RES MILITARIS
REVUE EUROPEENNE D ETUDES EUROPEAN JOURNAL OF MILITARY STUDIES
Social Science Journal

Application of MDS for Mapping Indian Farmers' Perceived Risks: A Diagnostic Approach toward Adoption of Crop Insurance

By

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Abstract

Farming risks play a great role with the fortune of Indian cultivators. But, Indian cultivators' financial crisis starts mainly when they cultivate with the borrowed fund and after certain crop loss they fail to pay back that money. Crop insurance brings definitely a solution of this big problem to these poor farmers. A diagnostic approach towards finding out different farm risks and designing a perceptual map for positioning these farm risks on the basis of their level of severity are highlighted as the prerequisites for the adoption of any crop insurance programme. Primary survey data have been collected for this purpose with manual circulation of structured questionnaires since November 2020 to January 2021. A multistage random sampling has been employed to select two districts from each of the select five states of this country and from each district two blocks are selected at random. Total 20 blocks have been selected and 25 respondents are selected randomly from the villages of each block. Considering different earlier literatures in this context, farm risks are selected purposively to perform the multi-dimensional scaling (MDS), and these risks are those which are most frequently faced by the farmers of these select five states of India. Thus, the relative positions of the perceived farm risks are framed on the perceptual map. After considering the position of each perceived risk, an ordinary least square regression (OLS) is attempted to explore the effect of farm risks' vulnerability as select multi-nominal variables on the adoptability of crop insurance as an outcome variable.

Keywords: Farming risks, Multi-dimensional scaling (MDS), Perceptual map, ordinary least square regression (OLS).

Introduction

Farming without any risk is just an impossible phenomenon in most of the countries across the world. Indian cultivators are also left with their misfortunes of losing crops during different uncertain events caused by several sources of risks. In one hand, India is highly dependent on farming activities and on the other hand, in every year Indian farmers have to experience abnormal crop loss due to infestation by pests and/or due to natural calamities like super cyclone, hailstorms, heavy rain falls, floods, erratic or no rainfall, droughts etc. (Kumar et al., 2011; Soni and Trivedi, 2013; Bharati et al., 2014; Kumbalep and Devaraju, 2018; Mukherjee, 2021). Moreover, rising input costs of production and other market-specific risks

are found also influencing immense on Indian cultivators. Therefore, in India farming is always considered as a risky business where farmers have to face a lot of uncertainties.

Crop insurance' has always been considered as a risk management mechanism for Indian cultivators. This is the institutional mechanism to indemnify the farmers against possible crop failure due to natural calamities and other specified reasons (Arnold, 2008; Selvaraj, 2010; Afroz, Akhtar and Farhana, 2017; Sindhu and Ariff, 2017). Unlike the growers of the developed countries, i.e., USA or Canada (Bharati et al., 2014), adoption of crop insurance by the growers in Asia-Pacific region does not meet the expectation of the government (Afroz, Akhtar and Farhana, 2017). It is also true to the Indian farming context that the concept of crop insurance is not new and started before independence, but till today majority of growers are found either unaware of crop insurance or avoiding it perceiving as a complex and costly affair. At least since 1970, central government of the country initiates the process of developing adoptable and smart crop insurance schemes for Indian cultivators (Mukherjee and Chattopadhaya, 2020). After experimentation with so many insurance schemes, presently the regulating authority, i.e., Agriculture Insurance Company of India Limited (AICI) extends the offer of three major insurance schemes such as Modified National Agricultural Insurance Scheme (MNAIS), Restructured Weather Based Crop Insurance Scheme (RWBCIS), and Pradhan Mantri Fasal Bima Yojana (PMFBY) for the Indian cultivators (as per the official report of AIC of India Limited, 2016).

Indian agriculture has to face changes in the forms of risks and their severities also. While considering the effect of newly augmented pandemic, i.e., COVID-19 in recent periods, all the economic activities including agriculture also has to suffer a lot from the new dimension of risk (Varshney et al., 2021). Rural households who are depending on farm and non-farm sectors (Mukherjee, 2021) have suffered a lot since lockdown announced by India's Prime Minister on March 23, 2020 (Cariappa et al., 2021; Varshney et al., 2021). This situation has made the rural livelihood disrupted, especially to those farmers who have taken credit from informal sources with a high interest rate and failed to repay that amount. As Indian agricultural trading is done physically, a lag time always remains in between the physical transaction of what is produced and receiving payments against that (Reddy, 2017). So, Indian farmers have to remain literally cashless for a longer period due to lockdowns during the first wave of COVID-19. Situation worsens to the small and marginal farmers dependent on informal credit by throwing them under heavy burden of debt (Varshney et al., 2021).

