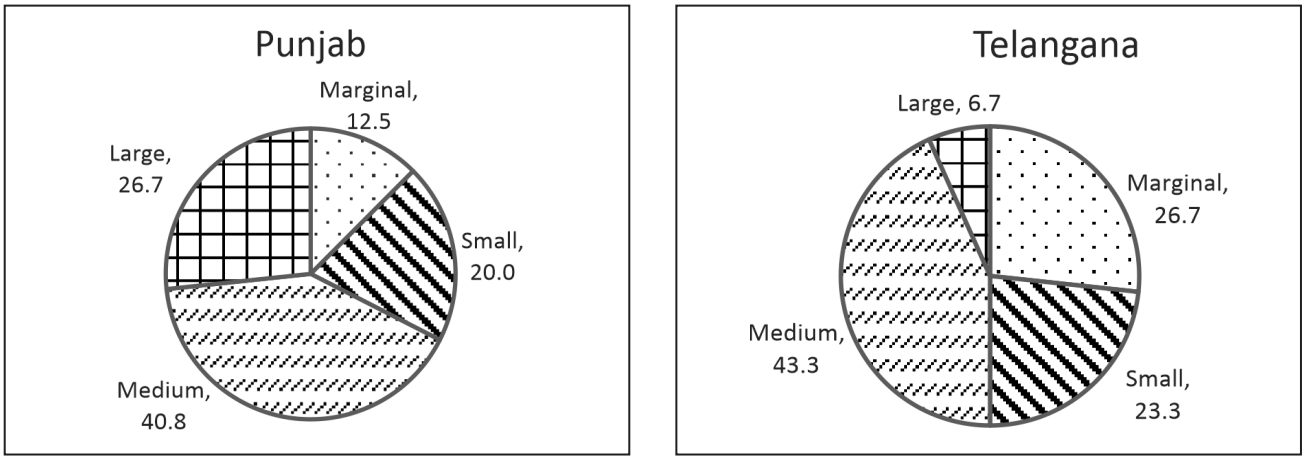

Figure 1. Distribution of sampled farmers according size of landholdings (%)

Data Sources and Methodology

In May 2020, the authors undertook a telephonic survey to collect information about the impact of the pandemic induced lockdown on farmers and the ways that they responded to its strictures. As part of the collaborative TIGR2ESS Project, the authors conducted a rapid survey of a sample of 150 farmers with different assets in two of India's contrasting agricultural zones: semi-arid Punjab and dryland Telangana (Figure 1). Under the ongoing FP4-TIGR2ESS project, the team maintains a series of databases of farmers in both Punjab and Telangana. From these a random selection of farmers, that were available via telephone, was made for the present study. The survey was conducted in the early month of May. This rapid assessment set out to gain insight into the lockdown's acute effects on harvesting rabi crops and planning for the upcoming summer (kharif) agricultural season.

The need to undertake a rapid investigation of the impact of the lockdown on rural farming communities was evident, so the team devised a questionnaire designed to capture information about farming activities. Based on preliminary discussions with various stakeholders, questions regarding labor availability and cost, machinery availability and hiring charges, marketing and procurement, and expected changes during the kharif season were engendered in a structured questionnaire. Farmers were appraised of the project and had provided consent to the telephonic survey, which required approximately 30-40 minutes to complete. An example of the baseline questionnaire has been included as a supplement.

The team surveyed farmers in two regions that, together, represent distinctive aspects of India's agricultural system. Punjab receives water from both the summer monsoon and winter rains, which allows farmers to produce multiple crops within a single year. It has long served as a major agricultural hinterland in South Asia. Telangana represents one of India's dryland agricultural centers, with a cropping system that relies far more on seasonal monsoon rains. Together, the two states provide complementary perspectives on a range of agricultural systems in India. The aim of selecting these two states was to produce a sample that could provide some general insights about India's agricultural system while also producing specific information about farming in Punjab and Telangana. The survey was assembled and conducted as quickly as possible given the time constraints facing the project.

