Evaluation of risk preferences and coping strategies to manage with various agricultural risks: evidence from India

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Abstract
The present study proposes to analyse farmers' attitudes towards risk and examine the effect of specific socio-demographic and socio-economic characteristics on farmers' risk attitudes in irrigated and rain-fed regions of Odisha, India. A total of 400 randomly selected farmers participated in the experiment. The study applies the Modi ed Holt and Laury Lottery method for measuring risk attitudes. The majority of the farmers are having a risk-averse attitude and only a few farmers have a risk-taking attitude. One-sixth of the farmers are having risk-neutral decision behavior. The effect of Socio-demographic and socio-economic variables on farmers' risk attitude is also measured using an ordered probit model dealing with risky outcomes. The study reveals a negative relationship between household size and a risk-averse attitude. The study also reveals a negative relationship between off-farm income source and risk-averse attitude. The study also finds that there is an immediate need to improve extension facilities in the study area to train these farmers regarding the best risk management practices for deciding the choice of a particular crop such as growing short-duration crops as well as climate-resistant crop variety. Storage facilities need to be improved and there is an urgent need for improved irrigation systems to increase production particularly in Bolangir district. The result provides government agencies an outline to know how risky farming environment affects farmers' production decisions and designing policies such as crop insurance, weather-based crop insurance and other safety nets that effectively address farmer's problem. The main intention behind this experimental design is to make the policy makers aware of the high degree of risk aversion existing in a rural developing farm setting. Socio-demographic and socio-economic variables can be taken as a reference while implementing policies dealing with risky outcomes.

1. Introduction
The farming sector in India is often characterized by high exposure to risk from extreme climatic events. The decision environment in the agricultural sector of the country is completely uncertain and very much dependent on the mercy of the weather (Parry and Carter, 1988). No doubt, farm production decision always contains a certain element of risk due to uncertain weather but somehow the producer must make risky choices to gain more return from the farm produce (Newbery and Stiglitz, 1981). Risk and uncertainty impact farm households' both production and consumption decisions (Morduch, 1995). Around half of India's working force directly depends on agriculture for their livelihood (Chand, 2017). The neoliberal restructuring of the economy has been associated with an inequitable sectoral growth process where agriculture has lagged (Patnaik, 2007; Vyas, 2004). To make matters worse, there has been an unprecedented agricultural and agrarian crisis as evident from the spate of farmers' suicides (Mishra, 2006a; 2006b; Vaidyanathan, 2006; Harris-White, 2008; Reddy and Mishra, 2009). Agricultural shocks have implications on the farm income and food security of millions apart from the availability of essential raw materials. Moreover, distortions in agricultural production and supply affect global exports and a rise in prices causing an inflationary situation in the country. Climatic shocks, therefore, affect crop production directly without proper adaptation and mitigation strategies. According to Reynaud and Couture (2012), understanding individual risk preferences is a pre-requisite to understand economic behavior. From a policy-makers' perspective, it is imperative to understand farmers' risk preferences to gain insight into the dynamics of how risk affects their decision behavior and to predict this behavior in the future (Ihli et al., 2013).

There are some studies (Anderson and Griffiths, 1982; Just and Pope, 1978, 1979; Sasmal, 1993; Saha, 2001; Goyari and Sharma, 2008; Czekaj and Henningsen, 2013) which evaluate the risk attached with the inputs...
affecting the yield. These studies used the generalized stochastic production formulation which consists of two parts where one part is the mean output function of inputs and the second part is the variance of production. In this formulation the marginal effect of input on the mean output and the variance of output are independent. The marginal effect of input on the variance of output reflects the risk attached to that input. There are various studies in the literature highlighting the use of experimental data to bring out individuals’ risk attitudes in both developed and developing countries. Therefore a variety of techniques have developed for testing it empirically which includes Lottery choice task decisions (Holt and Laury, 2002), self-assessment questions (Dohmen et al., 2011), willingness to pay (Kahneman et al., 1990), and hypothetrical gambles (Anderson and Mellor, 2009). The studies byBinswanger (1980), Humphrey and Verschoor (2004), Jacobson and Petrie (2009), Harrison et al. (2007), Ihli et al. (2013) analyzed risk attitudes of individuals in the context of a developing country whereas studies like Holt and Laury (2002), Dave et al. (2010) and Reynaud and Couture (2012) explored risk attitudes of individuals in a developed country context. Ullah et al. (2015) and Saqib et al. (2016) have used the Equally Likely Certainty Equivalent (ELCE) method to measure the risk perception of farmers in Pakistan. Using the Probit and Logit model, they have found factors like age, education, land ownership status, experience, farmers’ group, landholding size, off-farm income, and risk perceptions of floods significantly affect the risk attitude of farmers.

To deal with these considerable risks and uncertainties, agricultural households rely on several strategies: both ex-ante and ex-post. Households rely on ex-ante strategies such as spatial diversification (different and distant plots), cultivar (varietal) diversification, temporal diversification through sequencing of planting, diversification of income sources, and contingency savings; strategies which can be classified as ‘income smoothing’ strategies (Deaton, 1992; Morduch, 1995; Dercon, 1996). There are also in place a set of ex-post coping mechanisms such as cutting down on household consumption, dissaving, asset depletion and labour supply adjustments; which can be called as ‘consumption smoothing’ strategies (Rosenzweig and Stark, 1989; Deaton, 1992; Rosenzweig and Wolpin, 1993).

Green revolution technology has contributed immensely to the increase in the productivity of Indian agriculture. But it has remained confined to few states of India. Though the agrarian economy of Odisha has been directly influenced by the adoption of a scientific package of agriculture, it is not yet covered to a large extent and uniform in nature across the ecosystems and class of farmers. Odisha, though endowed with rich natural and mineral resources has always remained one of the least developed states in India. The Human Development Index (HDI), ranked Odisha 22 out of 23 Indian states in 2011 (UNDP, 2011). This low HDI value tells the story concerning meager access to basic facilities in the country. Nearly 37% of the population in Odisha lives below the poverty line (UNDP, 2011). In Odisha, recurrent droughts, floods, and cyclones threaten the livelihood of billions of people. When disasters strike, the livelihood of small farmers, pastoralists, fishers is the worst affected. Erratic and insufficient rainfall often causes drought and flood situations in this state. Being a coastal state it faces cyclonic storms almost every year. Crop loss and poor productivity of agriculture often leave the farmers in this state as the worst sufferers. Farmer suicide has been witnessed in many parts of this state. Odisha agriculture is primarily dependent on weather and any variation in weather patterns affects crop production. Some areas of the state are more vulnerable than others depending on their adaptive capacity and socio-economic and demographic status.

