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Risk Management Strategies to Cope Catastrophic Risks in Agriculture: The Case of Contract Farming, Diversification and Precautionary Savings

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Abstract: Risk management is an essential way for farmers to reduce uncertainty. In this research, a stratified random sampling method was used to survey 350 maize farmers in four different agro-ecological regions in Bangladesh. Using the multivariate probit model, this study explored the possible correlation between farmers' perceptions of catastrophic risks and their attitudes towards risk sources—as well as the possible correlation between contract farming, diversification and precautionary savings as risk management strategies. The results confirm the relevance of risk management adoption decisions and reveal that the use of one risk management tool may simultaneously influence the use of another risk management tool. In addition, the research results also show that age, education level, extension experience, monthly household income, farming areas, land ownership and risk aversion nature are the most important factors that affect the adoption of risk management strategies. The research results provide further explanation and information and provide a platform for decision-makers to predict appropriate risk management strategies.

Keywords: risk management tools; precautionary savings; diversification; contract farming; probit regression; Bangladesh

1. Introduction

Risk is an integral part of agriculture [1]. Producers often use different risk management strategies because it is an extremely risky sector [2]. Usually, the major risks faced by producers are categorized into five forms such as production, marketing, financial, human capital and environmental risk [3]. Global climate change has become a considerable concern over the last few decades that is one of the most influencing sources of production risk [4]. Natural catastrophes—for example, floods,

droughts, heavy rains, hailstorms, etc.—produce uncertainties for farmers about their production [5]. Thus, throughout the world climate change is an alarming concern [6]. During the 20th century, the average global temperature increased by 0.8 °C over land and 0.5 °C at sea due to global warming [7]. Bangladesh faces many effects of climate change caused by global warming that will exacerbate the environmental, socioeconomic and demographic pressures [8]. Climate change may lead to increased flooding, vulnerability to hurricanes and storm surges, increased drought, reduced freshwater supply and higher extreme temperatures [9]. Changes in temperature and moisture will directly pressure many climate sensitive species and lead to increased erosion and deterioration of soil quality [10]. Moreover, agriculture is highly dependent on climate change and whole inter-annual production variation in different regions can interrupt the ecosystem [11]. Thus, agricultural risk should not be perceived only by farmer perspectives but also must be identified as a warning for the country's economy [12]. While the agricultural sector is correlated with different sectors (for example, industry and services sector) of the economy, the risk management for this sector is crucial [13]. Risk management is the practice for risk reduction [14]. Despite the uncertainty in production and price, risk in all decision-making processes of farming arrangements is very common [15]. Consequently, it is essential to evaluate the risks prudently and implement a suitable approach [16]. Otherwise, the farmers' profit can decline because of improper decisions of risk management [17]. Moreover, inappropriate risk management choices can cause potential selling of assets, diminishing savings and reducing employment. Because of inefficiency in inappropriate risk management practices, farmers are obliged to lessen their investment for risk reduction, which may unpleasantly affect the production. So, the adoption of an appropriate risk management strategy is essential for farmers in reducing the adverse effects [18]. Contract farming, diversification and precautionary savings are considered as mostly practiced among several strategies used by farmers in Bangladesh.

Contract farming can be described as a corresponding contract between the buyer and the seller of agricultural production, which creates an agreement for the production and sale of agricultural products [19,20]. Contracts may be different from existing situations, however usually, the quantity and price of products are fixed [21]. Risk-sharing is considered as the main cause at the time of establishing the contract [22,23]. Here, preset fees provide the scope to reduce the highest risk [24]. Although contract farming is adeptly performed, it reduces risk and uncertainty rather than buying and selling on the open market [25]. Few researchers also consider that cooperative farming association can share different risks and mitigate the threats compared with relevant contracts and propose that contract would be a powerful alternative for sharing risk [26].

Furthermore, farmers have also been working to develop their income situation in order to reduce risks, such as expanding income from different external sources rather than agricultural activities. Such as, wage employment in rural enterprises, transportation management, construction services, agro-processing, shop-keeping, peddling, small, medium and large scale trading and contract services, etc. From an agricultural perspective, diversification can be seen as the reallocation of agricultural production resources, such as land, capital, agricultural machinery and shares of others [27]. Agricultural diversification attempts to diversify risk by generating a large number of earning sources, that is divided into on-farm diversification and off-farm diversification [28]. On-farm diversification is the redistribution of agro-production resources; it can also include organic beef production, poultry production, etc. [6]. On-farm income diversification is an alternative approach to reduce the variation of income and risk of farmers through diversified farming or agricultural initiatives [18]. For example, the simultaneous production of different crops or the allocation of land to other crops or other agricultural products. Furthermore, if farmers are seeking income changes or managing other financial risks associated with agriculture, then it can be described as off-farm income diversification. In general, farm labor used in different non-farm activities participation with the aim of rising household income and reducing risk effect [1].

Moreover, farmers also practiced precautionary savings as a self-insuring approach to reducing risk [25]. It comprises to accumulate the liquid asset, semi-liquid asset and fixed asset, along with the

resources in the form of money, crop portfolios, livestock, agricultural apparatuses and extra beneficial resources [29,30]. Usually, these are widely practiced by small growers as ex ante shock-absorbing approaches [31]. Moreover, age, schooling, family size, income and microcredit are some significant determinants that separately influence farmers' risk attitudes [32–34].

