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Risks in rainfed agriculture and adaptation strategies in India: Profile and socio-economic correlates

by Suresh A. Kurup, A. Amarender Reddy, D.R. Singh, and K.V. Praveen

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Abstract

Risks in rainfed agriculture has generated wide discussion India in the context of the reported farm distress. In this study, the risks in rainfed agriculture, major adaptation strategies followed by farmers and the covariates of adaptation strategies are studied. Results suggested that farmers face a multitude of risks in the realms of weather aberrations, input supply, crop management, and output marketing. The adaptation strategies were related to varietal management, community support, price stabilisation mechanism, government support, and self-insurance. The study points to the need for early warning system for weather and price forecasts, flexible credit delivery, supply of quality inputs at affordable prices and interventions for efficient output delivery. The farmers' adaptations to the risks were positively correlated with the value of owned assets, availability of farm labour and machinery as well as farm information. The study suggests considering risk as an integral component while developing farm income improvement strategies.

Keywords: Rainfed farming, risk perception, risk adaptation, adaptation index, farm income, climate change

1. Introduction

Agricultural activities all over the world confront multitude of risks and uncertainties continuously (Saqib et al., 2016). The income that the farmers realise from agriculture, particularly in rainfed region, is of high variability rendering it risky (Praveen et al., 2018). In India, where agriculture is the livelihood source of close to half of its 1.3 billion population, extreme climatic events instils risks of varying kinds and magnitudes for farmers (Swain, 2014). Due to high risks farmers usually make sub-optimal decisions (Yang et al., 2015; Karlan et al., 2014). Often, the impacts transcend to whole economy through slowing down of the rural demand for industrial goods. It has several social repercussions too. Incidence of farm distress is quite widely reported in media, and is expressed most severely as suicides of farmers, particularly from rainfed regions, reportedly due to direct and indirect effect of farm risk (Mishra, 2008; Bhullar et al.,2011; Grue`re and Sengupta, 2011; Nagaraj et al, 2014; Carleton, 2017). The simmering dissatisfaction has led to farmers' unrest in many states in India (Posani, 2009).

Risks are identified as a situation affecting the well-being of a firm or decision maker, associated with an element of probability (Moschini et al., 1999). A state of risk is considered to exist whenever knowledge of the situation enables the likelihood of various possible events to be assessed in advance (Williams and Schroder 1999; Cooper et al., 2003;). One incident of high risk manifested in Indian agriculture is the Bengal famine, which resulted in the death of about 1.5 to 3.0 million people during 1942-43 (Mukerjee, 2010). In the wake of the green revolution, the issue of risks was further discussed intensively (Mehra, 1981; Ray, 1983; Mahendradev, 1987; Larson et al., 2004; Sharma et al., 2006; Chand and Raju, 2009). Risks associated with agriculture in India, hence, have always remained an important issue, attracting attention of researchers and policymakers, and had attained a political overtone.

The pattern of risks in rainfed regions differs systematically from that in irrigated regions (Kerr, 1996), mainly due to the exclusive dependence on erratic rainfall to maintain desirable soil moisture for plant growth. However, resilience of the rainfed regions following a shock in the system will increase with the adoption of integrated farming systems with significant livestock component and hardy crop combinations (Rao, 2004; Raina, 2006; Deshpande, 2008). The net income generated by a rainfed farmer is typically much lower than that of a farmer in the irrigated system on the same piece of land. With emergence of a farming system that largely depend on industry-based inputs, the cost of cultivation in rainfed region has grown at a faster rate compared to value of output (Suresh et al., 2014). With the commercialisation of agriculture during the past two decades, the rainfed region in India has largely adopted high input intensive agricultural practices and farm technologies without much focus into salient difference in agro-ecology which has to support the intensive input application (Raina, 2006; Deshpande, 2008). The market economy and price (of inputs and outputs) and non-price factors (like Bt cotton technology) supported intensive agricultural practices. Commercialisation of agriculture forced rainfed farmers to take excessive risks beyond the capacity of the rainfed ecosystem. This has resulted in the terms of trade moving against the farming community in the rainfed regions of India (Suresh et al., 2014). Besides this, low level of development of institutional capabilities like credit, insurance and markets in rainfed areas were not able to provide necessary safeguarded against risks faced by the rainfed farmers (Rao, 2004; Chand et al., 2010; Deshpande, 2008). The enhanced risk and vulnerability and low level of institutional support on the face of faded traditional coping strategies on several fronts had implications on wellbeing of farming community.

The overwhelming importance of rainfed farming system emerges from the fact that as on 2015, only 48 % of net sown area in India is irrigated, and the rest is cultivated under rainfed condition depending solely on rainfall. The rainfed areas, which covers about 52% net sown area accounts for about 40% human population, 60% livestock, 40% foodgrain, 85% coarse cereals, 83% pulses, 70% oilseeds, and about 65% cotton (Venkateswarlu and Prasad, 2012). Even at the best possible growth scenario of irrigated agriculture, about 40% of the long-term additional food and 50% of fibre requirement needs to be met out from the rainfed regions.

Cotton in rainfed agriculture

Cotton is typically grown in rainfed regions in India. It occupied an area of about 11 million hectares in 2016, with a production of about 33 million bales. About 66% of cotton in India is rainfed. Being a cash crop, it is affected severely by risks in input and output side. Introduction of genetically modified cotton, namely Bt Cotton, forced farmers to undertake intensive cultivation with higher use of inputs like fertilizer, pesticide and seed. Cotton is a global commodity with widely fluctuating world prices, further the crop is highly susceptible to various pests and diseases, which make it a test case for studying the risks in rainfed agriculture in India (Gandhi and Namboodiri, 2006; Pray and Nazeem, 2007; Subramanian and Qaim, 2010).

Sources of risks in rainfed agriculture and their adaptation strategies

Farm income risks arise due to several reasons, and are influenced by weather, biotic factors, input induced factors and farmer specific factors (Donovan, 2012; Ramaswamy et al., 2003). Market vagaries influence income risk post-harvest, mostly through price fluctuations. Since risks in agriculture are of multi-dimensional, the adaptation to it also is multi-dimensional in approach. The polity in India has responded to the issues of the risks though several instruments- by announcing and effecting minimum support price (MSP)- a guaranteed price offered by the government at which it would procure the quantity supplied in the market- for many crops, rolling out crop insurance schemes, measures to deepen institutional credit delivery, various farm input subsidies, development and release of pest and disease resistant varieties, public distribution systems (PDS) and direct money transfer in line with targeted basic income on per hectare basis to the targeted population, to mention a few. However, the efficacy of these measures is a matter of debate. The Situation Assessment Survey (2013) of National Sample Survey Office (NSSO) reports that only about 31-39% farmers are aware of MSP, even for rice and wheat. Further, MSP is not operating except for a few crops, limited to selected states. The crop insurance scheme also not adopted by many farmers due to lack of awareness and low and delayed claim payments (Ghosh et al., 2020). Apart from these instruments, farmers also undertake several adaptation strategies, at individual as well as community level, both *ex ante* and *ex post* (Kaiser et al., 1993; Adger et al., 2003; Ramaswami et al., 2003). The *ex-ante* adaptation strategies are those adapted anticipating a risk before the risk incidence whereas the *ex-post* strategies are those adopted after the incidence of the risk to minimise its impacts. Risk perception is central to their adaptation (Lyle, 2015). Many times, the farmers do have unique adaptation pathways (Bardsley et al., 2018).

A response strategy to the farm risk needs identification of the risks faced by the farmers and the adaption strategies against it. There a number of studies on farm risks in India, mostly taking into account a single source of risk, for example, water scarcity, climate change, and ineffective crop insurance (Tripathy and Mishra, 2017; Shah, 2009; Aggarwal, 2008; Gaurav, 2015). A comprehensive profiling of risk and adaptation against is scarce. In this context the present paper (i) profiles farmers' perception on agricultural risk and the adaptation strategies followed by them both *ex ante* and *ex post*, and (ii) to identify the correlates of the adaptation.

2. Material and methods

The impact of risk is a product of farmers' exposure to risk, vulnerability to it and adaptive capability against it. The major drivers of changes in disaster risk and its impacts are exposure and vulnerability. Exposure to risks is based on several factors- incidence of risk and the probability that a farmer is exposed to it. Though vulnerability is a key concept used in disaster risk and climate change adaptation, it is applied for a wide range of contexts (Cardona et al., 2012). Some risks, mainly of climatic origin, falls upon the farmers rather uniformly. High level of exposure and vulnerability owes it largely to several factors including environmental mismanagement and the scarcity of livelihood options for the poor which could lead to skewed development (Cardona et al, 2012). The vulnerability reduction is a critical indicator for better risk management and adoption strategies. The farm risk management is product of all these factors, and is therefore influenced by farmer's perception (on weather, agricultural inputs, and their expectation from the institutions) built from their past experience (Donovan, 2012; Ramaswamy et al., 2003). Since risk in agriculture is multi-dimensional, the management of it also is multi-dimensional in nature (Sam et al., 2020).