Binswanger (1980) obtained a measure of farmer’s risk aversion for the sample farmer in India through gambling experiments. The present study reports on an experiment conducted in both irrigated and rainfed regions of Odisha, (India) that was designed to analyze determinants of farmers’ risk attitude, their preferences and overall coping strategies adopted to deal with various covariate and idiosyncratic risk and seeks answers to the following research questions: How do we measure the risk attitude of agricultural households? How various socio-economic distinctiveness affects farmers’ risk attitudes of a certain region?

The present study has several implications further than the useful lessons it highlights about investigating risk attitudes. First, it demonstrates how large scale field surveys in two geographically different located regions, can also be used to test theories of production decisions under the situation of risk and uncertainty. Second, it presents how different socio-economic and socio-demographic factors influence risk attitude and preferences which may form the basis for developing a theory. Finally, this study provides decision-makers with evidence-based tools as a guide to consider informal risk management strategies before offering them formal insurance.

The paper is organized in this manner: after the introduction and the statement of the objectives in the first section, a simple theoretical model is developed in the second section. The third section deals with the study region, data collection, experiment, and incentive design. Empirical results and subsequent discussions take place in the fourth section. Finally, the paper concludes with some policy implications.

2. Theoretical framework

The assessment of farmers’ risk attitude is essential under the situation of risk and uncertainty that prevails in agricultural decision making. There are various approaches developed so far in analyzing risk perceptions in the literature. Scholars like Marschak (1950), Tobin (1958) and Markowitz (1959) have developed the portfolio approach which requires only knowledge of the first two moments of the relevant probability distribution (Sankar and Myhili, 1991). Roy (1952) developed a safety-first approach to analyse decision problems involving risky choices. Roy suggested that in a risky situation many decision-makers would be concerned about the probability that their incomes fall below a certain level, called disaster level. His hypothesis is relevant for small investors who are eager to meet their commitments for survival. According to Ellis (1992), peasant farmers used to produce crops under severe uncertainty such as fluctuations in input price, natural disasters, and policy changes related to agriculture. These situations force farmers to think very cautiously before undertaking any production decisions (Walker and Jodha, 1986). Therefore it is not shocking to see when they exhibit risk aversion in their decision making. According to Binswanger (1980), the differences in risk aversion class are due to differences in constraints they face which plays an important role in their investment in technologies to continue the production process. There are differences in risk attitude among farm households which comes naturally to them while deciding production decisions under the situation of risk and uncertainty. In this paper, the author has adopted the Neumann and Morgenstern expected utility theory to identify the risk-attitude of a particular respondent using the following mathematical function:

\[ E[U(Pi, Xi)] = P1U(X1) + P2U(X2) + \ldots + PnU(Xn) \]  

(1)

Using the above mathematical formulation one can discuss the alternative behavior of a respondent towards risk. We can apply expected utility analysis in investment portfolio selection, purchases of insurance, games of chance, and in particular to the situation of choice among risky goods and services. To experiment, the author has offered 2 boxes i.e. box A (safe option) and box B (risky option) to the respondent. In this experiment, if the respondent prefers box A, he/she must draw a card out of that box and has a chance of getting either INR 250(0.34 USD) or INR 30(0.407 USD) for its probability. If the respondent selects box B then he/she must draw a card out of that box and has a chance of getting either INR 1(0.014 USD) or INR 55 (0.746 USD) for its probability. Here, the author has modified the Holt and Laury lottery approach in experimental design while replacing monetary standards with images of boxes of playing cards of 4 suits (Spades, Hearts, Diamonds, and Clubs) representing probabilities of different payoffs (INR 1(0.014 USD), INR 25(0.34 USD), INR 30(0.407 USD) and INR 55 (0.746 USD)). Every payoff is a
playing card of a particular suit. We have presented the choice tasks to all our respondents at once. Before we discuss the standard Holt and Laury (HL) lottery approach let’s discuss and compare individually between 2 boxes (Box A and Box B) using Neumann and Morgenstern Expected Utility Approach.

2.1. Case (a): BOX-A (Heart and Diamond cards with payoff INR25 and INR 30)

The way economists categorize a consumer’s attitude toward risk also applies here. Following the Neumann and Morgenstern (N-M) principle, we can categorize our respondent attitude towards risk as risk-averse, risk-taking and risk-neutral. A respondent is considered to be risk-averse, if E[U(X)] < U[E(X)]. The utility function for such individual will be strictly concave because the marginal utility associated with higher outcome values diminishes for this function. Mathematically, such a utility function can be expressed as:

\[ U(X) = X^{1/2} \]  

and

\[ MU_X = \frac{dU(X)}{dX} = \frac{1}{2} X^{-1/2} \]  

In our experiment, X is nothing but the payoff associated with the card game. According to N-M, a respondent is risk-averse if and only if:

\[ E[U(X)] = P_H U(X_H) + P_D U(X_D) < U[E(X)] \]  

H and D represent Heart and Diamond cards respectively.

In case of a fair game:

\[ E(X) = P_H X_H + P_D X_D = (0.5) (INR 25(0.34 USD)) + (0.5) INR 30(0.407 USD) = INR 27.5(0.399 USD) \]  

Since we assume that, U(X) = X^{1/2}, X_H = INR 25(0.34 USD), and X_D = INR 30(0.407 USD), P_H and P_D = 0.5

\[ E[U(X)] = P_H U(X_H) + P_D U(X_D) = (0.5) X_H^{1/2} + (0.5) X_D^{1/2} = (0.5)(25)^{1/2} + (0.5)(30)^{1/2} = 5.238 \]  

\[ U[E(X)] = U(X)^{1/2} = U(27.5)^{1/2} = 5.245 \]  

Since this value (5.245) is greater than 5.238 units of utility, a risk-averse respondent logically chooses not to play the game but instead hold INR 27.5(0.399 USD) with certainty.

A respondent is considered to be risk preferring if E[U(X)] > U[E(X)]. The utility function for such individual will be strictly convex because marginal utility increases as value of outcome increases shown in panel (B) of the figure. Mathematically,

\[ U(X) = X^2 \]  

and

\[ MU_X = 2X \]  

According to N-M, a respondent is risk-taking if and only if:

\[ E[U(X)] = P_H U(X_H) + P_D U(X_D) > U[E(X)] \]  

\[ E[U(X)] = P_H U(X_H) + P_D U(X_D) = (0.5) X_H^2 + (0.5) X_D^2 = (0.5)(25)^2 + (0.5)(30)^2 = 762.5 \]  

\[ U[E(X)] = U(X)^2 = U(27.5)^2 = 756.25 \]  

Therefore, a risk taking respondent decides to participate in the game since 762.5 (11.07 USD) > 756.25 (10.98 USD).

