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Perceived risk and risk management strategies under irrigated rice farming: Evidence from Tono and Vea irrigation schemes-Northern Ghana

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ABSTRACT

The study investigated risk perception, adoption of risk management instruments and the intensity of adoption among irrigated-rice farmers in the Upper East Region of Ghana. A multistage sampling technique was employed to draw 477 farmers for the study. The perception index, multivariate probit and Poisson regression models were used for the analysis. The results show that the perception index score was positive (0.43), which implies that farmers agreed that various types of risk (production, marketing and financial risks) affect their farming. It was found that the farmers combined diverse techniques to manage risk. All the farmers were using improved varieties and agrochemicals, yet none had any form of agricultural insurance. Also, farmers' socio-demographic, farm-level, institutional, risk perceptions and environmental changes have a significant and heterogeneous effect on risk management practice. Particularly, gender, years of education, total farm size, rice farm size and soil fertility status significantly predict crop diversification. Gender, years of education, total farm size, rainfall prediction and soil fertility status are the determinants of off-farm work participation. Again, gender, age, years of education, farming experience, extension access, the land tenure system, total farm size, rice farm size and market risk explains farmers' credit uptake. The practice of crop rotation is influenced by gender, farming experience, access to extension services, the land tenure system, total farm size, market risk perception, and soil fertility status; whiles extension services predict engagement in contract farming. Also, the intensity of adopting risk management instruments is influenced by farmers' age, farming experience, the land tenure system, extension access, total farm size and erratic rainfall, heterogeneously. Further, market risk perceptions augment crop rotation and credit access adoption, validating the Protection Motivation Theory. We recommend that insurance companies develop strategies to ensure the uptake of the policies by farmers within the irrigation scheme. Also, investment in organisations like extension services, research centres, and ICOUR is crucial for development because it may persuade farmers to use the right risk management tools. Further, stakeholders should consider farmers' risk perception when designing risk management policies.

1. Introduction

The 2030 agenda of the United Nations highlights the significance of food and agriculture in achieving the Sustainable Development Goals (SDGs). Consequently, investment in rural development and agriculture is critical for ending global poverty and hunger, as well as ensuring sustainable development, especially in Africa [1]. Globally, rice is a staple food for more than half of the world's population. Asia, sub-Saharan Africa and South America are the largest consumers [2]. Rice is a staple and the second-largest caloric food consumed in Ghana [3]. Rice production has been increasing steadily, with an annual growth rate of 30% [4]. In 2020, Ghana's rice production was around 973,000 metric tonnes [4]. Notwithstanding the upward trend in rice production, domestic production is insufficient to balance domestic demand [5]. Hence, the country must rely heavily on importation to satisfy the supply deficit. This suggests the need for policies and

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technologies to foster rice production in the country. However, regardless of policies such as Planting for Food and Jobs and the promotion of modern production technologies, including improved varieties and fertilisers, potential yields in rice production, and even farming, in general, are not realised by farmers in Ghana [6].

Subsequently, the inability of farmers to achieve the potential yield has been partly blamed on the risks involved in rice production. Like any form of farming, rice cultivation is confronted with varying risks ranging from production, market and financial risks [7–10]. Further, the over-reliance on rainfall for rice production has exposed it to climate change's repercussions. Hence, irrigated rice farming has been propounded as a better alternative. Generally, farmers practising irrigated agriculture are assumed to be shielded against various risks. Nonetheless, in reality, irrigated-rice farmers are equally exposed to a diversity of risks like pests and diseases, lack of capital, labour shortage, primitive rice varieties, lack of market, and, to some extent, recurrent drought and flooding— all of which are widely acknowledged in rain-fed farming [11–14]. For instance, Bannor et al. [15] reported that rain-fed and irrigated rice cultivation in Odisha, India, is equally confronted with abiotic stress, which limits productivity. Hence, it is apt to say that irrigated-rice farmers are not wholly protected against risks in their venture. Given that irrigation has been applauded as a better solution for farmers, the Government of Ghana, in collaboration with other funding agencies, established the Tono and Vea irrigation schemes. These irrigation facilities are gravity-based systems that supply water to farmer fields through canals. The facilities have a large dam that holds water and distributes it to the irrigable areas via the canals. Interestingly, the water in the dam is not only used for farming. The Ghana Water Company in the catchment area draws water from the dam to supply households. Due to the multi-function of the dam coupled with possible losses from the conveyance, evapotranspiration and field loss [16], there is periodic water scheduling (usually two or three days intervals/once or twice weekly) to the crop fields to prevent the dam from drying out [14]. Hence, the farmers occasionally experience intermittent droughts [14]. Sometimes, farmers are denied access to the water when the rice needs it most, which has severe implications for its growth. Though the farmers are practising irrigation due to water scheduling issues, these farmers are literally exposed to droughts.