It is a common practice in agriculture to use multiple risk management tools (rather than one) for managing risks [3]. However, when analyzing the factors affecting agricultural risk management, multiple risk management tools are often used. In other words, maximum earlier studies focused only on the influencing factors of a single risk management tool adoption, rather than recognizing the probability of simultaneous adoption and the potential relevance of the adoption decision. As example of studies which focused on the adoption of one or two risk management tools are: the usage of contract farming [1,35], adopting on-farm and off-farm diversification independently [36,37], whereas others focused on both diversifications [25,38]. Moreover, investigators also focused on precautionary savings adoption [1,29]. However, few literature has found on the concurrent adoption of different risk management tools. Thus, the present study is to assess the impacts of independent variables on farmers' decisions of adopting Diversification, Precautionary Savings and Contract farming to manage farm risk keeping in view the potential for simultaneous adoptions of these risk management tools. Moreover, the fact that farmers' responses about these tools are still under research. Most importantly, there is no study regarding this issue that has been done in Bangladesh.

In order to fill this knowledge gap, the current research is intended to explore different socioeconomic farm features, farmer risk perceptions and risk attitudes for the adoption of risk management tools to prevent risk rise under adverse climate conditions. This is done with the help of multivariate probit model. The main research content of this study is to find out the possible correlation between the different adopted risk management strategies based on the hypothesis that, socioeconomic characteristics, risk perceptions, and risk attitude have a significant impact on adoption decisions. The purpose of this study is to explore better risk management policy to ensure the increase of agricultural profitability, which have a positive impact on income as well as economic growth. The results of this study have many important implications for government departments, extension educators and other researchers. Policy makers can use research results to determine which types of farmers will use government-supported risk response tools (i.e., crop insurance) when traditional risk management strategies exist. Figure 1 represents the conceptual outline of this study.

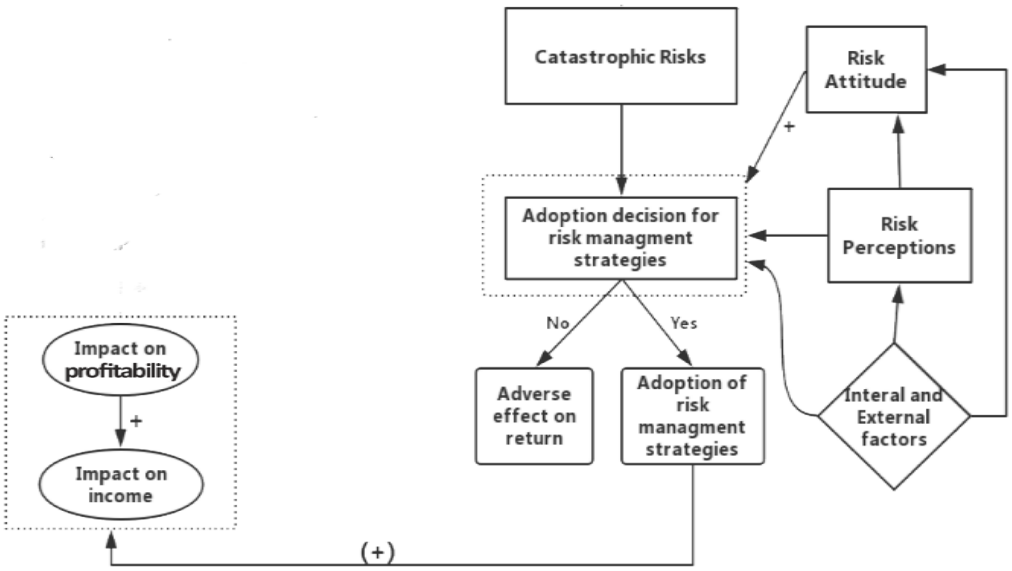

Figure 1. Conceptual framework.

2. Materials and Methods

2.1. Survey Design

The present study mainly focused on the adoption of contract farming, precautionary savings and diversification as risk minimizing tools for maize farmers in particular areas of Bangladesh. In this research, maize was chosen based on market potentiality. Because maize demand is increasing for the poultry and fish sector along with food in Bangladesh [39]. The overall development of agriculture in Bangladesh masks considerable regional differences due to farming methods, techniques, availability of irrigation facilities and farmers' attitudes in different parts of Bangladesh. Regional differences in agricultural productivity have negative effects on rainfall, temperature, humidity and other natural phenomena. The primary data collection was completed during May to July 2018 from 4 different major agro-ecological zones [40] representing the main maize producing regions in Bangladesh (Figure 2). Before the start of the study, a pretesting was done with the use of a questionnaire for further improvement for preparing the final questionnaire. By employing a multi-stage stratified random sampling technique, 350 samples were chosen from different farmers of 35 villages. Data collection is completed from 7 villages of Manikgonj district (wet agro-ecology), 10 villages of Dinajpur district (arid agro-ecology), 8 villages of the Comilla district (rainy agro-ecology) and 10 villages of Bogra district (semi-dry agroecology). In the first stage, the four regions took into account geography, climate, risk awareness and attitude to risk, characteristics of farms and farmers and planting patterns in different regions. In the second stage, a random sampling technique was used to select 10 representative Upazila from four regions. At stage 3, 35 villages were selected from 10 different Upazilas using a simple random sampling technique. At stage 4, 10 farmers from every village through stratified random sampling technique (Figure 3).