In Telangana, a group of 30 farmers from three villages (Houzebuzurg, Neredpalli, Nandiagma) was selected for the study. The average size of landholdings in Telangana was 2.3 hectares; the average landholding of the marginal (up to 1 hectare), small (1-2 hectares), medium (2-6 hectares) and large (>6 hectares) farmers was 0.7, 1.5, 3.0 and 7.49 hectares respectively. Farmers that owned less than 2 hectares formed 50% of the total sample while medium farmers formed 40% of the total sample (Figure 1). The primary occupation for all the sampled farmers in Telangana was farming. Working as farm labor was the most common secondary occupation, followed by employment in agriculture related business. In Punjab, the data from 120 farmers was collected from six districts namely Amritsar, Barnala, Ludhiana, Moga, Patiala and Sangrur. The average landholding in the state was found to be 5.1 hectares; that of the marginal, small, medium and large farmers was 0.8, 1.7, 3.9 and 8.1 hectares respectively. Farmers that owned less than 2 hectares formed 32.5% of the total sample in Punjab while medium farmers formed a major proportion (40.8%) of the total sample, and was followed by large farmers (26.7%). The primary occupation of the sampled farmers in the state was farming as about 91% of them were engaged in farming as their primary occupation, followed by dairying and livestock rearing.

In Telangana, some farmers became emotional and worried while answering, which is understandable by the pandemic shock. However, no one was reluctant and they answered everything patiently. In Punjab, farmers were worried about the lockdown and impending shortages and crop production. Nonetheless, they were willing to respond and did not defer the questions.

Results and Discussion

We found that labor shortages, higher wages, and expensive and limited transportation were indeed common challenges, but a combination of farmer action and state-level action helped to avert the worst possible outcomes. One major revelation was the effectiveness with which the farmers themselves identified and adapted to different issues. Over the course of the rabi season, farmers were by and large adaptable.

We found that the size of the farmers' plot was the critical variable for determining farmers' capacity to mitigate lockdown consequences, and their resilience

to disruptions. Farmer's landholdings varied from marginal (0-1 hectare), small (1-2 hectare), medium (2-6 hectare) and large (>6 hectare). In both Telangana and Punjab, the average landholding was modest; the average area of landholdings of the sampled farmers in Telangana was 2.3 hectares, while that in Punjab was 5.1 hectares.

In Telangana, about 47% of farmers faced issues of labor scarcity and about 30% claimed that there was an increase in wage rates (Table 1). As a result, the number of manual days, with the available labor, for harvesting increased; thus, delaying harvest. These delays had a greater impact on farmers with more than 2 hectares of land, as larger landholdings meant that a larger number of manual labor days were required, and thus, more delay in harvesting. About 33% of sampled farmers mentioned problems of gaining access to machinery for harvesting crops, and 7% claimed increase in hiring charges of machinery. The resultant harvesting delays led to considerable post-harvest losses. Most farmers resorted to the use of machinery for harvesting to mitigate labor shortage, but insufficient machines led to shortages and a rise in hiring charges of machinery. It was observed that the farmers waited patiently for the availability of machinery and cooperated well to overcome the crisis. Marginal farmers enlisted family members more than their larger counterparts to ensure the timely harvest of crop, thereby avoiding losses. Though both men and women participate in farm activities, rural women often multi-task, and assist in producing agricultural crops, as well as tending animals, processing and preparing food, collecting fuel and water, caring for family members and maintaining their homes (FAO, 2011). The practice of enlisting family members to do more work in the harvest risks potential increases in gender inequality, as women tend to work longer hours on smallholder farms and must often balance agricultural and household activities.

In Punjab, labor shortfalls were identified as a prominent problem during the harvesting of wheat crop as about 51.9% of surveyed farmers experienced shortfalls in availability of migrant and to a lesser extent of local laborers, and about 34.6% incurred increased costs of wages during the time of harvesting (Table 1). Local laborers were employed by 27.5% of total farmers, while about 7.5% drew on the labor of other small farmers, friends and family members who were not earlier engaged in agricultural activities (Table A1a). Consequent to the labor shortage, the rise in hiring charges seemed to be insurmountable. In a few villages of Punjab, the labor costs escalated by about 50%. As a result of the escalated wages, 16.7% of total farmers incurred higher expenditure on wages (Table A1b). However, about 6% of farmers decided to substitute labor with mechanization for harvesting wheat to counter the extreme escalation in wages. Most of the wheat produce in the state is harvested using machinery with labor playing an essential supplementary role. Overall, the labor shortage in Punjab was managed by farmers, and therefore, did not create any dire situation for the primary harvesting process. Only about 9% of the total farmers complained of problems in arranging machinery and 1.2% reported of problem of higher hiring charges of machinery. Since marginal and small farmers are often resource poor, high wages and labor scarcity hit them the hardest.