However, how these farmers perceive and manage risk in their endeavours is rarely available in the extant literature. Thus, the empirical gap in the literature is that studies on risk perception and management among farmers are either generic, skewed towards other crops or concentrated on rain-fed farmers, with a paucity of research into irrigated rice systems [17–20]. Although there are considerable studies on specific farming systems like risk management in aquaculture [21–23], risk management in maize production [24–27], risk management in poultry production [20,28] and risk management in rice farming [29–32], studies are silent on irrigated-rice farmers' risk perception and management strategies. Recent empirical evidence suggests that it is essential to investigate crop or farming system-specific risk perception and management strategies because it provides insightful information for informed decision making [33]. Hence, to make informed decisions and policies for the rice farmers cultivating under the irrigation schemes, it is imperative to understand their risk perception and unravel their management strategies which are lacking in the literature.

Therefore, this study seeks to (i) assess irrigated-rice farmers' perception of agriculture risk, (ii) investigate the adoption of risk management strategies among irrigated-rice farmers, and (iii) determine the intensity of adopting risk management strategies among irrigated-rice farmers. The contribution of this study is multifold; unearthing evidence about how irrigated-rice farmers perceive risks will be crucial in predicting their decision to adopt mitigating strategies. This information will be very worthy for researchers and industry players in their quest to prepare tailor-made strategies for rice farmers to hedge risks. Additionally, the evidence of farmers' risk perception is essential for farmers, advisory services, industry and policymakers when designing risk management instruments [34,35]. Also, understanding the factors that predict farmers' adoption of risk management instruments is crucial for researchers and policymakers as they develop strategies and programmes to address these issues. Further, knowing farmers' risk perception and risk management and providing the necessary support services for better risk management makes it possible to increase the resilience of their farms and minimise their impacts, particularly from an economic and social point of view. On literary contribution, this study will provide empirical evidence to support the foregoing debate on the influence of risk perception on risk management and the simultaneous adoption of risk management instruments.

2. Review of related studies

2.1. Risk perception and risk management

Risk is explained as imperfect knowledge, where the possible outcomes of an event can be estimated and known, whilst the risk perception of a decision maker measures their interpretation of the probability of risk exposure which is influenced by their culture, beliefs and value systems [18]. Perception is a subjective measurement of an individual's behaviour towards a stimulus [23]. In other words, perception is how an individual selects, organises, and interprets sensory information. Ahsan & Brandt [36] explain that risk perception is how an individual or a group of persons perceive how the occurrence of a phenomenon will negatively affect them. Risk is inevitable in agriculture, which warrants the need for risk management adoption by farmers to minimise risk's impact on the farm and improve their welfare. Nevertheless, farmers' perceptions of these risks are diverse. It is asserted that farmers' perception of risks partly predicts their attitudes and the mitigating strategy they employ to subdue the risk [37,38]. Therefore, in soliciting risk management instruments, it is imperative to consider how they perceive risks.

Using farmers' risk perception as an explanatory variable, Asravor [18] concluded that farmers perceived production and marketing risks as the dominant sources of risks they confront, influencing them to employ multiple off-farm and farm management strategies to hedge risks. Specifically, farmers' perception of market risk (e.g. prices of agro-inputs) significantly increases their use of inorganic fertiliser. In contrast, their production risks (e.g. crop failure) influence the diversification of crop production into animal production. A study in Pakistan unravelled that farmers' risk perception about floods significantly affects their attitude towards managing the risk [39]. Consistently, Saqib et al. [40] assessed farmers' risk perception and disclosed that their risk perception significantly and positively influences their adoption of agricultural credit as a risk management instrument in Pakistan. Likewise, Azumah et al. [41] found that Ghanaian farmers' perception of declined soil fertility significantly drives them to utilise migration to avoid risk. Again, Joffre et al. [22] probed risk perception and management instruments among Shrimp farmers in Mekong Delta, Vietnam. The authors unravelled that risk perception is a crucial predictor of risk management instruments. Moreover, a vast body of literature has similarly recognised the importance of perception in risk management [35,42,43]. Contrarily, Adnan et al. [44] assessed the influence of farmers' risk perception on the adoption of risk management instruments in Bangladesh. The study revealed that risk perception does not significantly augment the adoption of risk management instruments. The deviation of this finding from the previous results could be attributed to the approach to measuring risk perception (risk matrix) and the regression model (multivariate probit) used.