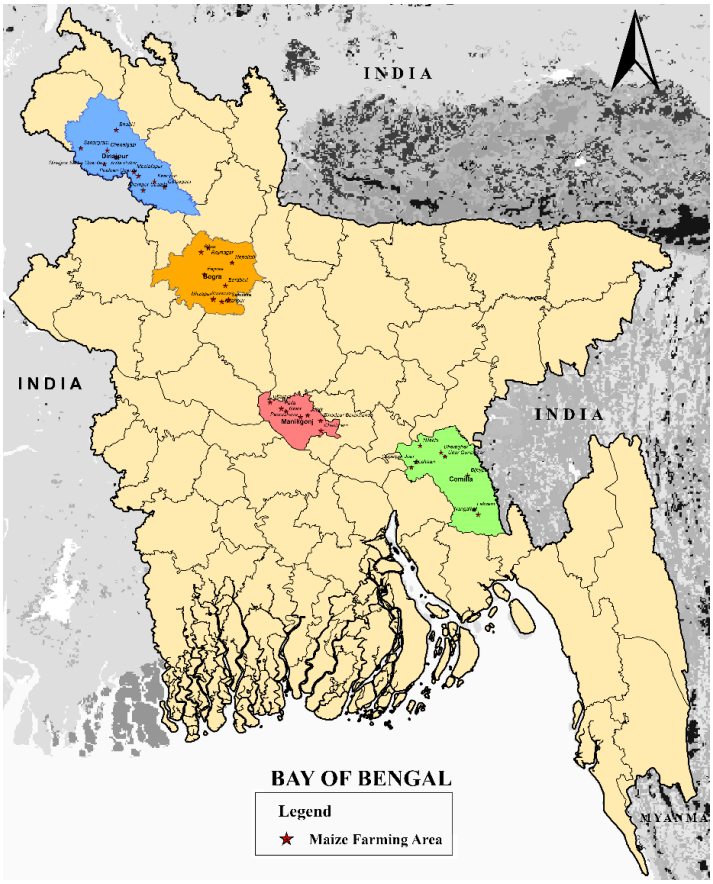

Figure 2. GIS (Geographic Information System) map of the study areas.

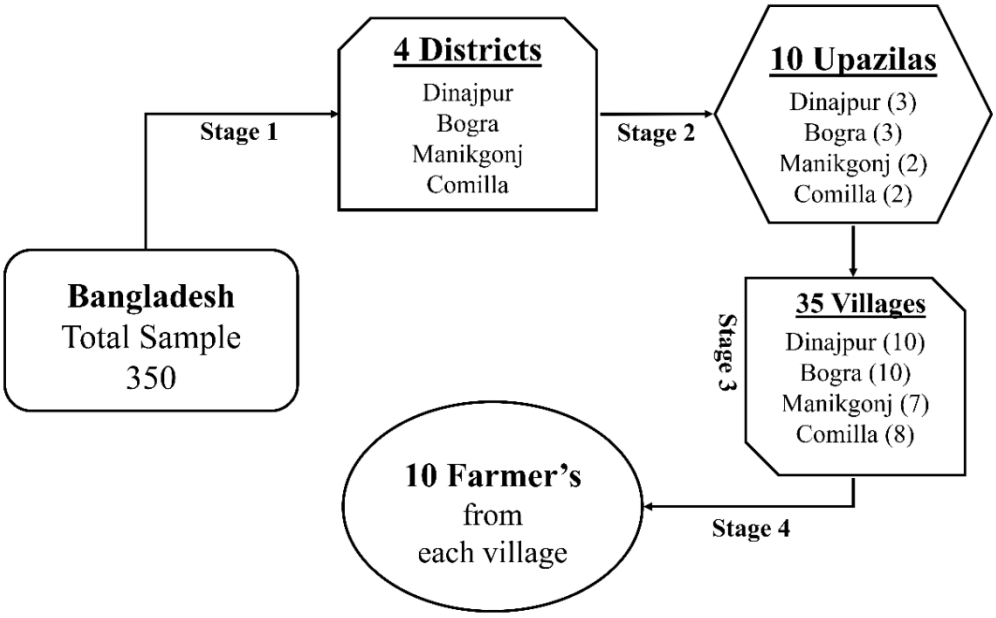

Figure 3. Survey design.

2.2. Variable Descriptions

The median probability model (MPM) rules have become so popular that they are now applied to a wider range of prior and correlated designs. MPM is defined as a model consisting of variables with marginal a posteriori probability of at least 0.5. MPM rules produce the best prediction models in orthogonal and nested correlation designs. This result is initially generated under a special kind of prior knowledge, such as the point quality mixing of non-information prior and g-type prior knowledge [41]. In this study, several dependent and independent binary variables were used under MPM rules. All dependent variables were selected in this study based on respondent responses.