Delayed and staggered procurement were also notable impediments to marketing in both states.

Table 1. Distribution of farmers according to the problems faced during harvesting of wheat crop (multiple response) (in per cent)

Category of farmers	Scarcity of labor		High wage rate		Availability of Machinery		High hiring charges of machinery		Any other	
	Pb	TS	Pb	TS	Pb	TS	Pb	TS	Pb	TS
Marginal	71.4	25.0	28.6	13.0	-	38.0	-	13.0	-	-
Small	50.0	29.0	33.3	14.0	16.7	29.0	-	-	-	-
Medium	48.6	62.0	35.1	38.0	10.8	31.0	-	8.0	5.4	-
Large	52.0	100.0	36.0	100.0	4.0	50.0	4.0	-	4.0	-
Total	51.9	47.0	34.6	30.0	8.6	33.0	1.2	7.0	3.7	-

Note: Pb is Punjab; TS is Telangana

Table 2. Distribution of farmers according to problems faced during marketing of rabi crops (multiple response) (in per cent)

Category of farmers	Delayed procurement		Staggered procurement		Less price than MSP		Delayed payment		Decline in demand		Transporta-tion		Any other	
	Pb	TS	Pb	TS	Pb	TS	Pb	TS	Pb	TS	Pb	TS	Pb	TS
Marginal	40.0	100.0	-	-	-	-	40.0	-	-	-	-	-	20.0	-
Small	25.0	85.7	50.0	-	-	-	25.0	-	-	14.3	-	28.6	-	-
Medium	29.4	100.0	35.3	-	2.9	-	5.9	7.7	2.9	23.1	23.5	23.1	-	-
Large	29.6	100.0	29.6	-	3.7	-	14.8	50.0	-	-	18.5	-	3.7	-
Total	30.0	96.7	31.4	-	2.9	-	12.9	6.7	1.4	13.3	18.6	16.7	2.9	-

Note: Pb is Punjab; TS is Telangana

About 97% of Telangana's farmers reported delayed procurement as a result of the lockdown (Table 2). Late procurement was expected to cause delay in payments. However, only about 7% of the sampled farmers faced the problem of delayed payment. Though transportation of machinery and produce was permitted, about 17% of sampled farmers in the state mentioned transportation issues as a constraint during the pandemic lockdown. However, all of the surveyed marginal farmers waited patiently for the effects of lockdown to recede to avoid incurring higher expenditure. Paddy grown rice is procured by the Government, who paid a higher price (Rs 1860/-) than last year (Rs 1810/-), so there were no price related difficulties. It is noteworthy that a few farmers sowed their rabi crop late and harvested late. Thus, the immediate aftermath of the lockdown was manageable for some.

The Punjab government, which has one of India's most advanced procurement systems, was well aware of the situation and took necessary steps to ease the lockdown for agricultural activities. The government employed extensive measures to ensure the timely procurement of wheat through a staggered procurement system that would limit gathering of farmers and avoid a sudden rush for transportation. Under this system, the farmers were issued tokens which stipulated the time and quantity to be sold, and any quantity over this amount was to be sold via another token at a later time so as to cater to the maximum number of farmers and avoid panic. Despite the arrangements, about 30% of the farmers reported the problem of delayed procurement. Also, about 31% farmers faced problems due to staggered procurement (Table 2). Delayed payments were experienced by about 12.9% of the total farmers. This problem was more worrisome among marginal farmers as 40% of the total number of marginal farmers complained of it. The delay in payments for the sale of produce that is sourced through commission agents had a more pernicious impact on smaller farmers than their larger counterparts, as it is their major source of income that comes from the sale of crops, while large farmers typically have additional reserves to draw on in the event of delayed payment. Despite the challenges, Punjab farmers managed to sell almost all the produce at the MSP. The effectiveness of procurement system set up by the state government was visible from the fact that only 1/5th of the farmers had to store their produce for a few days at home before selling it in the mandi. However, the majority did not need to store and thus, sold the produce directly in the market after harvesting (Table A2).