Therefore, in line with this research and development toward an adoptable as well as sustainable crop insurance policy, this pertinent study is undertaken as an endeavor of mapping the farmers' perceived risks following farmers' perceived level of similar severity among those farm risks.

Literature update

Cultivators' risk perception is very important area of research in the context of farm insurance though this is in an embryonic stage in Indian farming. There is really a lack of quality research work in India on the assessment of farmers' risk perception for the actuarial decision. But throughout the globe, conscious efforts have been made by different researchers to identify and evaluate cultivators' perception regarding different farming risks and their magnitude before designing the crop insurance product. Ogurtsov et al. (2008) have explained all the standard methods generally followed in risk perception evaluation process. After analyzing the magnitude of different risk aversion coefficients, their study suggests to follow an evaluation process of risk

measurement with the help of risk matrix and severity index. Senkondo (2000) attempts to measure farmers' risk perception and their risk aversion through a severity index of agro risks. Boyd et al. (2011) have nicely presented how crop insurance has become indispensible for managing and overcoming agricultural risks and disasters throughout the globe. While considering smart and sustainable farm insurance for any group of farmers, first it is to assess the farm risks and indexed risk insurance is very popular in today's scenario. It is a revealed fact that index insurance is always considered as a cost-efficient product in comparison with traditional insurance products (Alderman and Haque 2007; Barnett, Barrett, and Skees 2008; Hazell et al. 2010; Mahul and Stutley 2010). From the study of Jensen and Barrett (2016), it is highlighted as the weather-index does not need any costly household data and it acquires only the readily available and freely accessible data regarding rainfall, temperature, wind and storm, drought etc. through remote-sensing devices. This is also applicable in the context of Indian farming and risk mitigation.

Varalakshmi (2014), in the context of Indian farming, revealed that insured south Indian farmers are dissatisfied with the compensation amount of weather-index based insurance, i.e., RWBCIS as they perceive it inadequate. Her study also recommends AICI for an obvious disclosure about the policy-premium amount, sum assured and the probable process of claim settlement as the farmers also dissatisfied with non-availability of clear documentation of such information about RWBCIS. It is indispensible for any index-based insurance scheme to be designed on the basis of underlying index reflecting losses of property. From the study of Shirsath et al. (2019), a developmental approach is noticed toward designing RWBCIS with the methodology to determine the trigger value, i.e., the severity of the disaster.

Data and methods

First, to select the states of India from where the feedback of farmers are to be collected, top five performing states of India are chosen on the basis of total number of application submitted by the farmers (both loanee and non-loanee) willing to participate in PMFBY, the most popular crop insurance product offered by AICI, during Kharif crop season (rainy season of cropping) in 2020. The states are Madhya Pradesh (Total 44,32,266 applications), Chattisgarh (Total 36,85,843 applications), Odisha (Total 33,14,430 applications), Maharashtra (Total 28,34,257 applications) and Rajasthan (Total 13,39,733 applications) respectively in the Kharif crop season, 2020 (Source: Business Profile- All India for PMFBY, last accessed on 20th of October, 2020 from www.aicofindia.com).

Second, a multistage random sampling technique is employed for selecting two districts from each of the select five states and from each district two blocks are selected at random. In the final stage, data collection is done from 500 farmers by manual circulation of a pre-tested structured questionnaire prepared for the purpose. Here, total 20 blocks have been selected from the select five states and 25 respondents are selected from each block at random basis. The final sample size, i.e., 500 is found enough following the Cochran's formula (Cochran, 1977) of minimum sample size determination. Minimum required sample as per Cochran's formula is found 384 and here the sample size for this study fixed as 500 is proved to be enough to run. This primary survey has been conducted since November 2020 to January 2021 just after the first wave of COVID-19.

Third, sample farmers' feedback collected for this purpose following 10 point rating scale. Here, those farm risks are selected which are frequently faced by the sample farmers representing the select five states (Maharashtra, Rajasthan, Chattisgarh, Madhya Pradesh and Haryana) for this purpose. These risks selected finally for the analysis include pests and crop

diseases, excess rainfall, flood, drought due to absolute lack of rainfall, abnormality of wind and cyclone, rising input costs, and other natural or market-specific uncertain events.