2.2.1. Dependent Variables

Contract Farming

Contract farming refers to agricultural production according to the contract between the buyer and the seller. It generates agreements to produce and sell agricultural products. Here, farmers obviously agree to supply a certain amount of specific agricultural products. It prerequisites to meet the quality standards required by the buyer and deliver the goods within the time determined by the buyer. Additionally, buyers must promise to purchase products, and sometimes support is provided through the production processes, for example, agricultural inputs supply, land preparation and operational support. Contract farming offers a better-quality relationship among growers, sellers and all other facilitators involving with the value chain process. Although there are many practices in contract farming. In Bangladesh, buyers usually provide contract farmers with all agricultural inputs (machinery, seeds and fertilizers) on a credit basis. Under the supervision of actual actions and with the support of the buyer's input, farmers plant crops, which are then repurchased by the buyer. Through this project, contract farmers benefit from training in the best fertilizer use and planting methods, obtain high-quality investment and affordable production funds and provide a safe market for their products. This arrangement always requires the buyer to provide a certain degree of production support by providing input and technical advice. This arrangement is based on the farmers' commitment to provide specific commodities according to the quantity and quality standards determined by the buyers and the company's commitment to support farmers' production and purchase of commodities. Commonly, the farmer agreed with the buyer to sell the whole production at present market price with standard market quality. However, often buyers considered some quality deterioration because

of natural calamities. From different uses of contract farming, this study considers its importance in managing risk and incorporates it into the analysis: if farmers use contract farming only for risk management purposes, it is 1; otherwise, it is 0.

Diversification

Diversification is a risk management strategy that has been implemented since the beginning of farming [42]. Intercropping and crop diversification are two ways to reduce crop production risk caused by bad climatic circumstances and pests and diseases [43]. The main objectives of agricultural development include a sustainable increase in rice production and specific experiments on crop diversification at small farm farms in Bangladesh, with the aim of achieving self-sufficiency in food production in a sustainable manner. The government has also implementation programs for promoting crop diversification through appropriate seed fertilizer irrigation technologies, including high-value crops, fruits and vegetables, potatoes, oilseeds, beans and spices, which are expected to increase employment, rural income and improve nutrition. In addition to these methods, farmers' income can be increased by diversifying their earning sources (non-agricultural occupation or small enterprise) with the aim of negative outcome of financial risk reduction [44]. Rural income diversification helps poor farmers improve their living standards by increasing income and reducing vulnerability risks. For a country that relies heavily on agriculture, this diversification is important because it is associated with a variety of risks and uncertainties that hinder farmers' production and income and leave them vulnerable environment. The diversification of non-agricultural income sectors will help farmers cope with these dangerous situations. Among them, the important role of diversification in risk management is considered to be the focus of research. If farmers use diversified operations only for risk management purposes, they will be included in the scope of analysis as 1, otherwise it will be 0.

Precautionary Saving

Precautionary saving is a kind of saving (non-expenditure of part of income) generated when future income is uncertain. Due to the incompleteness of the insurance market, the preventive motivation to delay consumption and savings during this period has increased. Consequently, people will not be capable of insuring contrary to the bad state of the economy in the upcoming time. It can be anticipated that if the bad state is understood, they will make lesser incomes. In avoiding the adversative effect of future income variations and retaining a smooth consumption path, they established a precautionary reserve, named precautionary savings, through less consumption in the existing period, and resorting to it if the bad state is understood in the upcoming time. Precautionary savings comprise the accumulation of liquid and semi-liquid assets in the form of livestock, cash, crop stocks, farm and household equipment and other useful assets. Precautionary savings are widely used as an aftershock mechanism, mainly by small farmers. If farmers use precautionary savings as a post-risk response tool just for reducing the negative impact of adverse weather conditions on their agricultural income, then precautionary savings will be included in the analysis as 1, otherwise 0.

2.2.2. Independent Variables

Socioeconomic and Farm Features

In the present study, the independent variables comprise the age, education, agricultural practice, extension experience, household monthly income, farming areas and land ownership of respondents that may possess an influence on the risk attitude of farmers. In previous studies, they were reflected as the crucial factors to determine farmers' risk attitude [26,29,33,36,45–47]. Education, age and experience were continuous variables, specifying that the total number of years. In this study, educational status means total schooling years, i.e., respondent complete the primary school, it means 5 years of schooling. In addition, agricultural experiences indicate the total year of agricultural farming experience for producing any agricultural crops. Household income includes non-agricultural income

and farm income. The number of family members was considered while measuring the family size. In evaluating the farm size, the number of acres in which the family operates was considered. Moreover, land ownership and extension experience were considered as dummy, which indicates that the family owns lands and has extension experience is 1 and 0 otherwise.

Risk Perception

Different climate risks are floods, heavy rain, droughts, pests and diseases, hail storms and heavy winds. In order to calculate the risk perception, respondents were asked about the severity scoring and frequency of various risk sources. Here the Likert scale was employed to determine how production procedure were disturbed by these risks, fluctuating from 1–5, with 1 representing the lowest risk and 5 representing the highest risk for each set. Farmers' response was combined according to the basis of risk matrix [48] mentioned in Figure 4. Here it is used as dummy and categorized as low if it is between 2 and 5 and high if it is from 6 to 10. Here 1 denotes that respondents observed climate risk as high risk (6 and more in total) and otherwise, it is 0.

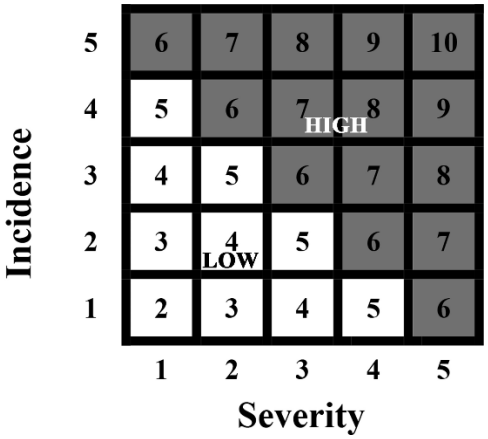

Figure 4. Risk matrix of farmer response scoring.