A respondent is considered to be risk neutral if E[U(X)] = U[E(X)]. The utility function for such individual will be linear because marginal utility is constant as the value of outcome increases shown in panel (c) of the figure. Mathematically,

\[ U(X) = X \]  

and

\[ MU_X = 1 \]  

According to N-M, a respondent is risk-neutral if and only if

\[ E[U(X)] = P_H U(X_H) + P_D U(X_D) = U[E(X)] \]  

\[ E[U(X)] = P_H U(X_H) + P_D U(X_D) = (0.5)(25) + (0.5)(30) = 27.5(0.399 USD) \]  

\[ U[E(X)] = U(27.5) = 27.5(0.399 USD) \]  

Therefore a risk-neutral respondent will be indifferent (see Figure 1).

2.2. Case (b): BOX-B (Spade and Club cards with payoff INR1 and INR 55)

The same logic applies here that discussed in Box A. Following Neumann and Morgenstern (N-M) principle, we can categorize our respondent attitude towards risk as risk-averse, risk-taking, and risk-neutral. A respondent is considered to be risk-averse, if E[U(X)] < U[E(X)]. The utility function for such individuals will be strictly concave because the marginal utility associated with higher outcome values diminishes for this function. Mathematically, such a utility function can be expressed as:

\[ U(X) = X^{1/2} \]  

and

\[ MU_X = \frac{dU(X)}{dX} = \frac{1}{2} X^{-1/2} \]  

In our experiment, X is nothing but the payoff associated with the card game. According to N-M, a respondent is risk-averse if and only if:

\[ E[U(X)] = P_S U(X_S) + P_C U(X_C) < U[E(X)] \]  

S and C represent Spade and Club cards respectively.

In case of a fair game:

\[ E(X) = P_S X_S + P_C X_C = (0.5)(INR1) + (0.5)(INR55) = INR28 \]  

Since we assume that, U(X) = X^{1/2}, X_S = INR1, and X_C = INR 55, P_S and P_C = 0.5

\[ E[U(X)] = P_S U(X_S) + P_C U(X_C) = (0.5) X_S^{1/2} + (0.5) X_C^{1/2} = (0.5)(1)^{1/2} + (0.5)(55)^{1/2} = 4.208 \]  

\[ U[E(X)] = U(X)^{1/2} = U(28)^{1/2} = 5.291 \]  

a risk-averse respondent logically chooses not to play the game but instead hold INR 28 with certainty.

A respondent is considered to be risk preferring if E[U(X)] > U[E(X)]. The utility function for such individual will be strictly convex because marginal utility increases as value of outcome increases shown in panel (B) of the figure. Mathematically,

\[ U(X) = X^2 \]  

and

\[ MU_X = 2X \]  

According to N-M, a respondent is risk-taking if and only if:

\[ E[U(X)] = P_S U(X_S) + P_C U(X_C) > U[E(X)] \]  

\[ E[U(X)] = P_S U(X_S) + P_C U(X_C) = (0.5) X_S^2 + (0.5) X_C^2 = (0.5)(1)^2 + (0.5)(55)^2 = 1513 \]  

\[ U[E(X)] = U(X)^2 = U(28)^2 = 784 \]  

Therefore, a risk taking respondent decides to participate in the game since 1513 > 784.

A respondent is considered to be risk neutral if E[U(X)] = U[E(X)]. The utility function for such individual will be linear because marginal
utility is constant as the value of outcome increases shown in panel (c) of the figure. Mathematically, $U(X) = X$ and $MU_X = 1$.

According to N-M, a respondent is risk-neutral if and only if

$$E[U(X)] = PSU(X_S) + PCU(X_C) = U[E(X)]$$  \hspace{1cm} (25)$$

$$E[U(X)] = (0.5)(1) + (0.5)(55) = 28$$  \hspace{1cm} (26)$$

and $U[E(X)] = U(28) = 27.5$  \hspace{1cm} (27)$$

Therefore a risk-neutral respondent will be indifferent.

From the above analysis, it is clear that the respondent will choose Box B than Box A to consider themselves as more risk preferring because Box B is giving more utility (1513) than Box A (762.5). To experiment, we defined, therefore, Box A as the safe option and Box B as the risky option because of different payoff values in these 2 boxes. If we will compare between 2 boxes then the respondent choosing or preferring Box A over Box B will be termed as Risk-averse. Friedman and Savage (1948) discover the possibility that a respondent can be both risk-averse and risk-taking depending on the card value i.e. payoff. This is because, for relatively lower value of the outcome, he may be risk-averse, whereas for relatively higher value of the outcome, he may prefer to take risk and the utility function will be cubic for such an individual, i.e., concave in case of low value of the outcome and convex for relatively higher outcomes (see Figure 2).

3. Data and methodology

Total samples of 400 households are collected, out of which 200 are from the irrigated region of Cuttack and 200 from the rain-fed region of Bolangir district. Experiments were conducted in two districts of Odisha from May to August 2016. The distance of each village from the main city Bolangir is 15–20 km in the case of rainfed region and a maximum of 30 km in case of villages of the irrigated region from Cuttack, the major city. Data is collected for the Kharif season only since in the rain-fed region, the farmers completely depend on monsoon and cultivate only in the Kharif season. So for maintaining uniformity, the author has collected data for one common season. The study is focused on landowning cultivator households to study their production decisions under the situation of risk and uncertainty.

These two districts were selected due to their distinct farming systems and agro-ecological and climatic conditions. To select farmers, the study has used a multi-stage sampling method based on the sampling lists. In the first step, the author has purposively selected the above two districts. In the second step, villages were selected randomly. In the third step, farmers were chosen at the village level. The farmers were then requested to participate in a household survey and an experiment. Participants were mostly either the household head or their spouse because they are those most likely to be faced with risky choices and important economic decisions. The author has applied the lottery-choice experiment suggested by Holt and Laury (2002) and Modi followed Holt and Laury method as in Ihli et al. (2013) for evaluating risk attitudes of sample households. The main reason of using Holt and Laury (2002) include its popularity in experimental economics and considered as the standard technique; its transparency i.e. easy to explain and implement, its incentivized design, and finally, it can be considered for further research use in different...
subjects where risk aversion behaviour exists. Total samples of 400 households are collected, out of which 200 are from the irrigated region of Cuttack and 200 from the rain-fed region of Bolangir district.

The Cuttack district is an irrigated district while Bolangir is a rainfed district on the basis of the argument that if one region is having more than 60 percent of its total cultivable land irrigated by canal or any other sources except rainfall then it is called as the irrigated region otherwise, it is called rainfed region (Chand et al., 2011). In the case of Cuttack district, more than 90 percent of cropped area is irrigated while in the case of Bolangir district it is about 41 percent2. Thus, by the definition, the author has selected two districts belonging to two different ecosystems and it enables us to study the differential aspects aforementioned issues related to the agriculture sector of both regions. However, a long process was involved while selecting the study villages and several underlying principles were prioritized. The step by step process involved in the selection of study villages starts with the selection of districts, then the block or subdivision, location and finally the villages. The study villages, keeping the objectives strictly in mind, are selected on the basis of the following reasons:

1. In the irrigated region, the study villages are connected with canal irrigation with two times cultivation facilities. The assured canal irrigation enables the farmers to go for both Kharif and Rabi cultivation. However, in the rainfed region, they only cultivate after receiving southwest monsoon and cultivate once in a year in Kharif season.