2.1.1. Risk management instruments

Risk management is a selection of tools among alternatives to reduce the impacts of risk on the farm as well as on a farm's welfare position. However, there is no "one size fits all" criterion; instead, a risk management planning process is required, composed of several measures that play a crucial role in decision making. In this regard, farmers have utilised various techniques to manage agricultural risks. These include risk reduction (ex-ante strategies to lower or minimise the risk) and risk coping strategies (ex-post strategies to mitigate risk) [45]. Furthermore, risk management instruments are categorised into formal and informal strategies. Informal strategies are practised at the farm level by farmers, whereas formal strategies are institutional and driven by national governments. Informal strategies at the farm level include income diversification, crop diversification, precautionary savings, selling of assets, etc. On the other hand, formal strategies are policies such as agricultural credit, crop insurance and pension schemes [46]. Further, Below et al. [47] claimed that farmers use a variety of risk management instruments to manage climatic risks, including diversification outside of farming activities, migration, crop and variety diversification, different timing of farm practices, irrigation, water conservation methods, and agricultural conservation. Similarly, Ashraf & Routray [48] found that farmers in Pakistan adjust their input use, manage water shortages, diversify their income and migrate to deal with drought risk. In addition, Ullah et al. [49] noted that farmers in Pakistan's flood-prone regions used diversification and precautionary saving to mitigate risks.

Another strand of earlier studies grouped risk management instruments into three, including (i) on-farm risk management instrument, (ii) on-farm non-agricultural risk management instrument and (iii) off-farm risk management instrument [44,50,51]. These studies indicate that agrochemicals use, irrigation, cultivating improved varieties, good management practices (conservation tillage or integrated pest management), and crop diversification are on-farm risk management instruments. Also, on-farm non-agricultural risk instruments encapsulate forward contracts, sales through cooperative organisations, and precautionary savings. Lastly, insurance (farm and personal insurance), pension contribution, off-farm employment and off-farm investment are considered off-farm risk management instruments. Broadly, risk management instruments disclosed in studies include diversification, insurance, irrigation, savings, contract farming, improved varieties, pesticides, weedicides, fertiliser, migration, storing feeds/seeds, planting shelterbelt, establishing drainage system, maintenance of watercourse, and ground water use [52–56].

2.1.2. Drivers of adopting risk management instruments

Despite numerous risk-mitigating strategies, farmers do not spontaneously practise them. Thus, farmers' utilisation of any of the risk-management strategies is influenced by many factors. On this account, Saqib et al. [40] disclosed that farming experience, level of education, risk perception, and income positively drive farmers to utilise agricultural credit as a risk-mitigating strategy. In addition, Azumah et al. [41] found that household size, primary occupation, FBO membership, and perception of depleted soil significantly influence farmers to migrate to circumvent farm risks. Moreover, Joffre et al. [22] disclosed that Vietnamese farmers perceived market risks to predict their adoption of risk management instruments. Furthermore, it was revealed that farmers' age, educational level, extension experience, monthly household income, farm size, land ownership and risk aversion are the most critical drivers of utilising risk management instruments [44]. Specifically, the authors expounded that farmers' age, extension experience, monthly income, farm size, education, land ownership and risk-averse status explain farmers' utilisation of contract farming. They added that age, education, monthly income, farm and extension experience, total landholding and risk aversion determine the adoption of diversification. Again, age, educational level, monthly income, farm and extension experience, landholding and risk aversion are associated with adopting precautionary savings to manage risk. Further, Sánchez-Cañizares et al. [50] identified a significant nexus among farmers' socio-demographic features (age, education, agricultural income), farm characteristics (farm size), risk perception and simultaneous adoption of risk-managing instruments. Likewise, Khanal et al. [57] uncovered that risk preferences negatively correlate with utilising diversification and good agricultural practices as a risk-mitigating strategy.