Looking ahead, there were notable differences among farmers with regards to planning for the upcoming kharif season, mainly due to variation in financial capacity. All farmers were apprehensive of the future, but those with smaller plots planned to make only slight changes to cropping, while those with larger plots planned to experiment with diversification. Of sampled farmers in Telangana, paddy was cultivated on about 55% of the total land used in the 2019 kharif season. Most farmers anticipated retaining this cropping pattern in the upcoming 2020 kharif season. Cotton was cultivated in 30% of the total area during the 2019 kharif season, but farmers predict this will be reduced to 25% in the 2020 season. Maize, groundnut, turmeric, chilli and other upland crops occupied 4%, 5%, 4%, and 2% of total area during the 2019 kharif season, however, the area dedicated to these crops is likely to change to 5%, 9%, 4% and 3% respectively in 2020. Thus, excluding paddy, changes in cropping pattern are predicted to be used as an approach to adapt to the lockdown (Figure 2a).

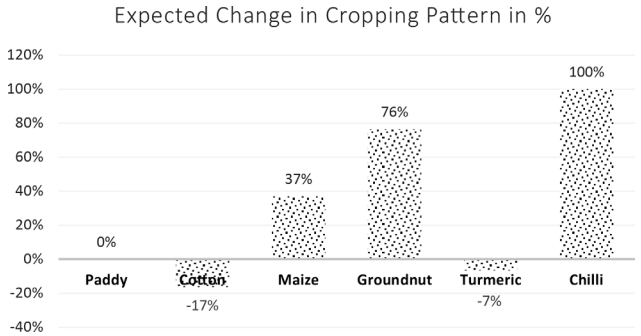

Figure 2a: Expected change in cropping pattern (%), Telangana

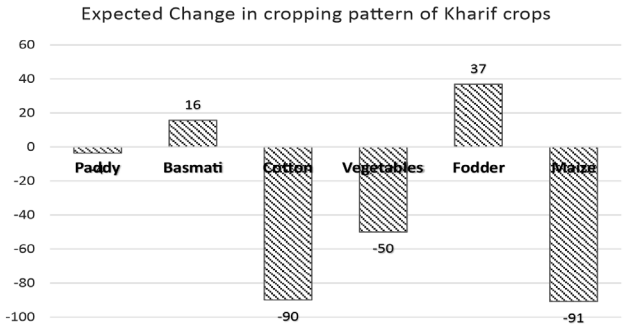

Figure 2b: Expected change in cropping pattern (%), Punjab

In Punjab, most of the farmers intended to cultivate paddy over the same area of farmland as they did in 2019. However, many reported plans to increase the cultivation of basmati rice as it has a shorter growing season and thus, the labor shortages could be averted by sowing late. Thus, some changes in cropping pattern are expected as an outcome of pandemic lockdown (Figure 2b). A large percentage of farmers (72%) anticipated labor shortage in the 2020 kharif season (Table 3). Further, most of the agricultural operations in the paddy-wheat system are mechanized, but paddy transplantation is still done manually and is labor intensive (Singh *et al*, 2017). In order to deal with the anticipated problem of labor shortage and the subsequent higher costs in the approaching 2020 kharif season, the majority (31.7%) of farmers expressed the plausibility of adopting mechanization for paddy sowing in Punjab (Table A3). They therefore began prioritizing the arrangement of machinery, especially arranging for Direct Seeded Rice (DSR) machines that would promote labor saving. Another 19.2% of farmers were planning to arrange labor from their own and nearby villages to meet the required demand in the forthcoming kharif and future seasons. A class analysis reveals that while more of the marginal farmers were keen to arrange labor while a larger proportion of the medium and large farmers were planning to undertake labor substitution with machinery.