2. The climatic risks that farmers face in both types of agriculture are not the same in their character and magnitude. In the irrigated region of study villages, mostly floods/submergence are a major threat and in the rainfed region drought type of situation occurs at any stage of crop growth.

The distance of each village from the main city Bolangir is 15–20 km in the case of the rainfed region and a maximum of 30 km in case of villages of the irrigated region from Cuttack, the major city.

3.1. Experiment design

All selected farmers in two different regions of Odisha participated in the experiment. The farmers were divided into several groups for the experimental sessions. The author has conducted 150 experimental sessions in two different regions for 3 months. Every day, the author has conducted 2 sessions one in the morning and one session in the afternoon time. A group of randomly selected farmers is involved in each session. It takes within one and a half hours for each group of the farmer to complete the session. The author has conducted the experimental sessions in village community halls, temples and classrooms in local schools in several villages so that all the selected farmers can reach within time and these are places where farmers are very much familiar. All the sessions were conducted in Odisha, the main language of Odisha. To further facilitate comprehension, the author has used playing cards with a different payoff. The experiment is conducted by placing the appropriate cards in two different boxes and also clearly explained to the respondent various monetary values associated with each card. The respondents then can make their decision by pointing towards a preferred box and drawing a card from that box. During this process, the author has recorded their preferred choice. The choice task was simple for the participants to understand because in Odisha all are familiar in playing cards. During the presentation, the author has also encouraged the respondent to ask any questions regarding the choice task. To motivate participants, the author has arranged small refreshment facilities after the end of the survey so that they will take the tasks more seriously. To avoid cognitive bias, one quiz test is conducted before the final experiment. The study has applied the Modified Holt and Laury method for measuring risk attitudes.

3.2. Incentive design

To motivate the farmers, it is essential to ensure some incentives in the form of real earnings to induce them for taking the task seriously (Ihli et al., 2013). The study has adopted a random lottery incentive system by Humphery and Verschoor (2004) based on which the author has informed the respondent initially before the experiment that once they completed all tasks, we will select one task at random and accordingly decide their prize money. However, it is subject to limitations since we are paying only a few respondents not all the respondents because we have assigned a number to all the group members. One member will be again selected at random from the group. Therefore the real prize money was decided based on their preferences across various mutually exclusive cases. The probability remains the same for the entire decision task. The prospective earning varies between INR 1 and INR 55 for the HL lottery. The payment in the experiment was conducted as follows: farmers were informed from the very beginning that one group out of the total number of groups will be randomly selected so that they can receive the prize money between INR 1 and INR 55 depending on their chosen task. One member will win the prize money by drawing cards again from the assigned group numbers. If the respondent selects box A, he/she has to draw a card out of the box and hence has the probability of winning either INR 25 or INR 30 with its probability. Similarly, if the respondent selects box B, he/she has to draw a card out of the box and hence has the probability of winning either INR 1 or INR 55 with its probability.

3.3. The Holt and Laury lottery method and its modification

Holt and Laury (2002) made 10 choices between two options such as safe option and risky option. Ihli et al. (2013) followed the same method with slight modifications. The author has adapted both the method. In this experiment, option A has the probability of respondent either winning INR 30 or INR 25 with respective probability; whereas option B has the probability of respondent winning either INR 1 or INR 55 with a certain probability (see Table 1).

The monetary earnings are indeed constant across 10 choice tasks and the probability of the prize money varies with a constant 10% across all the choice tasks. The expected value of both safe option as well as risky option changes as one respondent shifts from one choice task to the other. From the above table, the expected value of A is more than B up to 4th choice task but it is just the opposite from the 6th task onwards where the expected value of B is more than A. In this experiment, we have asked our respondent to make 10 choices of either option A or option B, one for each choice task. Here one can obtain the switching point determining the respondent’s risk attitude class when he/she switches from the safe to the risky option. If a respondent switched to option B in the case of the first four decision rows, we declared them as risk-taking respondents. Similarly, if a respondent switch to option B in between row 6 to row 9, we declared them as risk-averse respondent. Finally, if a respondent switch to option B in row 5, we declared them as risk-neutral respondent. Therefore a standard Holt-Laury value indicates risk-taking between choice tasks 1–4, choice task 5 implies risk neutrality and finally, 6–10 choice task indicates risk aversion of the sample respondent. Following Ihli et al. (2013), a constant relative risk aversion (CRRA) function is represented by u(x) = x1–β/1–β, where x represents prize and β is the latent risk coefficient. A respondent who has selected option A 6 times before switching to option B indicates a CRRA interval between 0.14 and 0.41 (Anderson and Mellor, 2009). To conduct a standard HL lottery experiment with rural farm households in Odisha, I found not a good idea, therefore I have modified the approach little bit to suit the analysis.

In our experiment, we have replaced monetary values with images of boxes of playing cards of 4 suits (Spades, Hearts, Diamonds, and Clubs) representing probabilities of different payoffs (Rs 1.00, Rs 25.00, Rs 30.00 and Rs 55.00) shown in Appendix A.

2 Odisha Agriculture Statistics, 2013-14.
3.4. Farmer-specific effects for risk attitude

Socio-demographic characteristics of farm households include their gender, age, education, and household size collected from various studies suggest that the aforementioned variables have a significant effect on the risk preferences of an agricultural household. Some researchers also found no such significant effect of the aforementioned variables on determining risk attitudes of farm households in their studies. Cronw and Gneezy (2009) found that female farmers are more risk-averse than male farmers; whereas Mosley and Verschoor (2005) found no such significant effect on risk attitudes. Nielsen et al. (2013) found that old farmers are more risk-averse than young farmers; whereas Maart-Noelck and Musshoff (2013) found no such significant effect of age on risk attitudes. Harrison et al. (2007) found that farmers attaining formal education are more risk-averse than farmers with no education; whereas Reynaud and Couture (2012) found no such significant influence of education on risk attitudes of farmers. Miyata (2003) found that farmers having large families are more risk-averse than with less family size; whereas Maart-Noelck and Musshoff (2013) found no such effect of household size on risk attitudes.