Risk Attitude

The most commonly used method to derive utility from economic entities is the equal probability deterministic equivalence model (ELCL) [49] in which the deterministic equivalence (CE) is derived for a series of risk results [24]. For instance, the respondent is asked to state the monetary value of the results, which makes him irrelevant to the equal probability between 30,000 BDT (total household income) and 0 BDT. Suppose the answer is 21,200 BDT. The respondent is again required to specify the monetary value of a result, so that the two risk results of 21,200 BDT and 0 Bangladeshi taka have the same probability. Now suppose that the answer is 11,600 BDT. This process will continue until enough data points are obtained. The utility value of the lower result (BDT 0) is 0 and the utility value of the higher result (BDT 30,000) is 1. Farmers' reaction to BDT 21,200 is that the estimated CE of uncertain expenditure is BDT 30,000 and BDT 0. The certainty equivalent is estimated as follows:

$$u(21,200) = 0.5u(0) + 0.5u(30,000) = 0.5(0) + 0.5(1) = 0.5 \quad (1)$$

In this following procedure, the utility value of each CE point was calculated. After deriving a large number of CE and comparing the equivalent with the utility value, the utility function of each farmer was estimated by using the cubic utility function. The equation for the cubic utility function is as follows:

$$u(w) = \alpha_1 + \alpha_2 w + \alpha_3 w^2 + \alpha_4 w^3 \quad (2)$$

where u(w) is the utility of wealth, here income is substituted for wealth. In cubic utility function, risk aversion, risk perception and risk attitudes are important components [50]. The second derivative is

given by $2\alpha_3 + 6\alpha_4 w$, the symbol of which depend on the symbol and extent of parameters α_3, α_4 and the level of wealth w. Therefore, it is possible to increase and decrease the marginal utility [51]. If the second derivative of the utility function is positive ($U'' > 0$), the risk-seeking attitude is indicated, if the second derivative of the utility function is negative ($U'' < 0$), risk aversion is indicated and if the second derivative of the utility function is zero ($U'' = 0$), individual's risk-neutral attitude is indicated [50]. An ordinal scale is typically used to measure utility. However, in order to define absolute risk aversion, it can be described as an ordinal scale, on which there is a utility function, can be transformed into a computable risk aversion measure by changing its shape [52,53]. The absolute risk aversion can be mathematically explained as:

$$r_a(w) = -\frac{U'(W)}{U''(W)} \quad (3)$$

The absolute risk aversion is mathematically defined as $r_a(W)$ is coefficient of absolute risk aversion, U′ and U′′ are first and second-order derivatives of wealth (W) or Income, respectively [24]. When the individual is averse to risk, the absolute risk aversion coefficient is positive; when the individual prefers risk, the absolute risk aversion coefficient is negative; when the individual is indifferent to risk, the absolute risk aversion coefficient is zero [54].

2.3. Empirical Model

A multivariate probit regression considering the probability of simultaneous correlation in the decisions to adopt diversification, contract farming and precautionary savings as risk management tools [55] can be stated as follows:

$$Y_{ij} = X_{ij}\beta_j + \epsilon_{ij} \quad (4)$$

where, Y_{ij} (j = 1, … m) is the ith producer (i = 1, … , n); indicates risk management plan (here, m = 3); $X_{ij} = 1 \times k$ is vector of observed variables; β_j signifies $k \times 1$ vector of unknown parameters need to be assessed and ϵ_{ij} is the unobserved error term [56]. Yij denotes binary variables and Equation (4) can be stated as follows:

$$Y_{11}^* = \alpha_{11} + X\,\beta_{11} + \epsilon_{11} \quad (5)$$

$$Y_{21}^* = \alpha_{21} + X\,\beta_{21} + \epsilon_{21} \quad (6)$$

$$Y_{31}^* = \alpha_{31} + X\,\beta_{31} + \epsilon_{31} \quad (7)$$

where, Y_{11}^*, Y_{21}^* and Y_{31}^* denote the latent variables for each single risk management strategy selection. While Yij > 0, Yij * equals to 1 and 0, otherwise. The estimation of unobserved parameters would be simple if the εij were independently distributed. Though it is mentioned above, there is a probability of concurrent adoption of different risk management tools and as a result, it is projected that these choosing decisions are interlinked. If we assume that, εij is multivariate normally (MN) distributed the elements of εij will be faced the stochastic dependence [57]. In the multivariate probit model, it is anticipated that the error terms mean vector is equal to zero and multivariate normally distributed. With the MN assumption, simulated maximum likelihood (SML) can be used to calculate the unknown parameters from Equation (3), which used Geweke–Hajivassiliour–Keane (GHK) simulator in assessing the MN distribution [4].

3. Results

3.1. Descriptive Statistics of the Variables

Table 1 represented the descriptive statistics of different variables of this study. It can be seen from the table that floods, rain fall, pest and diseases are the major production risk sources in the selected areas. To avoid the losses from risk growers were used various risk management strategies. About 53% of farmers adopted contract farming as a risk management strategy, slightly more than half of them, about 51% of farmers adopt diversification (inside and outside the farm), while 39% of farmers produce

maize with the adoption of precautionary savings from various sources. Majority of farmers reported risk aversion nature. These results are similar to previous studies, for example, Adnan et al. [1] Lucas et al. [58], Dadzie et al. [31] and Ullah et al. [45], likewise explained that maximum growers possess risk-averse nature and the tendency of avoiding risk while facing it.