Study area and sampling

The study inquires risks faced by the cotton farmers in the state of Maharashtra- a primarily rainfed state of India. Cotton is typically grown in rainfed regions in India. Being a cash crop, it is affected severely by risks in the input and output side. The high incidence of risk among cotton farmers of Maharashtra was revealed by both print media and also the past literature in terms of highest farmers suicides and distress (Bhise and Behere,2016).

A primary survey was undertaken during July-September 2015 using multi-stage sampling. At stage one, the state of Maharashtra was purposively selected as the state has the largest area under rainfed cotton in India and also it reported incidences of farmers suicides over the last decade. From the state, two districts, viz. Jalgaon and Yavatmal were selected purposively at the next stage, as the districts have a large area under cotton and are reported to have widespread farm distress. Jalagaon is a fertile district falling under the *Khandesh* region and Yavatmal falls under the *Vidarbha* region known as the epicentre of farm distress and farmers suicides in India. From each district, two tehsils (sub-district administrative units) were selected randomly in the third stage. These were *Ghatanji* and *Kelapur* from *Yavatmal* and *Parola* and *Jamner* from *Jalgaon* district. From each tehsil, 6 villages were then selected at random. The villages selected from each tehsil in both the districts are listed in Table 1 and a map of the study location is provided in Figure 1. At the final stage, a total of 244 farm households were selected - 121 from Jalgaon and 123 from Yavatmal. However, data from a total of only 207 farmers who provided data enough to do this this analysis only were included.

The information was collected by administering the survey instrument on a face-to-face interview with the identified farmers. The survey schedule consisted of questions regarding socio-economic variables pertinent to farmers, sources of risk faced by them, and coping and adaptation strategies followed. The questions on perception and adaptation were mostly qualitative, and was collected using a Likert type scale- ranging from 1 (strongly disagree) to 5 (strongly agree).

Conducting the survey

The survey was carried out through enumerators exclusively trained for the purpose. As part of training, the enumerators undertook full day pilot study in the field, supervised by the investigators of the project. The entire survey was conducted in two stretches of 12 and 10 days each. Overall, 24 villages were included in the data collection. The survey was in the form of one interviewer- one respondent format. The interview lasted for almost 75-120 minutes per respondent farmer. To have this time, the survey team reached the place of respondents in the early morning hours and stayed till late evenings. In addition to individual based survey, focussed group discussions (FGDs) were also conducted. Such FGDs involved key farmers of the region along with local level leaders and local self-governance institutions. The data, which were collected in the vernacular language (Marathi), were translated into English before entering into spread sheet. The data was subjected to analysis, by using SPSS software.

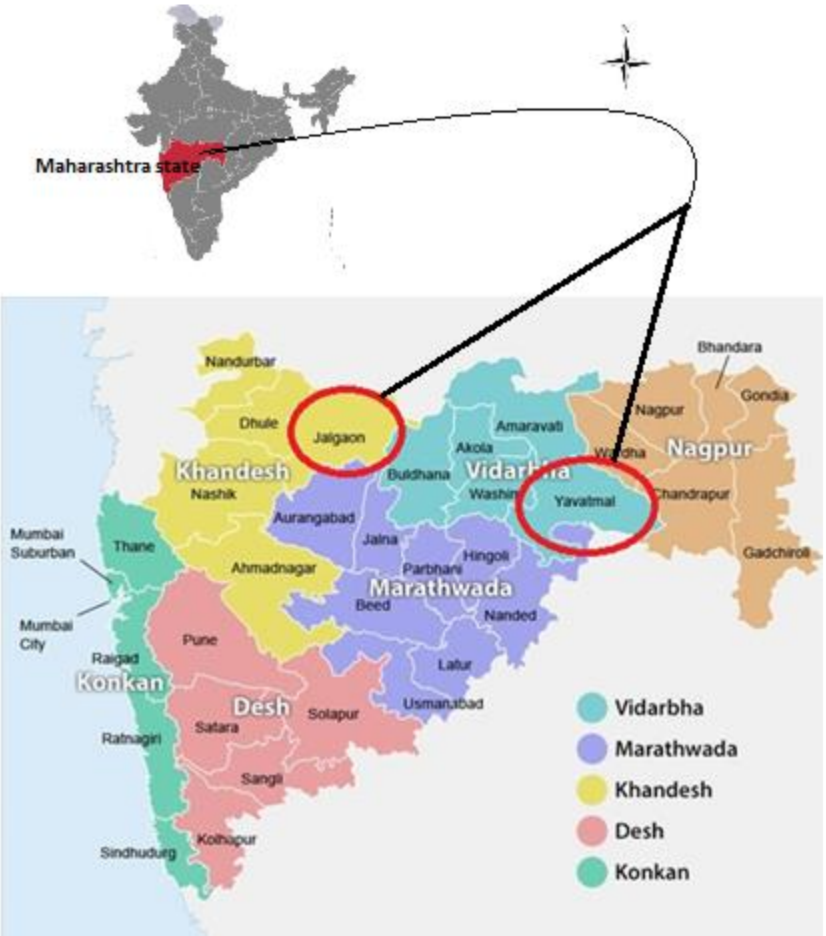

Figure 1. Map of the study area

Table 1. Villages selected for primary data collection

Jalgaon District		**Yavatmal District**	
Jamner (Farmers surveyed: 60)	**Parola (Farmers surveyed: 61)**	**Ghatanji (Farmers surveyed: 57)**	**Kelapur (Farmers surveyed: 66)**
Chinch Khede Deopimri PahurKasba Paladhi Sonale Sheri	Mehu Palaskheda Seem Pungaon Shevage Tehu Shirasmani	Bodadi Dahegaon Kohali Kumbhari Murali Pangadi,	Bahettar Kelapur Saikhed Susari TelangTakli Umari Rd

Analytical framework

While risks are associated with a probability of occurrence, they could act as a constraint on farming, particularly in rainfed farming system. Ramaswami *et al.* (2003) has provided a comprehensive review of studies in India on farm risks and possible adaptation strategies. The authors have noted that though the risks in agriculture are widely discussed, a profiling of risk in agriculture is conspicuous by its absence. Using field survey, this paper investigates the risks and adaptation strategies, broadly following the classification provided by Ramaswami *et al*.

Risk sources and adaptation strategies were studied using descriptive statistics. The extent of risks and adaptation strategies undertaken by them are analysed by calculating the share of farmers reporting them and the scores each individual obtains for specific risks. *Ex-ante* and *Ex-post* adaptation indices were calculated for 207 farmers (the information provided by remaining farmers were inadequate to undertake this analysis) individually. The adaptation indices were calculated using the primary data collected on a five-point scale. The adaption index for a particular farmer was arrived by calculating the total score a farmer received in for all the adaptation strategies (separately for ex ante and ex post) and dividing it by the maximum score possible. This provides a unique score for *ex ante* and *ex post* category for every farmer. The index, thus calculated, ranges between 0 and 1. The index for *ex-ante* adaptation encompasses the scores given for 11 adaptation strategies practised by the farmers surveyed, and that for *ex-post* includes the scores of 50 strategies. In arriving at this method, the implicit assumption is that all the adaption strategy has equal weight. In reality, the effectiveness of each adaptation strategy varies depending on several factors, including the agro-economic characters of the locality, micro climate, and farmer specific characteristics. Incorporating this into the analytical framework would have improved the results, but arriving weights for the large number adaptation strategies has several issues with respect to eliciting response from the farmers. Therefore, we go ahead with the assumption of equal weight for every adaptation strategy in calculating the adaption index. Accordingly, it is 1/11 for ex ante index and 1/50 for ex-post index.

Factors influencing composite adoption index

Since the composite indices ranged from 0 to 1, and no farmer was found to have the minimum or maximum possible index score, beta regression is used to find the covariates of adaptation index. In such cases, the Ordinary Least Square approach is not suitable for regression with a bounded dependent variable (Unlu and Aktas, 2017). Beta regression model accommodates dependent variables that are greater than 0 and less than 1. Beta regression is a model of the mean of the dependent variable y conditional on covariates x, which we denote by μ_x. Because y is in (0, 1), one must ensure that μx is also in (0, 1). It is done by using the link function for the conditional means (·). This is required since linear combinations of the covariates are not otherwise restricted to (0, 1) (Statacorp, 2019). The regression model can be expressed as:

$$g(\mu_x) = x\beta$$

or, $\mu_x = g^{-1}(x\beta)$ where $g^{-1}(\cdot)$ is the inverse function of $g(\cdot)$. The logit link applied here implies that

$$\ln\{\mu_x/(1-\mu_x)\} = x\beta$$

and that

$$\mu_x = \exp(x\beta)/\{1 + \exp(x\beta)\}$$

The conditional variance of the beta distribution is

$$\mathrm{Var}(y|x) = \{\mu_x(1-\mu_x)\}/(1 + \psi)$$

The parameter ψ is known as the scale factor as it rescales the conditional variance (Ferrari and Cribari-Neto, 2004; Statacorp, 2019).