Similarly, the author also collects information related to the socio-economic characteristics of farm households which includes their income, farm size, farmer group participation and access to credit, etc. Several researchers analyzed these variables in their studies influencing the risk preference of farm households. Some researchers found a significant influence of these socioeconomic variables on risk attitudes and at the same time, this paper also incorporated studies highlighting no significant influence of these characteristics on risk preferences. Cohen and Einav (2007) found that rich farmers are more risk-averse than poor farmers; whereas Tanaka and Nguyen (2010) found no such significant effect of income on risk attitudes of sample households. Wiki et al. (2004) found that farmers with large size of land are more risk-averse than small and marginal farmers; whereas Reynaud and Couture (2012) found no such significant effect of farm size on risk attitudes of farmers. Barham and Chitemi (2009) found that farmers joining as a member of any group or organization are less risk-averse. Eswaran and Kotwal (1989) found that farmers having access to credit are less risk-averse. Therefore we need to check empirically how these characteristics influence the risk attitudes of farm households in our study area.

3.5. Econometric model: an ordered probit specification

In this experiment, the outcome of interest is whether the risk attitude of a farmer is risk-averse, risk-neutral or risk-lover. Therefore the dependent variable has 3 categories/alternatives: risk-lover, risk-neutral and risk-averse. There will be 1 set of coefficients with two intercepts and there will be 3 sets of marginal effects, one for each category. A standard Holt-Laury value indicates risk-taking between choice task 1–4, choice task 5 implies risk neutrality and finally 6–10 choice task indicates risk aversion of the sample respondent. We might consider the risk attitude as arising from the value of a single indicator y*, the greater the value of y*, the higher the chance of being risk-averse. In this case, the outcomes are ordered. The empirical model can be written as:

\[ y^* = \beta' X + \epsilon \]

where \( y^* \) represents unobserved response variable (perhaps the exact level of choice made by the farmers); \( X \) represents the vector of explanatory variables and \( \beta \) represents the vector of regression coefficients. Since we cannot observe \( y^* \) directly only can observe various categories of responses:

\[ y_1 = 1 \text{ if } y^* < c_1 \]
\[ y_2 = 2 \text{ if } c_1 < y^* < c_2 \]
\[ y_3 = 3 \text{ if } y^* > c_2 \]

The model can be written as:

\[ y_1^{RL} = 1 \text{ if } y^* < c_1 \]
\[ y_1^{RN} = 2 \text{ if } c_1 < y^* < c_2 \]
\[ y_1^{RA} = 3 \text{ if } y^* > c_2 \]
where $c_1$ and $c_2$ are the thresholds that the latent variable must cross to change the value of $y$. We choose an appropriate function $F$ and compute the relevant probabilities:

\[
\begin{align*}
\text{prob}(y_{1R} = 1) &= F(c_1 - X\beta) \\
\text{prob}(y_{1R} = 2) &= F(c_2 - X\beta) - F(c_1 - X\beta) \\
\text{prob}(y_{1R} = 3) &= 1 - \text{prob}(y_{1R} = 1) - \text{prob}(y_{1R} = 2) \text{ also implies that prob}(y_{1R} = 3) = 1 - F(c_2 - X\beta)
\end{align*}
\]

In ordered probit model, $F$ is just the cumulative standard normal density. When $X$ includes just a constant and a single covariate, for example, we can write $X\beta = a + z\gamma$, our probabilities are:

\[
\begin{align*}
\text{prob}(y_{1R} = 1) &= \Phi(c_1 - a)/\sigma \\
\text{prob}(y_{1R} = 2) &= \Phi(c_2 - a)/\sigma - \Phi(c_1 - a)/\sigma \\
\text{prob}(y_{1R} = 3) &= 1 - \Phi(c_2 - a)/\sigma 
\end{align*}
\]

4. Results and discussion

4.1. Distribution of sample respondent by their attitude towards risk

Agricultural households in Odisha face several challenges in sustaining their livelihood. Yield risk, price risk, market risk, and health risk are very much rampant in the farming business. Therefore, their production decisions are overshadowed by the risk they generally face. Farmers in a rural state like Odisha always face several risky choices while undertaking their agriculture activities. So, it is crucial for the policymaker and social scientist to know how risky farming environment affects farmers' production decisions, and designing policies such as crop insurance, weather-based crop insurance and other safety nets that effectively address farmers (Ihli et al., 2013).

Table 2 represents the risk attitude classification of sample households. The study found nearly 65% of the farmers had a risk-averse attitude in two different regions taken together and only 20.25% of the farmers had risk preference and nearly one-sixth of the farmers had risk-attitude in two different regions taken together and only 20.25% of the farmers had a risk-averse attitude. The study also found that the higher the age, the more risk-averse a participant is. Highly educated farmers in the study region are more risk-averse as compared to farmers with relatively less education. Due to the bigger size of the farm households, their consumption needs are multiplied, and thus, they become more risk-averse as compared to farm households having relatively less family size. The study, therefore, finds a negative association between family size and their risk-averse attitude. The study also reveals a negative association between off-farm income source and risk-averse attitude. The more a farmer earns from off-farm sources, his risk-taking attitude increases significantly.

4.3. Ex-ante coping strategies adopted by the farmers to cope with various covariate and idiosyncratic risks

The immediate disaster preparedness or ex-ante strategies followed by farmers in 3 blocks of Bolangir district includes strategies like stocking food grains, saving money, selecting suitable crop, switching to a different crop, mixed cropping, using fertilisers, rainwater harvesting, raising bund heights, etc. The ex-ante strategies followed by farmers in the coastal area i.e. in 3 blocks of Cuttack district include strategies like stocking food grains, saving money, selecting suitable crops, switching to a different crop, mixed cropping, raising high bunds, etc. shown in Appendix B. The ex-ante coping strategies and the percentage of farmers out of the 400 samples (200 each) adopting the strategies as collected from Bolangir and Cuttack are highlighted in Table 5.

The farmers interviewed in Bolangir district revealed that practicing agriculture in a drought-prone area has left them with a few common practices which almost all the farmers take when they anticipate drought. Stocking grains and seeds is a precautionary measure necessary for them to undertake in case there is complete crop loss. They have used the grains to sustain their family till the next yield. The seeds are used in the next turn of cropping. Almost 85% of the sample farmers confirmed stocking food grains and seeds with a precautionary motive. Like the previous measure, most of the farmers revealed saving some money to cope with crop loss associated with drought. Similarly, 81% of the sample farmers out of the 200 samples considered saving money as a precautionary measure to deal with drought when the situation of drought arises. Nearly 19% of the sample farmers reported being unable to save money because of feeble income and other obligations. Some of them had other sources of income flowing in the drought conditions also, which agriculture. The average farming experience of the sample households is 24.21 years ranging from 3 to 55 years of experience. The average total annual income is Rs 36658.75 ranging from Rs 3750 to Rs 225000. About 50% of the participants are from Cuttack district and the remaining 50% of them are from Bolangir district.