Fourth, a multi-dimensional scaling (MDS) is employed to represent the relative positions of different farm risks over a perceptual map on the basis of farmers' feedback regarding the similar severity of these farm risks. To prepare this perceptual map, a paired comparison matrix has been designed taking farmers' feedback regarding each of the select farm risks through the 10 point rating scale. Here, '1' stands for mostly similar type of severity and '10' refers to not at all similar level of risks.

Fifth, an ordinary least square regression (OLS) has been employed to explore the effect of farm risks vulnerability as select multi-nominal variables on the adoptability of crop insurance, i.e., the dependent variable.

Following the paired comparison table of perceived risk matrix, the perceptual map has been prepared on the select farm risks. Now the MDS is performed and presented step by step. The details of iteration for the initial two-dimensional solution are presented in Table 2 as per squared distances following the "S-stress formula-1" of Young.

Table 2 *Iteration detail for the initial two-dimensional solution*

Iteration	S-stress	Improvement
1	0.32198	
2	0.27450	0.04748
3	0.27422	0.00028
Iterations stopped because		
S-stress improvement is less than 0.001000		

Validation of the scaling has been done with the help of "stress and squared correlation" (RSQ) in distances. For the risk matrix developed here shows:

The amount of stress = 0.19125, RSQ = 0.77198

The stress value and RSQ are found valid as the amount of stress is lesser than 0.2 and RSQ is greater than 0.7.

Thus, the results are found satisfactory and the matrix is found fit to run. The analysis is performed using Kruskal's "stress formula-1". Here, RSQ values indicate the proportionate variance of the interval data used for perceived risks in row-wise or in the entire matrix. The values are standing for corresponding distances when plotted in a perceptual map. Distances are represented on two-dimensional frame shown in the Table 3.

Table 3 *Two-dimensional representation of distances*

Sl. No.	Name of Perceived Farm Risks	Dimension 1	Dimension 2
1	Pests and crop diseases	-0.9116	1.2558
2	Excess rainfall	-0.9844	-0.8313
3	Flood	-1.1018	-0.2039
4	Drought	2.0212	-0.8842
5	Abnormality of wind and cyclone	-0.5808	-0.8901
6	Rising input costs	0.6172	1.0995
7	Others (natural or market-specific uncertain events)	0.9402	0.4542

Figure 1 represents the final perceptual map in this context which actually depicts the position of each perceived risk as an outcome of pair-wise comparative valuation of similar severity of farm risks through MDS.

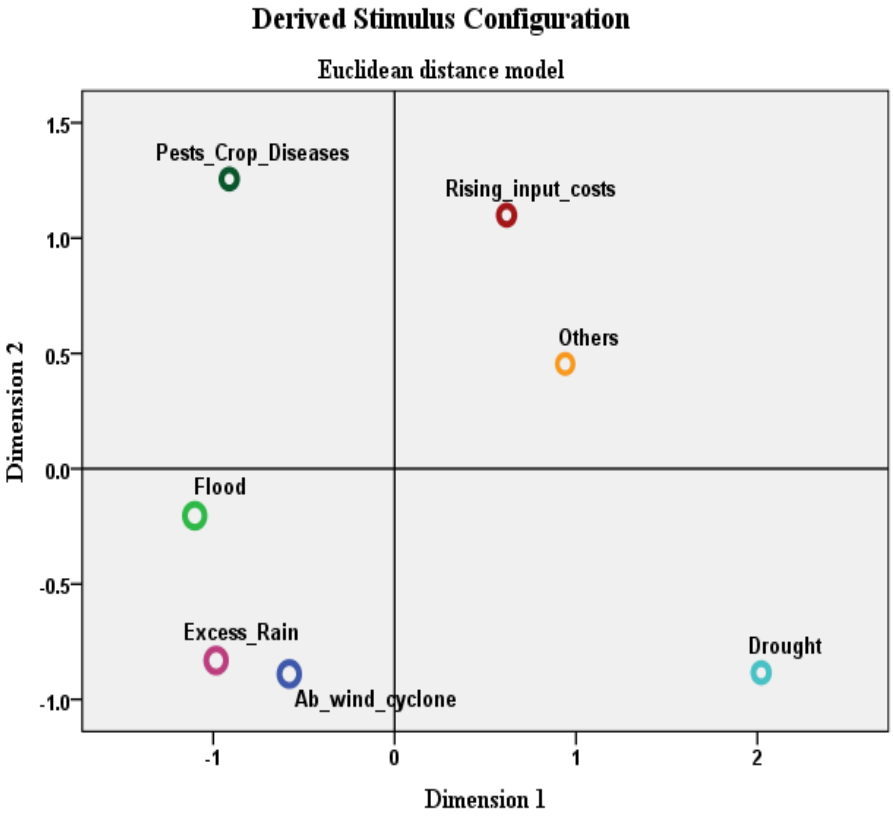

Figure 1 *Perceptual map indicating the relative positions of perceived farm risks*