In Telangana, 47% of total sampled farmers had been expecting trouble with regards to gaining access to high-quality seeds while 43% forecast unavailability and higher cost of fertilizers, herbicides, and pesticides in the 2020 *kharif* season (Table 3). As much as 13% of sampled farmers foresaw increases in labor charges to be permanent, and that these must be accounted for in upcoming seasons. All the above-mentioned issues may contribute to overall increased cost of cultivation in the future. About 33% of sampled farmers expected no problem and had no idea of what to expect in the forthcoming kharif season. Many Telangana farmers depend on local money lenders for credit. As many as 57% of the sampled farmers reported no difficulty in accessing credit for the upcoming season, but the

Table 3. Distribution of farmers according to anticipated issues to be faced during the approaching kharif season (multiple response) (in per cent)

Category of farmers	Buying of improved seeds		Buying of fertilizers/ agro-chemicals		Hiring of labor		Hiring of machinery		Prices of crops		Marketing of crops		Methods of cultivation	
	Pb	TS	Pb	TS	Pb	TS	Pb	TS	Pb	TS	Pb	TS	Pb	-
Marginal	9.5	50.0	14.3	-	47.6	-	9.5	-	9.5	-	4.8	-	4.8	-
Small	16.7	57.1	20.8	57.1	70.8	42.9	8.3	-	4.2	14.3	-	-	12.5	-
Medium	20.4	38.5	20.4	53.8	73.5	7.7	10.2	7.7	12.2	-	8.2	7.7	14.3	-
Large	56.3	50.0	50.0	100.0	143.8	-	43.8	-	25.0	-	12.5	-	62.5	-
Total	20.8	47.0	21.7	43.0	71.7	13.0	13.3	3.0	10.8	3.0	5.8	3.0	17.5	-

Note: Pb is Punjab; TS is Telangana

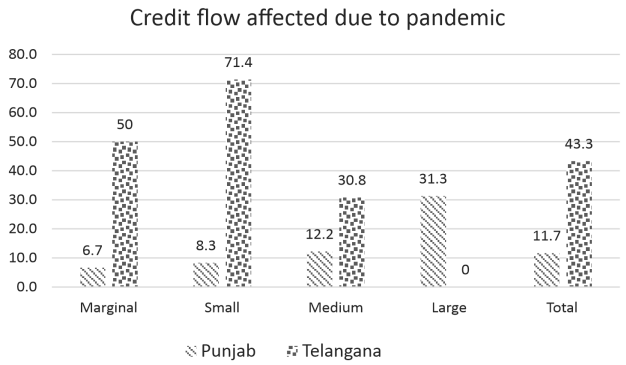

Figure 3. Distribution of farmers according to problem of insufficiency of credit

remaining 43%, which are predominately small and marginal farmers, faced situations of lack of credit availability during the lockdown (Figure 3). While state and central governments are taking all the necessary steps to protect agricultural activities, the lockdown is sure to affect production and distribution of farm inputs such as improved seeds, fertilizers, pesticides and herbicides. The timing of the application of these inputs is essential, and farmers were worried about the quality of inputs available and the higher costs to be incurred.

An upward of 21% of farmers in Punjab were bracing themselves for challenges in arranging inputs like seeds and fertilizers. In order to avert delays and unavailability of kharif crop seeds from the routine sources like local dealer shops, about 9.2% of the farmers planned to acquire seeds from fellow farmers, while about 5.8% planned to procure from the only regional agricultural university–Punjab Agricultural University–and its supported extension institution (Krishi vigyan Kendra- KVK) well before time (Table A4). Further, only about 12% of the farmers in Punjab complained about problems in accessing credit primarily due to restrictions in movement. As many as one-third of the farmers experienced decline in yields, but these were reported to be an outcome of factors other than those related to lockdown, and the majority of farmers that were affected were large landholders. Under these challenging circumstances it is perhaps no surprise that sustainable water use was not high on the agenda for many farmers, and in Punjab 32.5% of the farmers assumed the water use might increase. This was expected to be exacerbated by the preponement of the date of sowing was expected to tempt a larger use of water (Table A5). About 33 % of the farmers were moderately open to experimenting with new techniques and technologies to help mitigate excess water use (Table A6).