4.2. Ordered-probit regression results

Table 4 Highlights the results of the ordered-probit model. In this model, the HL lottery value is 0–10. With reference to this HL lottery value risk attitudes are highlighted as risk-averse, risk-neutral and risk-lover respectively taken as the dependent variable. A high value of HL indicates a more risk-averse behavior. In this model, variables such as age, education, farm size, HL lottery winner are all showing positive and significant factors influencing the risk behavior of sample farmers. The higher the age, the more risk-averse a participant is. This finding is in line with Nielsen et al. (2013) who got similar results. The fact that farmers attaining higher formal education are more risk-averse than farmers with no education is in line with our expectations according to Harrison et al. (2007) who got similar results. Farmers with large size of land are more risk-averse than small and marginal farmers are in line with Wiki et al. (2004) who got similar results in their study. The participants who played Modified HL lottery and won are more risk-averse than no winning. The study found that the farm household from Cuttack district possesses less risk-averse attitude as compared to those in Bolangir district. Therefore, Bolangir district farmers are more risk-averse. The study also found that the higher the age, the more risk-averse a participant is. Highly educated farmers in the study region are more risk-averse as compared to farmers with relatively less education. Due to the bigger size of the farm households, their consumption needs are multiplied, and thus, they become more risk-averse as compared to farm households having relatively less family size. The study, therefore, finds a negative association between family size and their risk-averse attitude. The study also reveals a negative association between off-farm income source and risk-averse attitude. The more a farmer earns from off-farm sources, his risk-taking attitude increases significantly.

Table 2. Risk attitude classification.

| Classification          | Frequency | Percentage |
|-------------------------|-----------|------------|
| Risk-taking Participants| 81        | 20.25      |
| Risk-neutral Participants| 60       | 15.00      |
| Risk-averse Participants| 259      | 64.75      |
| Total                   | 400       | 100        |

Source: Field Survey, 2016
prevented them from saving money for this purpose. Though none of the sample farmers revealed to be using drought-resistant varieties of crop, 70% of them revealed to be using an early maturing variety of rice (very short duration i.e. 85 days) which is beneficial in case of late-season drought or light dry condition because the chances of crop loss become less. Most of the farmers in the sample area were involved in vegetable

![Figure 3. The distribution of choices by the sample household and their risk attitude.](image)

Table 3. Descriptive statistics.

| Variables               | Definition                                      | Mean   | S.D    | Minimum | Maximum |
|-------------------------|-------------------------------------------------|--------|--------|---------|---------|
| Gender                  | Dummy – 1 if female, 0 otherwise                | 0.07   | 0.26   | 0       | 1       |
| Age                     | Age in years                                    | 48.79  | 12.41  | 20      | 85      |
| Education               | Dummy – 1 if literate, 0 otherwise              | 0.65   | 0.47   | 0       | 1       |
| Household size          | Number of household members                     | 5.66   | 2.53   | 2       | 17      |
| Farm size               | Total land in acres                             | 2.89   | 3.21   | 0.4     | 15      |
| Farmer group membership | Dummy – 1 if he is a member of any group, 0 otherwise | 0.26   | 0.43   | 0       | 1       |
| Income from source      | Dummy – 1 if yes, 0 otherwise                   | 0.4    | 0.49   | 0       | 1       |
| Farm experience         | Years of experience                             | 24.21  | 11.69  | 3       | 55      |
| District                | Dummy – 1 if participants are from Cuttack, 0 = Bolangir | 0.5    | 0.51   | 0       | 1       |
| Income                  | Total annual income in Rs                       | 366587.75 | 39954.87 | 3750 | 225000|

Source: Field survey, 2016.
Table 4. Results of the ordered-probit regression of Cuttack and Bolangir district (n = 400).

| Dependent Variable | Risk Attitude (Modified Hl. lottery) |
|--------------------|--------------------------------------|
| Gender (1 = female, 0 = male) | 0.04(0.38) |
| Age (years) | 0.02* (0.01) |
| Education (years) | 0.39* (0.23) |
| Household size (number) | -0.03 (0.04) |
| Farm size (acres) | 0.07***(0.03) |
| Farmer group membership (dummy) | 0.01(0.28) |
| other income source (dummy) | -0.09 (0.27) |
| District (1 = Cuttack, 0 = Bolangir) | -0.33* (0.25) |
| Farming experience (years) | 0.01 (0.01) |
| Constant | 0.01 (0.27) |
| Income (Rs) | -0.01 (0.01) |
| Hl. lottery (1 = played and won, 0 = no winning) | 5.13*** (0.43) |

Notes: Field Survey, 2016. Standard errors are indicated in parentheses. *, **, and *** are statistically significant at 10%, 5%, 1% level, 1 = risk averse, 2 = risk neutral, and 3 = risk lover.

cultivation besides paddy, which helped them to reap even after mild drought conditions or moderate dry weather conditions as water requirement in case of vegetables are less. But in situations of severe drought, this measure does not help the farmers. Almost 87% of the sample farmers revealed to be practicing mixed cropping as a preventive measure and 21% of the sample farmers revealed raising high bund in low embankment areas when water level kept on rising.

It can be observed from the analysis that the ex-ante coping strategies adopted in both the geographically distinct study areas are mostly different. Farming households in both areas set many scores on stocking food grains and saving money. A small portion of the sample farmers in Cuttack district has opted for flood-resistant crop variety while using drought-resistant crop variety is almost absent in Bolangir district. Instead, farmers in the drought-prone area have opted for the early maturing crop varieties. Mixed cropping was a coping strategy found to be used by farmers in both areas. So, from the table, it can be summed up that ex-ante coping strategies in the geographically distinct areas are different. Here the possible reason behind this difference could be the difference in the type of disaster they predict to face. Farmers will prepare differently for a cyclone and flood than a drought. The difference in their geographical position mostly decides the type of disaster they face. This difference marked by the difference in their tradition, culture, knowledge, and practices might be a reason behind the difference in their ex-ante coping strategies.