After beta regression, which suggests whether different covariates significantly affect the dependent variable or not, we find out the margins that provide the magnitude of such effects.

3. Results and discussion

3.1 Basic descriptive statistics of the sample farmers

The descriptive statistics of the relevant variables used in the analysis are presented in the Table 2. We are guided by the fact the adaptation strategies are influenced by certain endowments- the human endowment, production endowment and agro-climatic and institutional endowment. We hypothesise that the human endowment factors enable farmers to understand the information, its suitability to the situation and its adoption. Further, the risk perception is affected by the individual and psychological endowment of the farmer. Adoption of adaptation practices are idiosyncratic, and vary with the farmer specific characteristics. The production endowment affects the choice and/or desirability of a particular adaptation strategy. The production environment also affects the risk bearing ability of the farmers. Two important farmer specific characters like age and education help to capture her curiosity to learn and practice specific risk adaptation strategies and adopt. The younger farmers would be of relatively more risk-taking nature. The education of the farmer would help them to decode the information and enable to utilise the available risk adaptation strategies more effectively. Caste, an indicator of the social hierarchy in the rural settings in India is found to influence farmers accessibility to resources and information. Farmers belonging to Scheduled Caste (SC) and Schedule Tribe (ST) are known to be of less privileged in terms of accessibility to technologies and resources (Krishna et al, 2019). As a production endowment variable, the value of physical asset imparts required confidence to adopt newer techniques in farming. Access to financial resources, a critical production endowment variable, is captured by their access to institutional credit system, as indicated by the possession of Kisan Credit Card (KCC), a financial instrument to avail farm credits from institutional sources. The relevant social capital of the farmer is included by analysing their membership in various farmers' associations. Membership of farmers in various organisations provides accessibility of the farmers to various risk adaptation strategies. Distance to market is major institutional endowment variable. As the farmer become nearer to the market, the higher the chance that she adopts risk adaptation measures. In addition to these we have used the Principal component analysis (PCA) scores for risk attitude predicted for each farmer, calculated based on data on 7 statements on risk attitude recorded on a Likert scale, in the regression analysis.

The mean age of the farmer is about 50, with a standard deviation of 12 (Table 2). The farmers were fairly educated with an average number of formal education period to be to the tune of 8.7 years. The average size of operational holding was 6.7 acres. About 51% of farmers leased in lands for cultivation purpose. Farmers belonging to SC and ST constitute about 15% of total respondents.

Table 2. Basic descriptive statistics

Variable	Mean	Std. Dev.
Age of the farmer (Number of years)	50.3	12.0
Education (Number of years)	8.7	3.9
Distance to the nearest market (kilometres)	8.5	5.6
Value of fixed assets other than land and livestock (Indian Rupees)	168424	370704
Value of owned land (Indian Rupees)	317225	284277
Size of operational holding (acres)	6.7	5.9
Size of owned land (acres)	6.3	5.6
Cropping intensity (%)	112.9	48.3
Value of owned livestock (Indian Rupees)	54812	92521
Share of farmers belonging to SC/ST(%)	15.5	
Share of farmers who leased in land (%)	51.7	
Share of farmers owning KCC (%)	39.6	
Share of farmers having membership in various organisations (%)	38.2	
Share of women (%)	6.3	
Share of area irrigated out of operational holding (%)	43	
Ownership of any kind of livestock (%)	75.8	

3.2 Farmers' perception on risk

Farmers' perception on risk due to weather factors

The most significant weather variables that affect agriculture are rainfall and temperature (Figure 2). Drought has emerged as the riskiest weather component in farming (91.3 per cent of them agreed on it). Late-onset of monsoon and untimely rainfall emerged as 2nd and 3rd important risks. In the short term, as far as a farmer is concerned, weather variability is quite crucial as it significantly affects farm income (Birthal et al., 2015). Farmers required early warnings on the impending weather conditions so that adaptations can be carried out. Though there were weather forecasts provided in advance by both government and private agencies, it was more effective for short term or immediate weather conditions, rather than acting as a useful tool to plan crop calendars. Although, state government implemented contingency plans of ICAR for drought and delayed monsoons, there is certain lacunae in its implementation. The implementation agencies are not equipped with to quickly adjust with the requirements (Mase and Prokopy, 2014; Tadess et al., 2015).

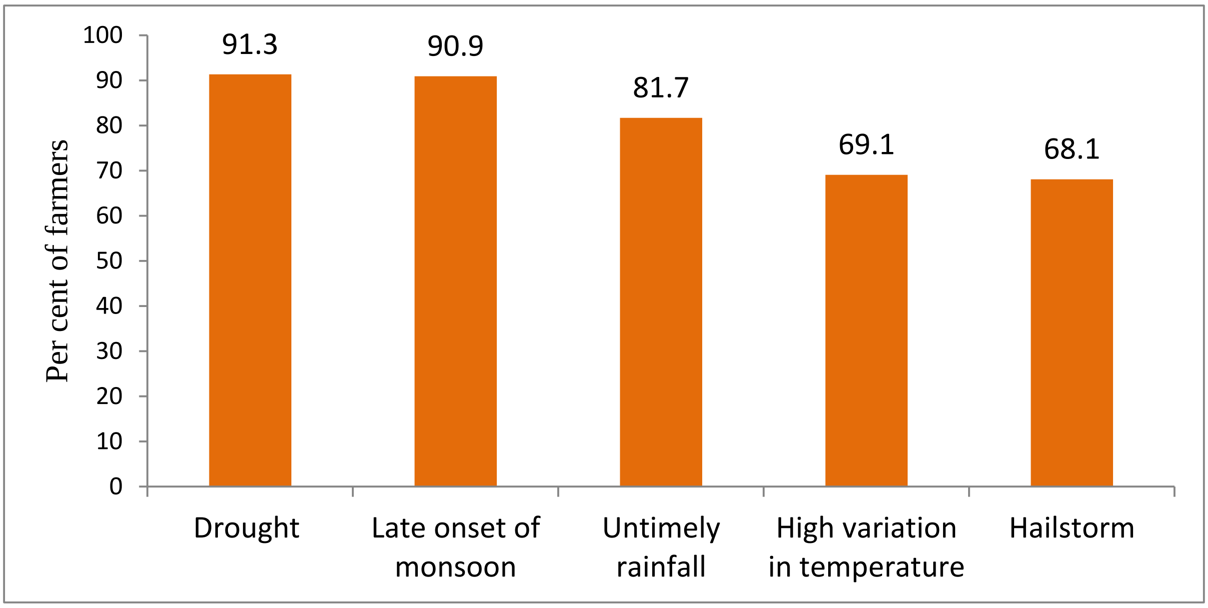

Figure 2. Perception of farmers on important weather risks

Farmers' perception on risk due to agricultural inputs and services

The risks in the inputs and services mostly pertain to its timely access in sufficient quantity and satisfactory quality, at reasonable prices (Figure 3-5). The major inputs and services considered were seeds, fertilizer, pesticides, machinery, irrigation, agricultural labour, credit, farm information and agricultural price realisation. The perception of the farmers was collected on a five-point continuum on a Likert type scale, starting with “strongly agree” to “strongly disagree”. The farmers were post-classified into dichotomous categories based on the response to the Likert type scale choices. Those farmers who agree either to “strongly agree” or to “agree” were considered as the farmers agreeing to the statement regarding risk perception.