Table 1. Descriptive statistics of the variables.

Study Variables	Description	Mean	Std. Dev (SD)
Contract farming	1, if practice contract farming and 0, otherwise	0.53	0.50
Diversification	1, if practice diversification and 0, otherwise	0.51	0.50
Precautionary savings	1, if practice precautionary savings and 0, otherwise	0.39	0.49
Age	Age of farmer (years)	38.23	13.17
Educational status	Schooling years	4.05	6.01
Agricultural experience	Farming experience (years)	18.32	14.98
Extension contact	1 if the farmer has contact and 0, otherwise	0.76	0.41
Family income	Monthly family income (BDT)	24,535.54	14,999.35
Family size	Number of a family member	5.34	2.37
Farm size	Total farm areas in acres	6.04	2.39
Land ownership	1 if the household is owner of the land and 0, otherwise	0.475	0.50
Flood risk	1 if risk value more than 5, otherwise 0	0.71	0.44
Heavy rain risk	1 if risk value more than 5, otherwise 0	0.73	0.41
Pest and diseases risk	1 if risk value more than 5, otherwise 0	0.79	0.28
Drought risk	1 if risk value more than 5, otherwise 0	0.41	0.51
Heavy wind risk	1 if risk value more than 5, otherwise 0	0.37	0.47
Hailstorm risk	1 if risk value more than 5, otherwise 0	0.43	0.51
Risk aversion	1 if the individual reflects risk averse attitude and 0, otherwise	0.78	0.39
Total respondents			350

Source: Survey data, 2018.

3.2. Correlation Coefficients of Different Risk Management Strategy

The correlation coefficients of three risk management adoption choices are estimated, as shown in Table 2. The coefficients are the pairwise correlation between the error terms in the multivariate probit model equation. Correlation coefficients are positively significant, which means that use of one risk management tool may influence the use of another risk management tool simultaneously.

Table 2. Correlation coefficients estimates in different pairs of risk management tools.

Risk Management Choices	Estimated Coefficients
Diversification and contract farming	0.3179 ***
Contract farming and precautionary savings	0.2617 ***
Precautionary savings and diversification	0.2874 ***

Numbers in parentheses indicate standard errors. *** specifies the significance levels at 1%.

3.3. Results of Multivariate Probit Model

Table 3 represented the calculated results of the multivariate probit model. It is found that the correlation coefficient of contract farming, diversification and precautionary savings are assessed with the help of probit estimation. In the estimation of the probit model, the correlation coefficients of each risk management strategy combinations are all positive. This means that the research results support the assumption that the interference items used in the risk management strategy are relevant. It also suggested to use the multivariate probit model instead of three individual probit model usage [26]. The positive correlation coefficient indicates that the farmers' risk management strategy selection also affects the adoption of one or more strategies. The likelihood ratio test of p_{kj} (14.3030) and Wald $\chi^2_{(45)}$ test (227.6115) also specify the use of multivariate probit estimation instead of using the individual probit model. It means the null hypothesis H_0 of conjoint nullity of p_{kj} can be rejected. In addition, this research found the social and farm features are the most important factors influencing the adoption decisions of different risk management strategies.

Table 3. Results of the multivariate probit model.

Explanatory Variables	Contract Farming	Diversification	Precautionary Savings
Age	0.0333 *	−0.0305 **	0.0187 **
	(0.0205)	(0.0131)	(0.0119)
Educational status	0.0509 ***	0.0293 **	−0.0331
	(0.0171)	(0.0197)	(0.0202)
Agricultural experience	−0.0401	0.1399 *	−0.0789
	(0.0147)	(0.0671)	(0.0601)
Extension contact	0.2149 *	0.2673 **	0.0113
	(0.1989)	(0.2029)	(0.0202)
Family income	0.00003 ***	0.00002 ***	−0.00001 ***
	(0.00000)	(0.0000)	(0.0000)
Family size	−0.0159	0.0140	−0.0127
	(0.0231)	(0.0199)	(0.0239)
Farm size	0.0119 *	−0.0298 *	0.0131 *
	(0.0701)	(0.0121)	(0.0689)
Land ownership	0.0301 **	0.0303 **	−0.0501 ***
	(0.0121)	(0.0201)	(0.0185)
Flood risk	0.0987	−0.2706	0.3470
	(0.2066)	(0.2025)	(0.2212)
Heavy rain risk	0.0381	−0.5053	0.5618
	(0.2111)	(0.2010)	(0.2086)
Pest and disease risk	0.2259	0.5885	0.0338
	(0.2158)	(0.2223)	(0.2234)
Drought risk	−0.0280	0.0033	−0.1237
	(0.0529)	(0.0448)	(0.5156)
Heavy wind risk	0.0729	−0.0327	−0.0203
	(0.0461)	(0.0224)	(0.0271)
Hailstorm risk	−0.0170	−0.2263	−0.0790
	(0.2684)	(0.2585)	(0.2922)
Risk aversion	0.7225	0.6501	0.5451
	(0.1673)	(0.1675)	(0.1783)
Log-likelihood value	−455.7527		
Wald χ^2 $_{(45)}$	227.6115 ***		
LR test $_{pkj}$	14.3030 ***		
Total respondents	350		

Numbers in parentheses indicate standard errors. *, ** and *** specifies the significance levels at 10%, 5% and 1%, respectively.