4.4. Ex-post coping strategies adopted by the farmers to cope with various covariate and idiosyncratic risks

The post-disaster management or ex-post strategies followed by farmers in Bolangir district includes strategies like adjustment in livestock management, seeking alternate employment, selling other assets, reducing expenditure, drawing upon common property resources, sowing short duration crop after crop loss, using agricultural input subsidy, etc. The ex-post strategies followed by farmers in Cuttack district includes strategies like adjustment in livestock management, seeking alternate employment, selling other assets, reducing expenditure,
After the advent of disaster, the farmers in Bolangir district mostly face the problem of managing their income, source of livelihood and maintenance. Like this a drought-prone zone, farmers often suffer from long or short dry weather, insufficient rainfall and sometimes mild to severe drought. Some of the farmers in the study area who owned livestock revealed of adjusting in their livestock to manage the after impacts of drought. Nearly 12% of the sample farmers owning live stocks changed the composition of animals and birds. They preferred to keep livestock requiring less food, fodder, and water than to animals needing more fodder and water. Similarly, 14% of the sample farmers spoke in favor of the destocking of animals after a severe drought as it becomes costlier to provide them with food, fodder and water and death due to disease and lack of nutrition increases resulting in a total loss. Some of them sold animals to manage their expenditure. Some farmers engaged themselves in alternative employments to meet the immediate needs in case of a complete crop failure. Almost 27% of the sample farmers worked under the immediate opportunity of job availed by many government relief programs and 24% of the sample farmers revealed to have temporarily migrated to get a better wage into nearby cities. Mostly the marginal farmers admitted to having sold different assets to meet the needs in case of severe drought. All the farmers admitted to reducing their expenditures towards food, clothes, and festivals to manage the losses incurred by the disaster. Almost 55% of the sample farmers revealed that they had reduced the expenditure towards their children’s education such as withdrawing their tuitions, postponing fresh admissions and in some cases withdrawing from schools to get additional income sources by employing them in work. Nearly 49% of the sample farmers responded to collecting firewood in days after a disaster for not being able to afford other sources of cooking or to reduce their expenditure in that regard. Only 7% of the sample farmers used to continue farming by using water pumps provided they were having both nearby water resources and financial assistance. All the farmers in the study area used agricultural input subsidy in case of crop loss because of severe drought.

Cuttack district suffers from flood situation either in the form of flash floods due to waterlogging or heavy flood due to cracks or destruction of the river bunds almost every year. The proximity of this area with two rivers and heavy rainfall either in this area or at river heads results in the flood situation in this region in most of the years. As flood affects agriculture severely the farmers in this area practice much post-disaster management or ex-post strategies. Out of the total sample, 18% of the sample farmers reported of changing the livestock composition after the advent of the disaster and also the same number of farmers reported of destocking of animals because of many reasons like the spread of animal diseases in animals, food and fodder deficiency and for money requirement. Out of the 200 sample farmers, 18% of the sample farmers reported of getting engaged in relief works to earn immediately after the disaster having no other alternative income source. Only 18% of the sample farmers revealed of migrating to nearby cities temporarily to get paid works to manage the financial loss incurred due to crop loss. Nearly 37% of the sample farmers reported of selling assets during post-disaster periods to meet urgencies. All the sample farmers reported having reduced expenditures toward food consumption and purchase of clothes and towards festivals in post-disaster periods. Almost 71% of the sample farmers reported of changing the livestock composition after the disaster. Some of the farmers in the study area who owned livestock revealed of changing the livestock composition after the severe drought. They preferred to keep livestock requiring less food, fodder, and water than to animals needing more fodder and water. Some of them sold animals to manage their expenditure. Some farmers engaged themselves in alternative employments to meet the immediate needs in case of a complete crop failure. Almost 27% of the sample farmers worked under the immediate opportunity of job availed by many government relief programs and 24% of the sample farmers revealed to have temporarily migrated to get a better wage into nearby cities. Mostly the marginal farmers admitted to having sold different assets to meet the needs in case of severe drought. All the farmers admitted to reducing their expenditures towards food, clothes, and festivals to manage the losses incurred by the disaster. Almost 55% of the sample farmers revealed that they had reduced the expenditure towards their children’s education such as withdrawing their tuitions, postponing fresh admissions and in some cases withdrawing from schools to get additional income sources by employing them in work. Nearly 49% of the sample farmers responded to collecting firewood in days after a disaster for not being able to afford other sources of cooking or to reduce their expenditure in that regard. Only 7% of the sample farmers used to continue farming by using water pumps provided they were having both nearby water resources and financial assistance. All the farmers in the study area used agricultural input subsidy in case of crop loss because of severe drought.

Table 6. Ex-post coping strategies adopted by the farmers to cope with various covariate and idiosyncratic risks.

| Ex-post coping strategies | Bolangir district (No. of farmers) | % of farmers | Cuttack district (No. of farmers) | % of farmers |
|--------------------------|-----------------------------------|-------------|-----------------------------------|-------------|
| 1.1. Adjustment in livestock management | 24 | 12 | 36 | 18 |
| 1.2. Destocking of animals | 28 | 14 | 36 | 18 |
| 2.1. Seeking alternate employment | 54 | 27 | 72 | 36 |
| 2.2. Migration | 48 | 24 | 72 | 36 |
| 3.1. Selling other assets | 58 | 29 | 74 | 37 |
| 4.1. Reduced expenditure towards food consumption | 200 | 100 | 200 | 100 |
| 4.2. Clothes and festivals | 200 | 100 | 200 | 100 |
| 4.3. Education | 110 | 55 | 142 | 71 |
| 5.1. Drawing upon common property resources | 98 | 49 | 60 | 30 |
| 5.2. Fuel wood collection | 166 | 83 | 148 | 74 |
| 6. Use of water pump | 14 | 07 | 112 | 56 |

Source- Field Survey, 2016.
impacts are more or less the same-loss of life, property, livestock, finance and more importantly livelihood. It breaks down their financial and physical strength in a slow and continuous process. So, with limited survival options available to them farmers undertake similar strategies irrespective of their geographical location, to save their life and livelihood.

As we observe from the above discussion one-size-fits-for-all is not a solution while aiding farmers of the different geographical environments in their ex-ante coping strategies, which is in line with our hypothesis of coping strategies followed by farmers in geographically distinct areas are different. But the analysis of ex-post coping strategies is not in line with the proposed hypothesis. This research suggests a few potential areas be addressed by the policymakers to improve livelihoods and standard of living. There is an immediate need to improve extension facilities in the study area to train these farmers regarding the best risk management practices for deciding the choice of a particular crop for example growing short-duration crops as well as climate-resistant crop variety. Storage facilities need to be improved and there is an urgent need for improved irrigation systems to increase production particularly in Bolangir district. Serious efforts should be made by the state government to manage, conserve and restore these natural resources for the betterment of these resource-poor farmers.

4.5. Challenges experienced by farmers in adapting to climate change

Till now we have discussed many adaptations and coping strategies which farmers undertake to cushion their land and productivity against the impact of climate variability in the form of erratic rainfall pattern, resulting into drought and flood condition in different parts of the state, which has been explained by surveying two geographically distinct areas. But as it has been observed the direct relation between crop productivity and weather vulnerabilities continues to date, it brings the necessity to know the challenges that our farmers face which exposes them to the vulnerable situation posed by these climatic threats even after adopting different strategies. As has been discussed earlier, farmers in the study areas have been following many strategies to reduce the impact of the disasters in their land, there are certain challenges that stand in the path of farmers while trying to have an effective set of adaptation and coping. These challenges though seem very common; these are the problems that make the farmers’ management of strategies cripple.