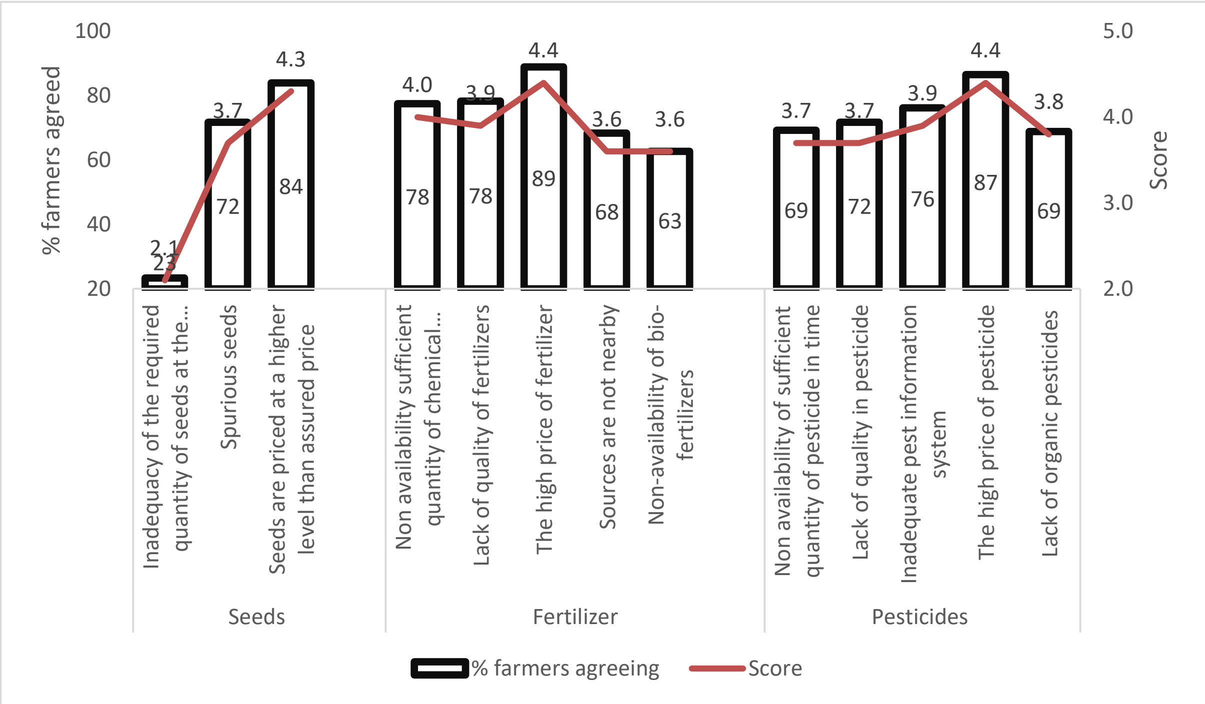

Figure 3. Farmers perception on risk on seeds, fertilizer and pesticides

a. *Seeds*

The seed system in India had undergone significant changes recently in terms of intensive participation of private enterprises in the seed sector. Even though the private sector seed industry was active in cotton for a long time, its presence deepened with the introduction Bt technology (Mungerkar et al., 2006; Spielman et al., 2011). The rights for selling the Bt cotton were with the private sector (Ramasundaram et al., 2011). All farmers purchased seeds from the private sector. High price of seeds, poor seed quality and lack of availability of desired seeds at the appropriate time were the most important risk factors (Figure 3). Certain Bt cotton hybrids were of high demand, but were not available sufficiently, paving way for black market, and higher prices. Also some farmers were in view of cultivating Bt cotton varieties, which require low dose of inputs. However, the seeds of varieties were not available commercially.

Farmers faced issues of spurious seeds as well. The marginalised sections and small farmers faced the issue of poor-quality seeds and charging of higher prices more adversely. The results indicate that the show that the private seed companies are neglecting rainfed areas and farmers in timely supply of quality seed at reasonable price (Ismail et al., 2013).

b. Agro-chemicals

The Bt cotton was introduced to contain certain borer pests (Cotton boll worm, *Helicoverpa armigera*), and to reduce consequent application of chemicals. This has helped to reduce the usage of pesticides notably, in the initial phases of the technology introduction. The field survey indicated emergence of sucking pest complex as a serious problem in cotton, which has led to increase in expenditure on pesticide (Vonzun et al., 2019).

Major problems concerning fertilizers were high price (with scores of 4.43), expressed by close to 90 % farmers. Shortage of urea and phosphatic fertilizers was reported by almost 78% of farmers. Price concerns existed more severely in pesticides. The lack of appropriate information on pesticides was also indicated by more than three-fourth respondents. This information is important since cotton continues to have the highest proportion of area treated with pesticides in India (Subhash et al, 2017) and use of excessive pesticides in cotton is a serious problem, which not only increase costs but also invite new pest complex (Kranthi and Stone, 2020).

c. Farm labour, agro-machinery and irrigation

Seasonal agricultural labour scarcity is a pressing issue in Indian agriculture (Kareemulla et al., 2013; Basin and Kashyap, 1992). Cotton is a major labour-intensive crop, especially during cotton picking (Singh, 2017). Higher wage rate and lack of availability of the farm labour was reported by 79% and 78% farmers respectively (Figure 4). The farmers perceived the problem more intensely in recent times on account of unintended effects of some government programmes, notably operation under Mahatma Gandhi National Rural Employment Guarantee (Act) (MGNREGA) programme, that squeezes labour availability during peak agricultural seasons. In response to labour scarcity, farm mechanisation is deepening in India, but not in cotton picking. The share of labour in cost of cultivation of cotton has risen over a period of time- from 33% in 1978-79to 44%in 2009-10 (Suresh et al., 2014). More than 60% of farmers reported inadequacy of farm machinery. Custom hiring centres can be helpful in routine operations like land preparation; however, this system was also not effective in cotton picking, as indicated by 73% of farmers (Figure 4).

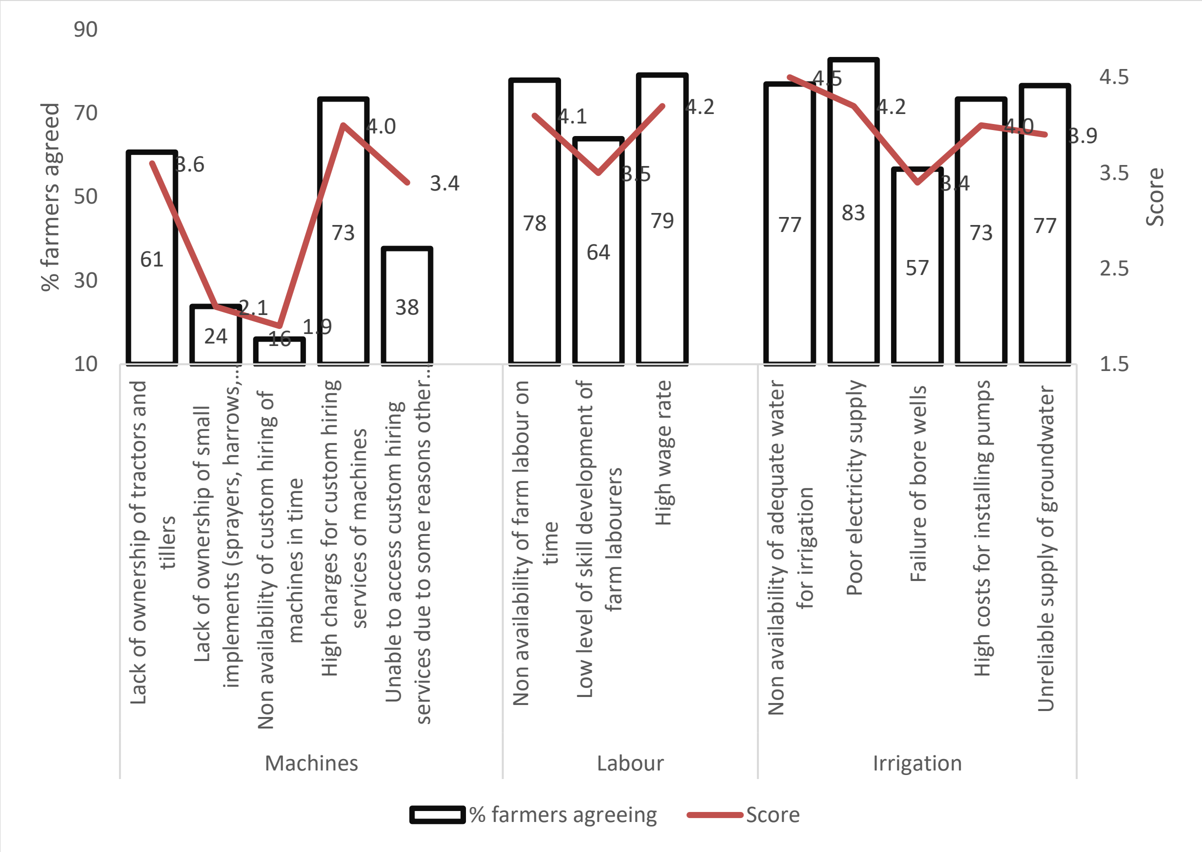

Figure 4 Farmers perception on risk on machinery, labour and irrigation

d. Irrigation

The extent of irrigation depends on several factors, the most important one being water availability. Wells (dug wells and tube wells) constitute the major irrigation water source in the region. The respondent farmers had installed groundwater structures, like tube wells, and, in many cases, these irrigation structures have failed. Poor quality of electricity supply and deepening of water tables severely impinged extraction of groundwater, as most of the groundwater structures and motors failed during the drought years (Figure 4). The issue of lack of irrigation water is pervasive warranting focused intervention towards water conservation, efficient usage and shifting cropping pattern (Hanjra and Qureshi, 2010; Reddy et al., 2020).

e. Credit, farm information and price risk

Cotton farmers need more credit, cotton being input intensive crop. Farmers surveyed (98 per cent of them) availed credit for both agriculture and non-agriculture purpose, from multiple sources- both institutional and non-institutional (Mishra, 2008; Mohan, 2004; Hoda and Tervey, 2015). About 37% of farmers reported inadequate credit availability from institutional sources, mainly due to the inability, and lack of repayment capacity in the evaluation of the banks (Figure 5). The informal credit is at exorbitant interest rates and force farmers in to indebtedness and distress (Ramakumar and Chavan, 2014; Gruere and Sengupta, 2011). As per the reports of All India Debt and Investment Survey, NSSO, farm credit accounts for 32.5% of private capital formation in agriculture during 1975-76 to 2011-12 (Hoda and Tervey 2015).