4. Discussions of Parameters Estimates

4.1. Factors Influencing the Adoption of Contract Farming

Farmer's age, education, extension experience, household monthly income, farm areas, land ownership and risk-averse nature are the major influencing features among the analyzed factors that affect the adoption of contract farming. It is found that age is positively correlated with contract farming adoption. In the time of facing adverse climate conditions, the elderly farmers have more experience, which is the reason for making less risky adoptions. Earlier studies have shown that there is a different relationship between age and adoption of contract farming as a risk management strategy. The current research established positively correlated relationship between farmers' educational level and their choice of contract farming for risk management. More educated growers are interested in collecting information on contract agriculture to increase their farm income and increase the stability of farm operations. The agricultural experience of farmer negatively influences on contract farming. Less experienced farmers possess the tendency to adopt contract farming. Less experienced farmers are likely to adopt contract farming to divert the risk to another source as they have less ability to cope with the negative shocks. Wainaina et al. [59] also exposed an adverse correlation between

agricultural experience and adoption of contract farming to manage risk whereas Wencong et al. [36] identified a affirmative association. More extension contact increases the probability of using contract farming. Since extension services make farmers aware of using risk management strategies for the reduction of negative effect of catastrophic risk. The results found positively correlated between the increase in farmers' monthly income and contract farming adoption for managing risk. Growers having higher income are more probable in practicing contract farming in making a high profit and low-risk investment [60].

Farming areas have a positive impact on farmers' choice of contracting operations as a risk management tool. Large farms provide farmers with a huge asset base and encourage them to accumulate liquid assets to cope with fluctuations in farm income caused by adverse weather conditions. Moreover, the outcome is similar to Kouame [54], Fawole et al. [61] and Wencong et al. [36]. This study found that land ownership positively influenced the adoption of contract farming, as compared with tenant farmers, landowners can make more direct decisions under contract farming. Similarly, Wencong et al. [36] specified that owning larger land assets is a sign of high risk-tolerant ability.

The impact of farmers' risk perceptions and their adoption decision on contract agriculture depends on numerous factors. Among them, risk of flood has positive correlation and found similarity with other research [36]. In order to prevent the huge loss of production, farmers select contracting. Risk of pests and diseases have positive influence on contract farming. Moreover, the risk perception of drought discourages the contract farming adoption. Drought may cause a significant loss of production, causing a decline in net income. Due to the winter, irrigation water is scarce all over the country. Bangladesh faces frequent adverse climatic conditions leading to strong winds, so maize kernels may drop before maturity, resulting in losses. There is also a negative correlation between hailstorm and contract farming. Farmers' risk aversion also possesses an influence on the adoption of contract farming with the aim of minimizing risk. Kouame [54], Wainaina et al. [59] and Wencong et al. [36] established a positively correlated association between risk aversion and contract farming adoption of farmers. However, the risk perception of farmers is subjective in nature, which may affect other significant factors in the process of decision-making about contract farming adoption. Therefore, it is suggested to carefully interpret the baseline results as causal effects.

4.2. Factors Influencing the Adoption of Diversification

The significant variables in the diversification equation are age, education level, monthly household income, farm and extension experience, the proportion of own land and the risk aversion of farmers. In this study, age negatively correlated on diversification adoption choices. Faced with so many adverse climate conditions, the elderly farmers have more experience, probably that is why they usually follow the production-based because they know how to deal with the adverse climate conditions in a better way. Previous studies revealed a mixed correlation between age and diversification adoption as risk management strategy. For education, it is also found positively correlated association with diversification adoption choice. Due to the high level of education, farmers pay more attention to collect information on diversification, so as to increasing farm earnings and constancy. The farming practice positively correlated with diversification decision. Experienced farmers have a tendency of choosing diversification for managing risk. More experience allows farmers to keep more information about disaster management. Furthermore, perhaps more experienced farmers often know about diversification benefits. Most of them adopt agricultural diversification for avoiding catastrophic loss of agriculture, but there are also some farmers who make money by doing works other than agriculture in off-season or their idle time. Additional extension contacts increase the possibility of greater use of on-farm and off-farm diversification. Because this services provide knowledge about the income source, divert the sources of risk to others and reduce losses. It is found that there are positively correlated. Farmers with a higher income, more inclined to diversification, that also produces more benefits for the diversification of enterprises, so as to obtain more benefits. However, previous research established a positive correlation between household income and off-farm diversification and negatively correlation

with on-farm diversification [46]. The larger the farm, the greater the capacity to take risks. As a result, they are less likely in need of risk management strategies adopted. Our current research also agrees with this statement. This study established a negative correlation between diversification and cultivated land area, indicating that small farms tend to be diversified to minimize catastrophic risks. Ullah et al. [45] also found negatively related with these two factors, but previous research suggest that larger farms are more prospective in choosing diversification to reduce risk [36]. It is found that land ownership possess a positive influence on the diversification of risk management because the landowners are more direct and easier to make diversification decisions than tenants. They believe that the larger the scale of land proprietorship means the greater the wealth, the stronger the stability and the larger the assets, which leads to stronger risk tolerance and the lower the interest of risk management.