Table 7 presented the challenges faced by farmers and the percentage of farmers reporting to have faced the mentioned challenges in three blocks of Bolangir district which is geographically located in a hilly area and is regularly prone to droughts and dry spells of different magnitude and in three blocks of Cuttack district which is geographically located in the eastern coastal belt and is continuously threatened by floods of different magnitude. The table shows that 86% of the sample farmers in Bolangir district complained of not having proper irrigation facilities.

Farmers in this area mostly depend on rain-fed cropping. A few farmers have planted their own bore wells to improve the irrigation process. But as the cost of making a bore well set up is high enough many farmers found it unaffordable. Many farmers for not having water resources close to their land depended solely on rainwater. Lack of government bore well was found to be a great hindrance to farmer adaptation. Almost 67% of the sample farmers complained of having a shortage of land makes it difficult to follow many strategies like practicing mixed cropping, crop diversification or to adapt to horticulture, etc. Most of the complaining farmers are marginal farmers having land less than 2 acres or in case of some farmers no land at all. 88 farmers reported weather unpredictability has stood as a major challenge. The erratic rainfall pattern leads to short term or long term dry weather which affects crop growth but they do not leave their land unsown even when they get a forecast as they anticipate if it rains and they would not have sown it will incur them loss too. Farmers in this area do not face problems regarding credit availability anymore, as the co-operative society makes credit available to most of the farming groups. Nearly 45% of the sample farmers reported facing a lack of farm animals as a problem to their adaptation. Lack of farm animals prevails due to financial constraints to purchase and maintain the livestock in this area. Similarly, 24% of the sample farmers revealed to have a shortage of farm input because of financial constraints. Nearly 90% of the sample farmers reported that the fertility of their agricultural land has been deteriorating requiring extensive fertilizer application. Almost 47% of the sample farmers reported about an insecure property right being an obstacle. Some of the farmers who reported do not own land of their own, which prevents them from taking proper adaptation measures. Some other reported working in other’s land along with their own due to insufficient land of their own. Most of the farmers in this area obtained the assistance of agricultural extension. But some of the farmers found it less informative. Almost 97% of the sample farmers reported about their crops being prone to pests and diseases almost every year. Nearly 68% of the sample farmers reported not having received any formal training or information on the uses of fertilizers and pesticides. Many of them use it on their own accord, while some of the reported farmers followed the advice of other farmers.

5. Conclusion

The present study underlines the significance of measuring risk attitudes of farmers for climate-sensitive sectors such as agriculture to effectively handle climate-induced hazards and disasters using household-level data in Bolangir (rain-fed) and Cuttack (Coastal) region of Odisha, India. After exploring various determinants of farmers’ risk attitudes in the mentioned two districts, the study finds that the variables such as age, education, farm size, HL lottery winner are all showing positive and significant factors influencing the risk behavior of sample farmers. Farmers with large sizes of land are more risk-averse than small

| Challenges faced by farmers | Bolangir district (No. of Farmers) | % of farmers | Cuttack district (No. of Farmers) | % of farmers |
|----------------------------|-----------------------------------|-------------|----------------------------------|-------------|
| Lack of irrigation         | 172                               | 86          | 58                               | 29          |
| Shortage of land          | 134                               | 67          | 142                              | 71          |
| Unpredicted weather       | 176                               | 88          | 182                              | 91          |
| Lack of credit            | 94                                | 2           | 88                               | 44          |
| Lack of farm animals      | 90                                | 45          | 120                              | 60          |
| Shortage of farm inputs   | 48                                | 24          | 116                              | 58          |
| Poor soil fertility       | 180                               | 90          | 126                              | 63          |
| Insecure property rights  | 94                                | 47          | 98                               | 49          |
| Less contacts with development authorities at different level | 14 | 7 | 108 | 54 |
| Prone to pests and diseases | 194 | 97 | 200 | 100 |
| Lack of knowledge on the use of fertilizers, pesticides etc. | 136 | 68 | 110 | 55 |

Source: Field Survey, 2016.
and marginal farmers and similarly, the participants who played Modified HL lottery and won are more risk-averse than no winning. The study found farm household from Cuttack district is less risk-averse as compared to Bolangir district. Therefore, Bolangir district farmers are more risk-averse. The study also found that the higher the age, the more risk-averse a participant is. Highly educated farmers in the study region have more off-farm income source and risk-averse attitude. The more a farmer earns from off-farm sources, his risk-taking attitude increases significantly. After exploring various informal risk management strategies, the study finds that there is an immediate need to improve extension facilities in the study area to train these farmers regarding the best risk management practices for deciding the choice of a particular crop for example: growing short-duration crops as well as climate-resistant crop variety. Storage facilities need to be improved and there is an urgent need for improved irrigation systems to increase production particularly in Bolangir district. Serious efforts should be made by the state government to manage, conserve and restore these natural resources for the betterment of these resource-poor farmers.

Nevertheless, the results of this study do need to be interpreted with some caution. This present study suffers from many limitations that need to be noted. First, the sample size is not enough to represent the total population. The author has interviewed 400 sample farmers, 200 sample farmers from the irrigated region of Cuttack and 200 farmers from the rainfed region of Bolangir district. However, taking a sample of 400 farmers in total is not enough to study the production decision, and risk preference of farmers of an agrarian economy of a particular state. Second, the author has measured the risk attitude of farmers using N-M expected utility theory which has its own limitations. Third, experimental design is very much different from an actual farming setting. Hence, the question always ponders with experimental results to provide reliable inferences that can be extrapolated to the real world. Yet, the findings which emerge from this study have their relevance in guiding policies and interventions specific to the intensity of damage caused by covariate shocks such as droughts and floods which are increasingly anticipated with the changing behavior of climate across districts of Odisha. It is crucial for the policymaker and social scientist to know how risky farming environment affects farmers’ production decisions and designing policies such as crop insurance, weather-based crop insurance and other safety nets that effectively address farmer’s problem. The main intention behind this experimental design is to make the policymakers aware of the high degree of risk aversion existing in a rural developing farm setting. Socio-demographic and socio-economic variables can be taken as a reference while implementing policies dealing with risky outcomes. The observations made in these two areas help us to deduce that some challenges are common in both geographic areas whereas some problems that the farmers face are area specific. The difference in their geographical position is to be kept in mind while formulating climate-specific policies. In addition to that, the level of development in the area and the sincerity of authorities and officials set many scores while assisting the farmers to face the challenges. Strengthening extension services is the need of the hour to convince farmers to change cropping practices in response to extreme climate change.

**Declarations**

**Author contribution statement**

Asis Kumar Senapati: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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The authors declare no conflict of interest.

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