f. Farm Information

Right information is the life-line of modern-day agriculture. The extension system in India, on which the responsibility of information dissemination is vested, faces several constraints at present, in terms of lack of adequate manpower, infrastructure, and funding (Sajesh and Suresh, 2016). The major public extension systems are the vast network of agricultural development offices of the state government, *KrishiVigyan Kendras* (KVK) of National Agricultural Research System (NARS) led by Indian Council of Agricultural Research (ICAR), and print and electronic media. During recent years, usage of electronic media including mobile phone and other information and communication technologies (ICTs) have acquired greater role. Cotton being the commercial crop the major sources of information to the farmers continued to be the dealers of inputs, though the reliability is rated poor (Yaseen et al., 2018). Bereft of access to reliable farm information system, a “hidden hunger” for extension services is quite perceptible. The private extension services in India is reluctant to work in rainfed areas (Godgil et al., 2020). Overall, the problem of information appears as a constraint in cotton production and marketing, and often manifests into the status of risk, particularly when the requirement is urgent.

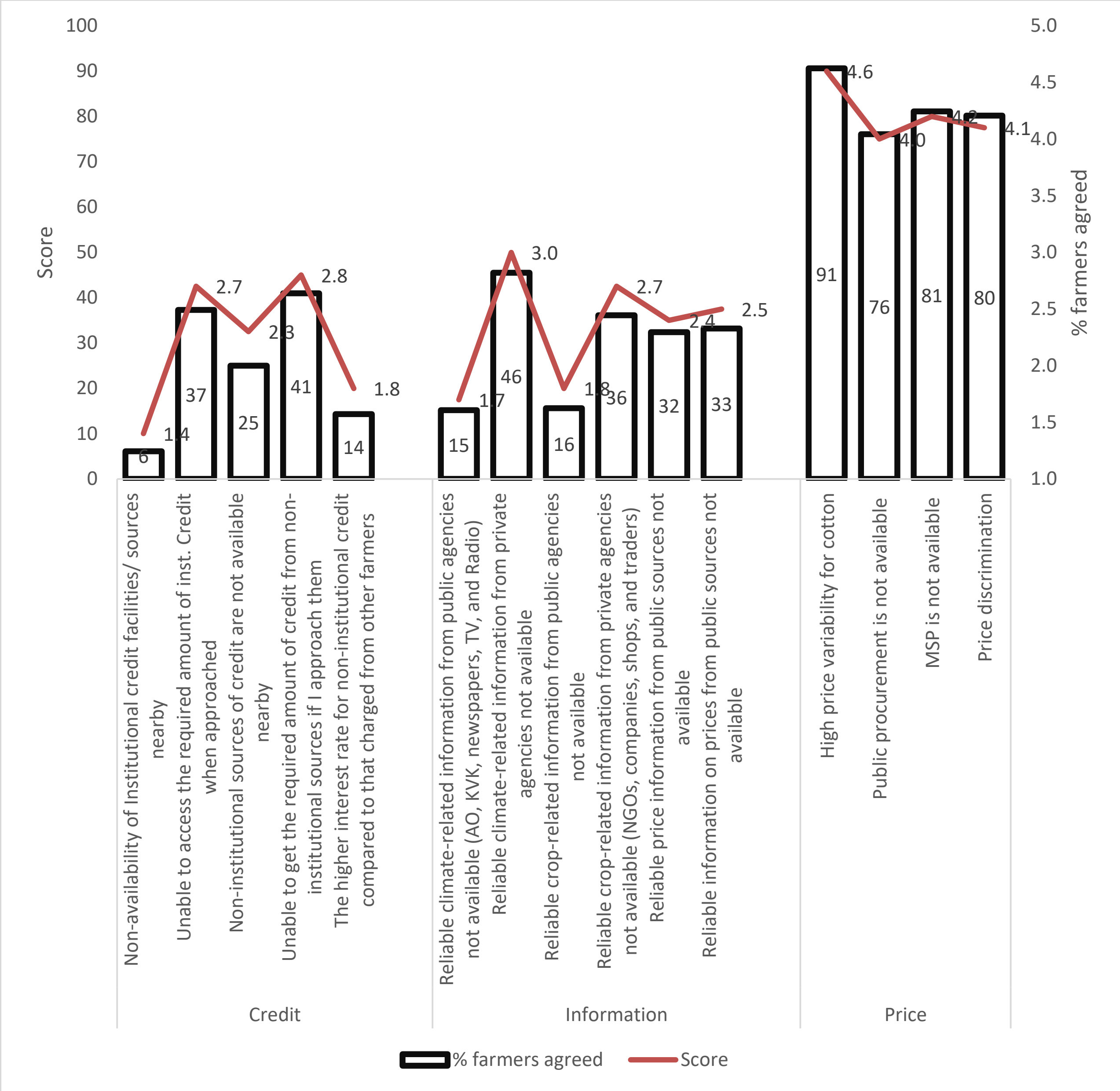

Figure 5.Farmers perception on risk on credit, information and price

Price risk constitutes an important component of farm income risk. The farmers faced high price volatility, expressed by more than 90% of farmers. Non-operation of MSP system, discrimination in price realisation and lack of public procurement were identified as the major risk sources. Compared to foodgrains, price risk is higher in commercial crops, which lead to severe farm risk (Sekhar, 2003; Fayet and Vermeulen, 2014).

3.3 Risk adaptation strategies

The strategies adopted by the farmers, though can be classified into *ex ante* and *ex post*, it cannot be considered as water tight compartments, as some of the *ex-post* adaptations can turn out to be *ex- ante* adaptations as far as the next seasons is concerned (Ramaswami et al., 2003). Migration was one such example, and it can be taken as a socially and culturally differentiated phenomenon and not a viable diversification option as happening in some other vulnerable communities (Adam et al., 2018).

Ex-ante adaptation strategies

The major *ex-ante* strategies adopted by the farmers are presented in Figure 6. They included irrigation arrangements, share cropping, stocking foodgrains, and varietal diversification. Intercropping and varietal diversification were widely practised, as a tool to deal with risk and they have the potential to reduce risks in multiple ways (Walker and Ryan, 1990). Intercropping in cotton was carried out by more than one third of farmers, with an aggregate score of 2.6, mainly by using *tur* (red gram). Red gram, being hardy, could withstand drought to a great extent, and could provide some income in case of water shortage/drought. Varietal diversification in cotton was widely practised with the mean number of varieties used as 2.2 per farm. The number of varieties cultivated was related to the total area under cotton cultivation, and on certain demand side factors like market preferences for cotton bolls. Adoption of biotic and abiotic stress-tolerant varieties had remained an important adaptation strategy.

One major strategy was investment in irrigation *ex-ante*, either by construction of micro-watershed on farm and development of farm ponds, or deepening/ renovating existing community wells or installing other irrigation facilities including lift irrigations/ water diversions, repairs of the irrigation systems, installation of newer pipes etc. Some farmers have installed micro-irrigation (mostly drip irrigation system) as well, to reduce water wastage and improve irrigation efficiency. However, micro-irrigation is not adopted widely, due to heavy capital expenditure and they require pumping water through motors. Mixed farming (farm household having crop and livestock enterprises together) was practiced by most of the households. The ownership of bullocks was widely prevalent, for draft purpose.

The efficacy of crop insurance as a risk adaptation mechanism is debatable. Only about one third farmers insured their crops. The major hindrances were lack of implementation capabilities with the local implementation agencies, no accountability at local level, inadequacy to cover up losses and delays in claims payment. Such issues in crop-insurance in India were also reported by several other researchers, which dents the effectiveness of crop insurance as an adaptation mechanism (Bhende, 2005; Nair, 2010; Mahul et al., 2012).