The perceptual map highlights that every farm risk has unique position considering its perceived severity of devastation. Finally, all the perceived risks are proved to get prior consideration by the actuarial expert or insurer during adoption of a crop insurance programme. For this reason, in the next step, the study computes risk vulnerability as well as adoptability indices in favor of crop insurance undertaking the OLS regression method.

OLS Regression

Adoptability of crop insurance is dependent on farm risks vulnerability. The OLS regression has been conducted to explore the effect of farm risks vulnerability on the adoptability of crop insurance. Table 4 in this analysis shows that the model is good to fit which signifies that the explanatory variables added to be regressed on the dependent response variable are well fit to run.

Table 4 *Chi-square test: model's goodness-of-fit*

	Chi-square	df	Sig.
Pearson goodness-of-fit test	8.058E+14	498	0.090

Results of OLS regression is reflected through the Table 5. It indicates the effect of farm risks vulnerability on the adoptability of crop insurance.

Table 5 *Regression coefficients and their significance (**statistically significant at 5%, *statistically significant at 1% level)*

Predictors	Coefficient	Std. Error	P> /t/
Pests and crop diseases	2.158879	1.105864	.004*
Excess rainfall	-.3975697	.2924067	.015**
Flood	5.163708	1.300146	.012**
Drought	3.207733	.2945009	.005*
Abnormality of wind and cyclone	-.4219503	.302512	.001*
Rising input costs	-.1325771	.078921	.625
Others (natural or market-specific uncertain events)	-.0059185	.3561427	.268
Constant	.254681	1.37215	.482

Negative estimates in the regression model signify the negative impact whereas positive estimates signify the positive association of farm risks' vulnerability on crop insurance adoptability. Rising input costs, others (natural or market-specific uncertain events), and the constant terms are found statistically insignificant in this regression analysis.

Summary and Conclusion

The present study has been initiated to investigate Indian farmers' risk perception and whether there is any impact of different farm risks on the adoptability of crop insurance. Through the study this is also attempted to establish that assessment of cultivators' perceived risks should be the pre-requisites of insurers' crop insurance adoption.

Here, in this study, the perceptual map highlights the unique position of every farm risk considering its perceived severity. Pests and crop diseases get a complete distinctive place in a separate quadrant as the source of risk is not related to natural calamity and here unknown species of pest or disease plays a distinct role with the fate of Indian cultivators. Rising input costs for farming and other farm risks (natural or market-specific uncertain events) are closer with each-other and get the place in a single quadrant over the perceptual map. It signifies that from cultivators' perception, these two risks are to some extent associated with each-other. Calamities like flood, excess rainfall, and abnormality of wind and cyclone are placed in a single group considering the severity of their risks. Farmers perceive their devastating power of damaging crop of similar type and cultivators may assume probable cause and effect relationship between these sources of risks. Drought is a kind of risk where crops are damaged due to absolute lack of rainfall. This source of farm risk is perceived by the farmers as a completely separate risk. Moreover, this is found as a stand-alone source of farm risk on the basis of its severity.

From the OLS regression, it is clearly evident that rising input costs and other sources (natural or market-specific uncertain events) of risks have no significant impact from the farmers' perception on the national crop insurance adoption. On one hand, vulnerability of farm risks like pests and crop diseases, flood, and drought should have significant positive impact on crop insurance adoption policy. On the other hand, vulnerability of farm risks like excess rainfall and abnormality of wind and cyclone should have negative impact on crop insurance adoption. The result implies that when the severity of pests and crop diseases; flood; and drought rises, crop insurance is more likely to be adopted. But, when the intensity of excess rainfall and abnormality of wind or cyclone increases, crop insurance adoption is to be

minimized. These results are based Indian cultivators' perception regarding severity of different farm risks and their possible effect on national crop insurance adoptability.

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