Conclusion and Policy Implications

Farmers with access to more land were better able to adapt to the changed circumstances and better positioned for the upcoming kharif season, while farmers with access to less land and fewer assets were more likely to draw on household labor. Individual farmer initiatives and state government support enabled the successful management of these obstacles, and facilitated the planning required to tackle the likely constraints during the approaching kharif season.

During the crisis, large farmers were better positioned to address the labor shortages with machinery, while the marginal and small farmers relied on their informal networks and household help from family members who would not normally have been involved in agriculture to ensure timely harvest. These strategies are well attested in the literature on smallholder farming (Netting, 1993). Harvest machinery allowed some farmers to make up for labor shortfalls. However, availability of machinery hiring centers, skilled technicians and service centers in the vicinity play a major role in adopting those technologies. Interestingly, the relatively affluent farmers with access to comparatively larger landholdings were able to combine usage of machinery and labor based on their resources and issues. They appear to be positioned on an important resilience threshold.

A range of public, private and research-led capacity building programs, training courses and information technology together can help build resilience to future lockdowns. Policies aimed at mitigating lockdown–induced distress must focus on small and marginal farmers by ensuring easier access to credit to meet the financial needs to mechanize and use expensive labor and farm inputs and giving them preference during public procurement. To help these vulnerable smallholder communities accommodate the increased wage rates, it is crucial to fix a ceiling rate of agricultural wages that could be enforced through local authorities. The likely economic impact of the lockdown on agriculture in the forthcoming kharif and future *rabi* seasons might be minimized if crop diversification and farming techniques that are less labor-intensive or reduce the concentration of demand of labor are

incorporated in the future plans. Also, easy availability of paddy rice sowing machinery, which could be made available through partnerships with custom hiring centers and NGOs, would be very useful. These steps would not only increase the sustainability of India's agriculture while weathering the lockdowns necessary to stem the spread of COVID-19, but also provide strong grounds for growth in the state agricultural sector and farmer prosperity in the long run.

The national rural employment guarantee scheme under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), 2005 can also play a role. By providing employment, the scheme can assure additional income that can sustain farmers during adverse time periods, especially during a lockdown. Increasing smallholder resources may also facilitate continued crop diversification and the implementation of less-labor intensive techniques of paddy-rice sowing, which are measures that can increase long-term sustainability.

The systematized procurement of paddy rice has brought transparency and benefitted millions of farmers. However, the marketing of crops that do not fall within the government procurement system are facing severe issues of transportation, middlemen and marketing techniques especially during a pandemic period where social distancing and fear of COVID-19 made farmers succumb to pressures. A clear trading system for all the crops from the farm gate–the place of production–will be beneficial to farmers in the future growing seasons.

Digital and information technologies may also strengthen the resilience of marginal and small farmers. There has been a significant increase in the usage of smartphones in villages. Information related to the sources of different farm inputs (ranging from seeds to agrochemicals) and labor availability in their vicinity may help mitigate costs. Increased information technology use can help farmers learn about prices, close the communication between small and large farmers, unavailability, and increase employment opportunities for the daily wage earners.

The findings presented here underscore the fact that in both semi-arid and dryland regions, farmers with limited access to land and resources are most susceptible to disruption from lockdown policies that restrict the movement of mobile labor. These finding have important ramifications for how public, private, and research-led initiatives can best aid policymakers in increasing the resilience of agricultural systems. Initiatives that equal the playing field for farmers with smaller landholdings by controlling for labor scarcity, strengthening procurement systems, supporting crop diversity, and making capital-intensive machinery available can help move farmers toward a resilience-threshold and improve their ability to cope with crisis, including the challenges of national lockdowns. The role of the federal and state Governments, farmer cooperatives and other agricultural related institutions is critical to cope with unpredictable socio-economic environment and improve adaptability and resilience threshold of the vulnerable farmers in the future. These findings from the semi-arid and dry regions in India have important implications and relevance for other regions of the world with similar climate parameters.