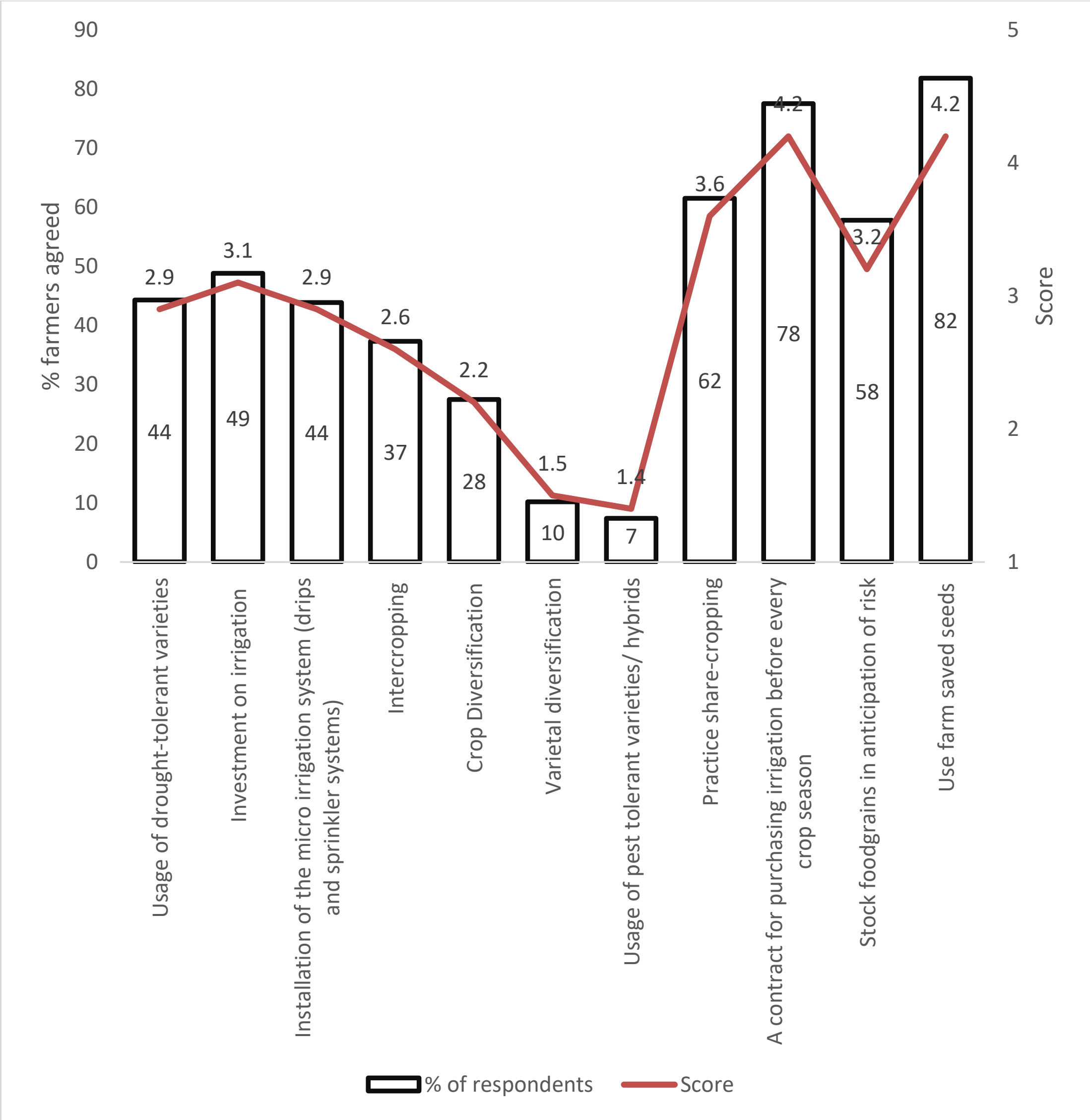

Figure 6. Major *ex- ante* risk adaptation strategies adopted by the farmers Source: Authors' estimates based on field survey

Ex-post strategies

Farmers adopt a bunch of strategies after the risk incidence (Figure 7-9). For example, against low rainfall or drought, some of the strategies included replanting with short duration crops and attempt to gap filling, adopted by almost 58% of farmers (Figure 7). Reduction in the quantity of fertilizer, replanting with hardy crops and purchasing irrigation water were some temporary measures practised. In India, close to 50% of the smallholders participate in water market to fill up the gap in the ownership of irrigation assets (Mukherji, 2008). During a pest attack, the immediate response is to apply chemical pesticide, practised by more than three fourth of the respondents. Farmers sought an expert opinion as well. Quality farm information is a critical input at times of risk.

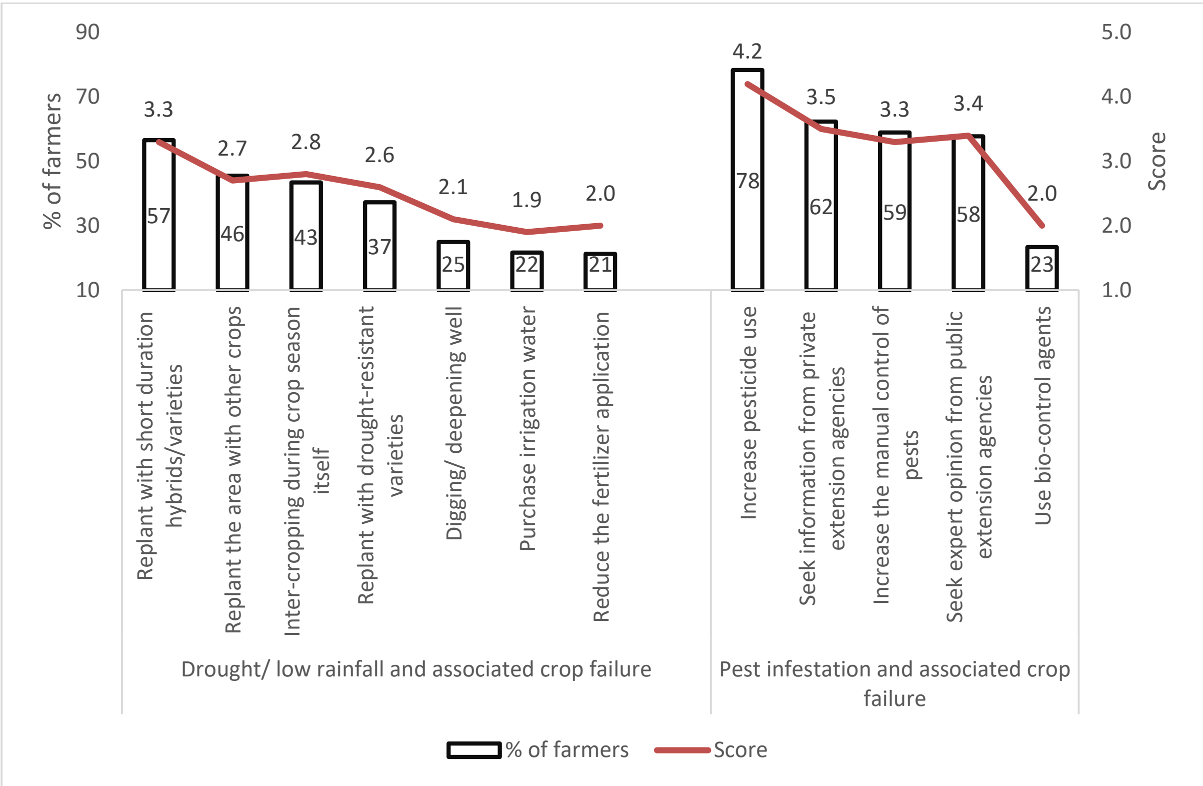

Figure 7. Major *ex- post* risk adaptation strategies adopted by the farmers (rainfall and pest) Source: Authors' estimates based on field survey

In agrarian society of developing countries, the community level measures and social capital carries significant influence on an individual's adaptation strategies. Some of these measures include availing farm loan/ other materials including staple food, interest-free loans etc. from the community/ caste group (Figure 8). However, the response towards the community-level risk management mechanism was quite low, particularly dependence on common property resources (CPRs). Jodha (1986), in his seminal work portrayed the significant role of CPRs in protecting farmers at times of distress. However, evidence suggested a weakening of the system over a while. Seeking financial assistance from members was widely practised. Credit-related risk adaptation strategies were also widely adopted. The most common measure was to avail a loan for consumption purpose from non-institutional money lenders, traders etc. The major institutional source of finance was farmer co-operatives. Farmers avail the facility of rescheduling loans quite frequently.