Different variables have different effects on farmers' risk perception and risk management strategy selection. There is a positively correlated relationship between farmers' perception of the risk regarding pests and diseases and drought with the diversification measures in dealing with the agricultural disaster risk. However, farmer's perceptions of flood risk, heavy rain risk, high wind risk and hail risk have a negative impact on diversification. The perception about flood risk has negative correlation and similarity with [45] but differs from [29]. In Bangladesh, mainly winter is the cropping period for maize during which the flood frequency is very little, however with scarce irrigation water. In order to avoid production loss, farmers should diversify their business, especially seek more off-farm income to decrease the risk of loss. Pest and disease risk positively correlated to the decision-making of risk management tools as diversification. This kind of risk will lead to a significant loss of produce. In order to achieve sustainable income, farmers must diversify their sources of income. On the other hand, the risk perceptions of heavy winds and hailstorms hinder the diversification adoptions. Farmers' risk aversion will also affect their diversification as risk management strategy. The outcomes show that maximum farmers are risk averse. However, the risk perception of farmers is subjective in nature. In determining these risk perceptions, it may also affect other determinants of participation in the process of decision-making about diversification adoption. Therefore, it is advisable to carefully interpret the baseline results as causal effects.

4.3. Factors Influencing the Adoption of Precautionary Savings

Age, household monthly income, farming areas, land ownership and risk aversion nature of farmers are the most important variables among the analyzed factors to choose precautionary savings as risk management strategies. The current study found that age positively correlated with precautionary savings adoption. Elder farmers are more experienced in risk and production losses. Hence, they keep some cash as precautionary savings to face a risky situation. The outcome of the study for age is inconsistent with Jensen and Pop [62] as they discovered that age negatively influence on farmer's decisions to adopt precautionary savings, but similar to Mishra [63] carried out that of precautionary savings adoption is positively related with age. Growers having more schooling and experience are more probable to evade the precautionary savings adoption for the management of catastrophic risks. For the case of education, the outcome is coordinated with Kouame [54] that educational status is negatively related with the adoption of precautionary savings, but indifferent with Mishra [63], he perceived a positive impact of the heads of the household whose education on their adoption choice of precautionary savings. Deressa [64] established that age and educational status positively correlated on farmer decisions to sell livestock while facing risk. More extension facility increases the possibility of greater use of precautionary savings. Because this facility provides information about the income source, divert the sources of risk to others and reduce losses. Monthly earnings of households discourage farmers from adopting the risk management approach. Many farmers of the study area nurture animals that are exchangeable with money for coping up with a negative shockwave to farm enterprise because of natural calamities also do some off-farm work for coping up with natural hazards.

The outcomes mentioned above also indicate the size of the farm positively and significantly influences the decision of farmers to adopt precautionary savings as a strategy for risk management. The larger size of the farm provides a bigger base for the asset to the farmers and encourages them for asset accumulation in liquid form for management with income variations of their farm causing sue to unfavorable conditions of the weather. Agricultural experience is likewise possessing a significance in the choices of adopting a risk management approach, the outcomes expose that a farmer who has less experience has a tendency to adopt precautionary savings compared with a farmer possessing more experience. The study establishes that land proprietorship negatively influenced on precautionary savings adoption for managing risk, because landowners have more assets, so they have a smaller need to probable in precautionary savings adoption than tenants.

Farming risk rising from different risk sources may end up in crop failure and may severely affect the farmers' livelihood for whom agriculture is the main source of income. These risk sources modify farmers' income from a farming area and persuade them to capitalize on some liquid or semi-liquid resources which can be used as a buffer stock for guiding the farm enterprises in tough phases. Farmers' behavior regarding risk similarly forms the decision to adopt precautionary savings as a strategy to overcome the undesirable influence on their farm profits because of unfavorable climate situations. In this research flood risk, heavy rain risk and pest and disease risk positively correlated with the adoption of precautionary savings as risk management strategy while the risk of drought, heavy winds and hailstorm negatively correlated.

5. Conclusions

In agricultural production, farmers practice different risk management strategies. It was found that the largest farmers in the maize producing areas of Bangladesh adopt several risk management strategies simultaneously. Alternatively, maximum earlier studies overlooked the relationship between the choice of farmers' risk management strategies and the probability of adopting multiple risk management strategies at the same time. Therefore, the purpose of this study was to analyze the factors that affect the choice of contract farming, diversification and precautionary savings as risk management strategies and to identify the probable correlation among these choices with the help of multivariate probit model.

Therefore, the results of the study confirm the correlation between risk management adoption decisions and reveal that the use of one risk management tool may make it more probable to simultaneously use another risk management tool. The research results also emphasize that age, education level, extension facility, household monthly income, farming land areas, land ownership, and risk aversion nature of farmers influence adoption decisions.

Although the study was limited to four maize growing areas in Bangladesh, the results could be extended to all developing countries, especially those without formal/national risk management tools (like crop insurance) or lacking or ineffective. In risk management, using more abundant information and probability analysis method can better understand risk management.

Furthermore, this study is also constrained by respondents' decisions and the factors by researchers' choice. The possible results of choosing depending on food safety and poverty are beyond the objectives of this study. Future research can reveal the important role of these choices with the wide-ranging welfare of farmers. The Bangladesh government should take the necessary steps to improve people's awareness about crop insurance as a key risk-reduction strategy through advanced extension services and pilot different training courses and use the simultaneous risk management strategy to stabilize farmers' income.

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