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ANNEXURES

A1. Distribution of farmers according to measures taken to tackle labor issues for rabi crops, Punjab (%)

a. Issue of scarcity of labor

Category of farmers	Arranged local labor	Engaged other farmers, friends and family members
Marginal	33.3	0.0
Small	25.0	0.0
Medium	32.7	4.1
Large	18.8	21.9
Total	27.5	7.5

b. Issue of high wages

Category of farmers	Adopted mechanization	Incurred higher wage	Negotiated for lower wages
Marginal	6.7	6.7	0.0
Small	4.2	12.5	0.0
Medium	8.2	16.3	2.0
Large	3.1	25.0	0.0
Total	5.8	16.7	0.8

A2. Distribution of farmers according to management of wheat produce, Punjab (%)

Category of farmers	Sold to neighbours and local retail market	Stored at home or neighbours' storage	Sold in Mandis	Other/Multiple
Marginal	20.00	13.33	66.67	-
Small	0.00	0.00	79.17	20.83
Medium	0.00	0.00	77.55	22.45
Large	3.13	3.13	65.63	28.13
Total	3.33	2.50	73.33	20.83

A3. Distribution of farmers according to measures planned to deal with perceived shortage of labor during kharif season, Punjab (%)

Category of farmers	Arrange local labor	Arrange machinery	Arrange both local labor and machinery	Crop diver-sification	Engage Fellow farmers for labor	Incur high expenditure	Wait for labor
Marginal	26.7	6.7	13.3	0.0	6.7	6.7	6.7
Small	20.8	29.2	4.2	8.3	0.0	0.0	8.3
Medium	12.2	40.8	16.3	0.0	0.0	0.0	4.1
Large	25.0	31.3	6.3	0.0	0.0	9.4	0.0
Total	19.2	31.7	10.8	1.7	0.8	3.3	4.2

A4. Distribution of farmers according to measures taken to deal with expected shortage of paddy seeds during kharif season, Punjab (%)

Category of farmers	Arrange from other farmers	Purchase from PAU	Incur high expenditure	Still waiting
Marginal	0.0	6.7	0.0	6.7
Small	4.2	8.3	4.2	0.0
Medium	12.2	2.0	2.0	4.1
Large	12.5	9.4	3.1	3.1
Total	9.2	5.8	3.3	3.3

A5. Distribution of farmers according to expected change in water use in kharif season, Punjab (%)

Category of farmers	Greatly increased	Moderately increased	No change	Decreased
Marginal	0.0	20.0	73.3	6.7
Small	0.0	37.5	62.5	0.0
Medium	4.1	32.7	61.2	2.0
Large	3.1	34.4	50.0	12.5
Total	2.5	32.5	60.0	5.0

A6. Distribution of farmers according to readiness to adopt new technology for paddy cultivation, Punjab (%)

Category of farmers	Very open	Moderately open	Moderately opposed	Very opposed	No response
Marginal	0.0	13.3	6.7	0.0	80.0
Small	0.0	41.7	8.3	4.2	45.8
Medium	6.1	36.7	0.0	4.1	53.1
Large	6.3	28.1	6.3	0.0	59.4
Total	4.2	32.5	4.2	2.5	56.7

A7. Distribution of farmers according to measures taken to tackle shortage of machinery for wheat harvesting, Punjab (%)

Category of farmers	Arranged machinery immediately when required	Waited to arrange machinery
Marginal	0.0	0.0
Small	0.0	8.3
Medium	4.1	4.1
Large	0.0	3.1
Total	1.7	4.2

A8. Distribution of farmers according to measures taken to deal with transportation issues, Punjab (%)

Category of farmers	Incurred higher cost	Pooled resources with fellow farmers	Stored part of produce	Completely stored	Sold locally
Marginal	0.0	0.0	0.0	0.0	0.0
Small	12.5	4.2	4.2	8.3	4.2
Medium	6.1	2.0	2.0	4.1	2.0
Large	15.6	0.0	0.0	0.0	0.0
Total	9.2	1.7	1.7	3.3	1.7

A9. Distribution of farmers according to source of information, Punjab (%)

Category of farmers	Govt official	Local farm societies	Shopkeeper	Media	Multiple	Other
Marginal	20.0	13.3	33.3	13.3	20.0	0.0
Small	16.7	8.3	33.3	8.3	16.7	16.7
Medium	20.4	14.3	8.2	20.4	30.6	6.1
Large	34.4	3.1	18.8	25.0	12.5	0.0
Total	23.3	10.0	19.2	18.3	20.0	9.2