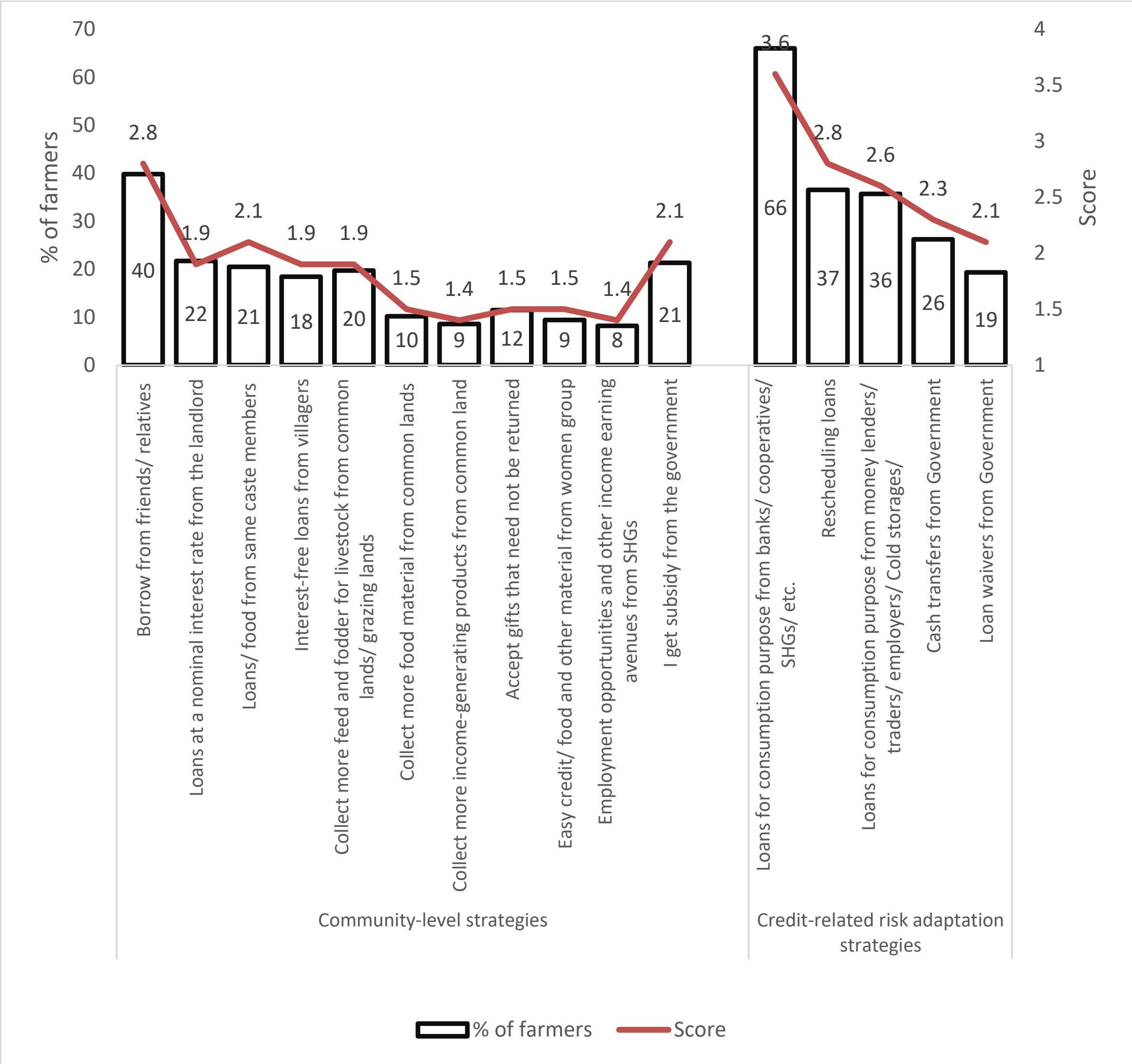

Figure 8. Major ex- post risk adaptation strategies adopted by the farmers (community credit related strategies)

Certain *ex-post* strategy belongs to the realm of markets also, viz selling the produce to same commission agents (58% farmers) and stocking the produce expecting better returns (48%). But, due to financial urgency farmers stock output for only a short duration, mostly till the Cotton Corporation of India starts its procurement operations.

Income and consumption smoothening by farmers in extreme situations were mainly by mortgage of the assets. The institutional mechanisms for availing loans for consumption smoothing during risky situations are ineffective for a capital-constrained farmer, forcing her to depend on non-institutional sources. Farmers' short duration self-insurance strategies revolve around liquidating assets, including jewellery, livestock and land.

One of the most frequent adaptation strategies in the extreme situation was to have a greater number of family members participating in the labour market, as reported by 14% of farmers. However, the propensity to join the labour market suffers from certain social stigma, as it was believed to affect the prestige of the family especially among women. In extreme situations, family members of the affected families migrate to other cities, in search of manual jobs. Mostly they get absorbed in construction works in cities. Though starting small scale rural enterprises as an off-farm income measure is suggested as an adaptation strategy (Simmons and Supri, 1997), it was not observed in our survey.

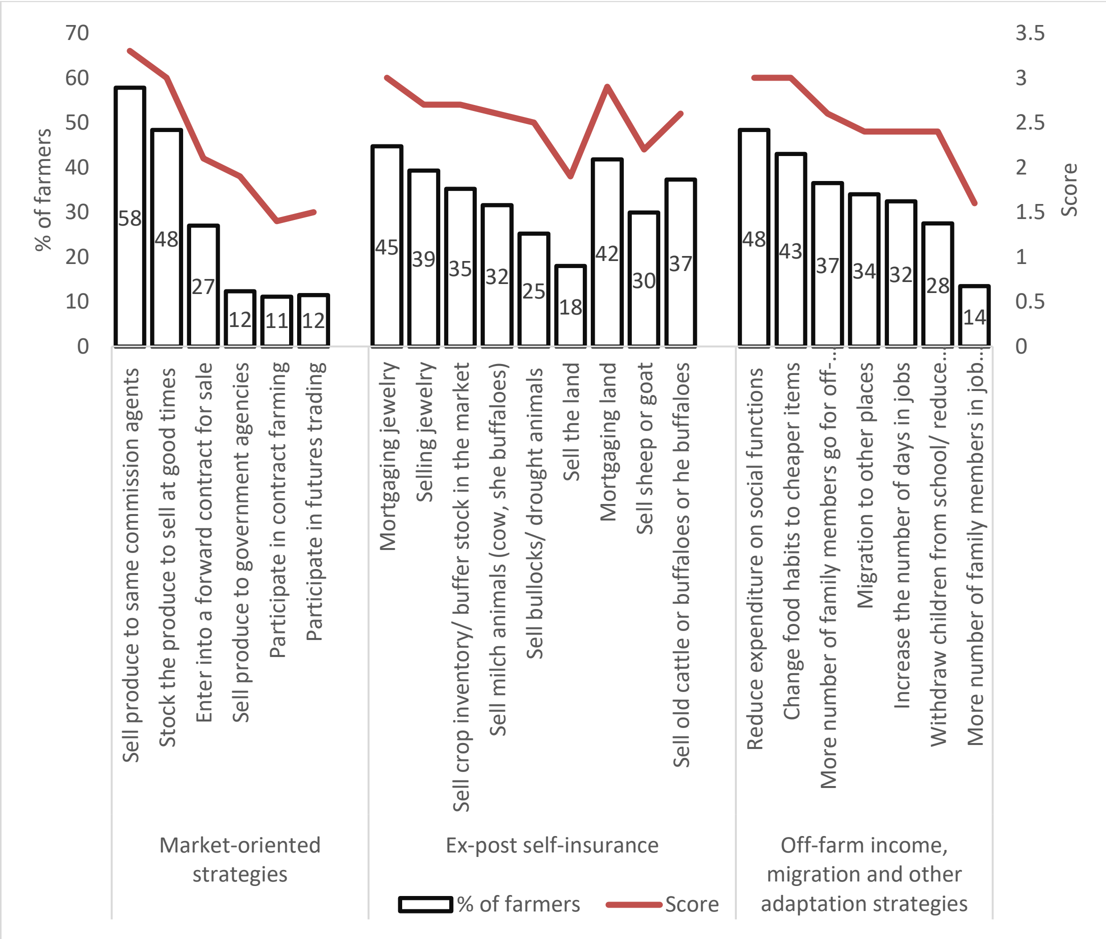

Figure 9. Major ex- post risk adaptation strategies adopted by the farmers (market, self-insurance and alternate income sources)

Another set of the strategy was related to a reduction in expenditure at the household level. This includes changing food habits towards cheaper food, reported by as high as 43%

farmers. An equally important measure was to reduce expenditure on social functions, including the postponement of marriages. Reduction of education expenditure, mainly through avoiding expensive schools, private tuitions and limiting expenditure on education stationeries forms strategies for some households.

3.4 Adaptation indices and covariates

We, first constructed composite *ex ante* and *ex post* adaptation indices for individual farmers which were subsequently regressed against certain potential correlates of interest. The values of the composite indices range between 0 and 1. The pattern of the distribution of the index values are provided in table 3. The normality of the distribution of the adaptation indices for both *ex-ante* and *ex post* adaptations is tested by using Shapiro-Wilk test for normality and the results are provided in Figure 10 and the results are summarised in Table 4. While the *ex-ante* adaptation index is normally distributed, the normality hypothesis of the *ex post* indices is rejected at 5% level. There was a difference in the distribution pattern of *ex ante* and *ex post* adaptation indices of the farmers. The farmers were classified into low, medium and high adopters based on the quartile deviation of the distribution of the indices. The proportion of farmers falling in the high index category is higher in the ex-ante adaption compared to ex-post adaptation.