In Pakistan, Akhtar et al. [26] also demonstrated that education, the number of livestock, farming experience, perceptions of biological risks and the risk-averse nature of maize growers are significant and positive predictors of utilising diversification to manage risk. Contrarily, farm size was found to affect the adoption of diversification negatively. The authors further iterated that farming experience, farm size, perception of price, and biological risks and risk attitude significantly drive using agricultural credit to manage risks. In Tanzania, Mgale & Yunxian [32] identified that farm income, technological intensity, income diversification activities, access to market information, and storage facilities significantly influence the adoption of risk management instruments. In Ghana, Martey et al. [58] found access to seed, extension service, labour availability and farm household location as essential variables that drive farmers to utilise drought-tolerant maize (improved variety) to circumvent drought risk. Again, Eliha et al. [59] unravelled that education, farm size, farming experience, family size and access to weather forecast information are the significant drivers of rural farmers in Punjab, Pakistan, to adopt innovative management strategies to mitigate extreme weather risks. Further, in Pakistan, ground water market participation is now considered a viable option to alleviate water shortage. However, farmers' involvement in the ground water market is influenced by farm size, education, soil fertility, adoption of improved varieties, water cost and family size [56]. The authors expatiated that water cost, family size and education decreased ground water market participation, while farm size, soil fertility and the adoption of improved varieties positively influenced the same.

It is worth stating that most of the explanatory variables disclosed in related studies to influence the adoption of risk-managing strategies have been significantly interpreted contextually. For instance, Adnan et al. [44] and Adnan et al. [24] argued that aged farmers have much experience in farming and have once, or several instances, been confronted with risks which push them to adopt either contract farming, diversification or precautionary savings to handle agricultural risks. Contrary to this, Akhtar et al. [26] argued that age does not predict the adoption of diversification, precautionary savings and agricultural credit as risk-mitigating strategies. Again, educated farmers are mostly abreast with the consequences of risks and befitting risk management instruments, which subsequently drive their adoption [32]. Further, higher-income farm households are more likely to diversify or invest in other off-farm ventures because they have enough capital [25,26,32]. In addition, a larger farm size increases the potential for crop diversification, thus allocating some portions of the land to cultivate other crops [18].

2.2. Theoretical background

The utilisation of risk management instruments among farmers is geared towards avoiding risks such as pests and diseases, depleted soils, fluctuating prices, droughts, etc. Therefore, risk theories are appropriate when exploring risk-mitigating strategies. Theories like Prospect Theory, Risk as Feelings Theory, Risk Sensitivity Theory, Situated Rationality Theory, Risk Compensation/Risk Homeostasis Theory, Protection Motivation Theory, Habituated Action Theory, Social Action Theory, and Social Control theory have been used in risk management studies [18,32,60,61]. However, this study is concerned with irrigated-rice farmers' instruments used to manage risk. Hence, the Protection Motivation Theory (PMT) was adopted to anchor this study. The PMT has explanatory power when investigating decision making under risk [18]. The fundamental argument of this theory is that individuals are very likely to protect themselves from risk when they expect adverse repercussions, and they desire to avoid these negative consequences. As such, they take preventive measures to manage the risk. Thus, the perception of risk and management increases when there is a reason for concern or its outcome will be unpleasant if not addressed. Rogers [62] posits that the Protection Motivation Theory has two primary constructs;

risk perceptions and perceived capacity to counter risk. Thus, the theory suggests that farmers' perception of the consequences of risk influences the utilisation of management techniques. The study proposed risk perception as a significant construct to test its explanatory power in adopting risk management strategies. The risk perception construct explains a farmer's subjective judgment about the characteristics and severity of risk in farming. Under the perception constructs, variables such as production, market, and financial risks are considered. Although related studies have utilised the PMT to explore risk perception and its influence on risk management adoption [32,63,64], only a handful of studies applied the theory in the Ghanaian context [18,65,66]. Thus, using the theory to explain risk management decisions among Ghanaian farmers is limited, especially for irrigated-rice farmers. Hence, this study will add to the limited knowledge of farmers' risk perception and adoption of risk management instruments as stipulated in the Protection Motivation Theory.