Table 3. Frequencies of the ex-ante and ex-post adaptation indices

Composite Ex-ante index	**Frequency**	**Per cent**	**Composite Ex-post index**	**Frequency**	**Per cent**
Low index (1st quartile 0-0.55)	62	29.95	Low index (1st quartile 0-0.40)	52	25.12
Medium index (2nd and 3rdquartile 0.56-0.75)	94	45.41	Medium index (2nd and 3rdquartile 0.41-0.56)	108	52.17
High index (4th quartile 0.76-1)	51	24.64	High index (4th quartile 0.57-1)	47	22.71

Table 4: Shapiro-Wilk test for normality

Variable	**Observations**	**W**	**Z**	**Prob>z**
Composite Ex-ante index	207	0.993	-0.115	0.545
Composite Ex-post index	207	0.98379	2.105	0.017

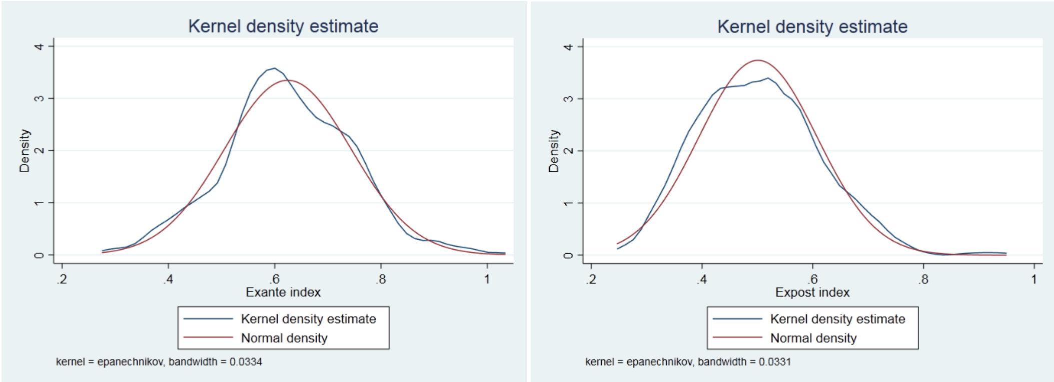

Fig 10. Kernel density plots with normal density

Tables 5 and 6 report the estimation results for the correlates of composite *ex-ante* and *ex-post* adaptation indices respectively. The caste of the farmers emerged as the most significant correlate of adaptation. It is important to note that the farmers belonging to the disadvantaged categories are constrained in their ability to adapt to risks in farming through different adaptation measures (Krishna et al, 2019). In the context of vulnerability to climate change, particularly of the disadvantaged sections, their adaptive capacity turns out to be very critical in their livelihood. While the tenancy and operational holdings affected the *ex-ante* adaptation negatively and significantly, the share of irrigated area improved the farmers *ex-ante* adaptation. Risk attitude was another variable that significantly affected the *ex-ante* adaptation indicating that the risk averse nature of the farmers affected their adaptation in the opposite direction. In the case of ex-post adaptation also the farmers belonging to categories other that scheduled caste/tribe showed better adaptation. Among the other correlates, while distance to the nearest market negatively influenced the ex-post adaptation, the value of land owned influenced it positively. KCC ownership and membership in farmer association had negatively influenced the ex-post adaptation index. The coverage of KCC in the area was very poor during the survey period and the response from farmers suggested that they depend more on non-institutional sources for immediate credit requirements for agricultural purpose as it is a general case in rainfed areas and farmers.

Table 5. Correlates of the ex-ante index and the marginal values

Variables	Coefficients	Standard errors	Marginal values
Age	0.004	0.003	0.001
Gender (dummy)	0.182	0.132	0.043
Caste of the farmer (dummy)	0.197**	0.086	0.045
Education	-0.004	0.008	-0.001
Tenancy status (dummy)	-0.134**	0.064	-0.031
Distance to the nearest market	0.003	0.006	0.001
Kisan credit card ownership (dummy)	-0.052	0.064	-0.012
Membership in farmer associations (dummy)	-0.073	0.067	-0.017
Value of fixed assets	0.000	0.000	0.000
Value of land owned	0.000	0.000	0.000
Livestock value	0.000	0.000	0.000
Operational holding	-0.027*	0.016	-0.006
Cropping intensity	-0.001	0.001	0.000
Share of irrigated area	0.002**	0.001	0.000
Risk attitude (PCA Score)	-0.044*	0.026	-0.010
Constant	0.276	0.236	

Note: *, **, *** indicates significant at 10%,5% and 1% level

Table 6. Correlates of the ex-post index and the marginal values

Variables	Coefficients	Standard errors	Marginal values
Age	0.000	0.002	0.000
Gender (dummy)	-0.017	0.112	-0.004
Caste of the farmer (dummy)	0.223***	0.075	0.055
Education	-0.002	0.007	0.000
Tenancy status (dummy)	0.037	0.056	0.009
Distance to the nearest market	-0.010*	0.005	-0.002
Kisan credit card ownership (dummy)	-0.107*	0.056	-0.027
Membership in farmer associations (dummy)	-0.109*	0.059	-0.027
Value of fixed assets	0.001	0.000	0.000
Value of land owned	0.001**	0.000	0.000
Livestock value	0.000	0.000	0.000
Operational holding	-0.020	0.014	-0.005
Cropping intensity	-0.001	0.001	0.000
Share of irrigated area	-0.001	0.001	0.000
Risk attitude (PCA Score)	0.019	0.022	0.005
Constant	0.336*	0.202	

Note: *, **, *** indicates significant at 10%,5% and 1% level

4. Conclusion

The vulnerability to risks by farmers in the rainfed region are high, as they are exposed to a multitude of risk including climate change; short term fluctuations in weather; issues related to access to inputs; and prices of inputs and outputs. This is because vulnerability is a function of exposures, sensitivity and adaptive capacity of the farmers, is critically affected by the adaptation strategies. Farmers attempt to minimise the effect of risk by adaptation strategies- both ex *ante* and *ex post*. However, the type of adaptations and its intensity is determined by the adaptive capacity, determined by several social and economic factors. Farmers' perception of agricultural risk is crucial in determining the adaptation along with other socio-economic factors. The quintessence of the study is to provide the farmers' perception of risk, the extent of adaptation that they were able to adopt and the factors that determine these adaptation measures.

The constraints in accessing inputs like seed, fertilizer, and pesticides in terms of quantity, quality and price pose risks to farming. Spurious seeds, non-availability of the required quantity of seeds, and its high prices affect its adoption. The deficiencies in timely availability of quality fertilizer, notably for phosphatic fertilizers and urea, are risk factors. Most of the farmers avail credit from multiple sources. The failure of commercial banks in catering to the credit needs of the agrarian population necessitates the revival of the cooperative credit institutions. Water management is critical to manage risk in rainfed regions. Water scarcity is one of the critical areas that would accentuate farmers vulnerability to climate change due to high probability of exposure to the scarcity and limited adaptive capacity against it. Groundwater has emerged as a major source of irrigation, and large-scale extraction of water without efforts to recharge impinges sustainability of the very system. Adoption of micro-irrigation like drip and sprinkler and watershed approach suffers due to lack of capital, community participation and high cost of repair and maintenance. Availability of farm technologies, notably in terms of the crops and varieties that are suitable for cultivation under risky biotic and abiotic stresses are critical. This needs greater research focus on developing risk-tolerant varieties. In view of the ability of the livestock sector to absorb risks and smoothen the farm income, the constraints binding the livestock farming needs to be eased. This includes lack of organised milk marketing system, and facility to maintain pure breeds of native cattle so as to have good quality draft bullocks, seed money through institutional finance to start new livestock ventures and efforts to conserve and rejuvenate common pasture resources.

It was found that the farmers face serious constraints in accessing timely reliable weather forecasts and price signals. Establishment of early warning systems on weather forecasts is a need of the hour. Attention is needed to improve the flow of farm information. The emerging information and communication technologies (ICTs) can help in providing market intelligence. Development of risk transfer mechanisms through crop insurance needs revamping in the light of field experiences. The farmers highlighted the institutional weakness as major reason for the disinterest in insurance. The price risks at the output marketing stage critically affect farm income. This warrants urgent intervention with appropriate policies to ensure price to farmers. The relevance of institutionalised market intelligence system to provide probable price forecasts with sufficient accuracy can help farmer to make informed choices. Given the urgent need to have advance estimates of farm prices, efforts are needed, at least on pilot basis to generate information on farm prices and disseminate it. Such policy efforts need to be supported with field level actions including timely operation of the procurement systems, like CCI and forward contracts.

We also provide the correlates of adaptation, which helps formulate future strategies. Future research can focus on finding and validating the present results to other locations, especially for rainfed farming. Nevertheless, in the future, it would also be interesting to empirically analyse agricultural risks faced by the farmers practising different cropping patterns.

Limitations of the study

The farmers included in our study were asked to score different risk sources and adaptation strategies. We have only attempted to identify the different risk sources and identify the correlates of the adaptation using certain indices. The results largely applicable to the study regions. However, the study provides a profile of risk adaptations of the farmers against it in a major cotton growing rainfed region of India having similar social and economic settings.

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