2.3. Conceptual framework

The conceptual framework, as illustrated in Fig. 1 explains that farmers' socio-demographic features (gender, age, household size), farm-level characteristics (farm size, farming experience), institutional variables (access to extension services, the land tenure system, FBO membership) and risk perceptions predict their intention to utilise a particular risk management instrument. Also, experience with changes in the ecology, such as erratic rainfall, soil fertility, and frequent drought, informs farmers' decisions to employ strategies to manage risk.

3. Materials and methods

3.1. Study area

The study was carried out in Ghana's Upper East. It is situated between longitude 0° and 1° west and latitude 10° 30"N and 11°N. It shares boundaries with Burkina Faso to the north, Togo to the east, the Sissala district of the Upper West region to the west, and the West Mamprusi District of the Northern Region to the south. It has a total land area of 8842 km^2. The regions have extensive and predominately natural rice-growing lowlands [67]. Again, Northern Ghana, including the Upper East Region, is the country's top producer of stable crops and animals [68]. Bidzakin et al. [6] underlined that the Upper East, Northern and Volta regions contribute to 80% of rice produced in Ghana. Again, the existence of irrigation facilities influenced the choice of the study area. Nonetheless, farmers in this area are confronted with several agricultural risks. The region is adversely affected by climate change incidents such as droughts, floods and dry spells threatening welfare [69]. It is emphasised that Northern Ghana, including Upper East, is simultaneously experiencing severe insect infestation, population increase, and intensification of land usage [18]. Empirical evidence suggests that the Upper East is among the most sensitive regions vulnerable to agricultural risks [69].

3.2. Sampling and sample size determination

A multi-stage sampling technique was used to select the study area and respondents. Firstly, purposive sampling was employed to choose the region and districts. Thus, the Upper East region was purposively selected. Also, the Kassena-Nankana East, Builsa North, Bongo district and Bolgatanga municipal were chosen purposively. The Kassena-Nankana East and Builsa North host the Tono irrigation scheme, while the Bongo district and Bolgatanga municipal host the Vea irrigation scheme, hence the choice of these four districts. A list of farmers obtained from the Irrigation Company of Upper Region (ICOUR), a body that oversees the irrigation schemes in the study area, indicates that there are 2000 and 1000 farmers cultivating rice under the Tono and Vea irrigation schemes, respectively. Via a simple random sampling approach, 477 rice farmers were selected and interviewed. The Yamane [70] approach for sample size determination was employed to determine the sample size for the study. The approach is stated as follows:

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

where n = sample size, N = population, and e = random error. In this study, the total population of irrigation (N) was 3000, and the random error term used was 5%. This resulted in a sample size of 353 farmers. However, 124 farmers were added to increase the sample size to 477. This was necessary to improve the generalisation of the study's findings. Nonetheless, the proportional sampling approach was utilised to draw a proportional sample of farmers from each irrigation scheme. Thus, 318 farmers were drawn from the Tono irrigation scheme and 159 from the Vea irrigation scheme.

3.3. Source of data and analytical approach

Cross-sectional data from rice farmers were collected using a structured questionnaire. The survey instrument comprises both closed and

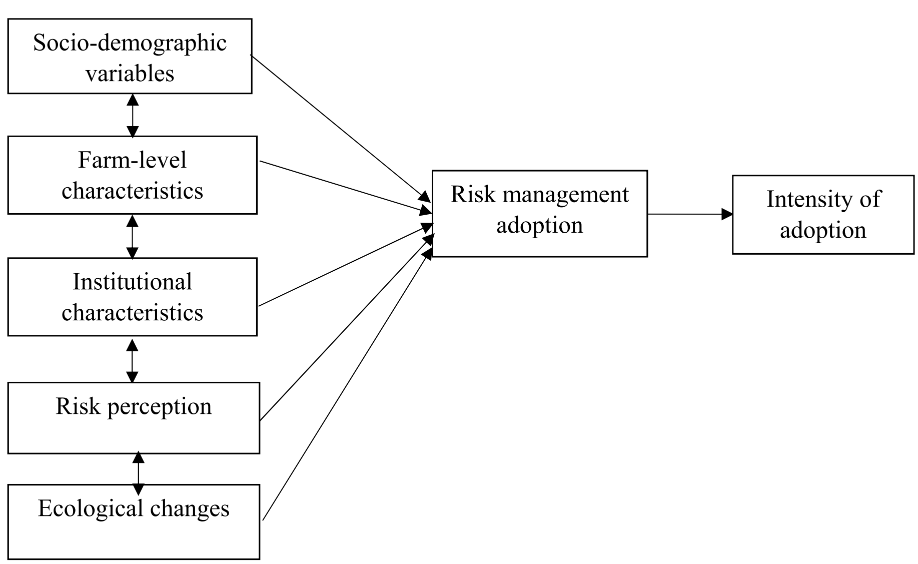

Fig. 1. Conceptual framework.

open-ended questions. This allowed for information that the researcher might have unknowingly overlooked. The questionnaire covered demographic characteristics, farm-level and institutional characteristics, risk management instruments, risk perception and access to credit. Parameters integrated into the questionnaire were coined in consultation with relevant studies. The survey instrument was validated via initial pre-testing with 20 rice farmers. Afterwards, the necessary inputs and adjustments, including changes in wording, phrases and terminologies, were done. The data were collected digitally with the World Bank's app *Survey solution* on tablets to reduce the time and errors associated with data recording and entry from a paper-based questionnaire. The *Survey solution* further ensured data accuracy and consistency. The perception index, multivariate probit regression and Poisson regression models were used to investigate farmers' perception of agricultural risks, determinants of risk management instruments adoption, and intensity of adopting risk management instruments.

3.3.1. Farmers' perception of agricultural risk

The perception index was utilised following earlier studies see Refs. [71–73], to assess farmers' perception of risks confronting them. The value of the perception index lies between −1 and 1, enabling the researcher to conclude whether farmers have negative or positive perceptions about risks [72,73]. The questions for eliciting farmers' perceptions were developed into a five-point Likert scale. Three broad categories of risks were considered; production risks, market risks, and financial risks see Refs. [23,74]. Under the production risk factors, seven items were asked to gather farmers' perceptions of production risks. Also, four items were used to investigate farmers' market risk perceptions, while two were used to solicit farmers' financial risk perceptions. During the data collection, respondents ranked their level of agreement with each perception statement. A farmer who highly disagreed with a particular risk statement was assigned a value of −1, disagreed was assigned −0.5, neutral was assigned 0, agreed was assigned 0.5 and highly agreed was assigned 1. Following Avane et al. [72] and Amrago and Mensah [71], the simple arithmetic mean was used to compute the farmer's perception index as follows;

$$\text{Perception index} = \frac{\sum \pi}{N} \tag{2}$$

where N is the number of perception statements, and π is the mean score for each perception statement, which is estimated as:

$$\pi = \frac{\sum Frequency_1 * Weight_1}{n} \tag{3}$$

where n denotes the number of respondents.

3.3.2. The adoption of risk management instruments by farmers

The multivariate probit (MVP) regression was used to estimate the factors affecting irrigated-rice farmers' adoption of risk management instruments. Researchers consider the multivariate probit model a suitable method to estimate several correlated binary outcomes simultaneously [75]. The study identified several risk management instruments used by farmers. However, five were unskewed or appropriate for the analysis (i.e. crop diversification, crop rotation, bonding, contract farming, and off-farm work). The skewed ones were automatically dropped during the analysis by the STATA software. Farmers were found to combine multiple management instruments concurrently to hedge risks. Therefore, overlooking the correlation among the risk management instruments may result in biased estimates [75]. To account for such an interdependent relationship, the MVP regression model is propounded as a suitable approach [50,67,73].The MVP estimation jointly analyses the influence of a set of variables on each risk management instrument. It estimates a set of binary probit models, considering the correlation in the error terms. It makes it possible to determine the relationship among the risk management instruments, and any potential relationships among unobserved disturbances [67]. Univariate models like the probit and logit do not consider the correlation in the adoption equation's error terms. Therefore, when adoption decisions are correlated, the implementation of such models becomes unsuitable [67]. The estimates may be inaccurate and skewed if the correlation among the risk management instruments are ignored [50,67,73].

The MVP approach produces two diagnostics that determine the model's goodness of fit; that is, the likelihood ratio (LR) test and the Wald test of correlation coefficients rho. One way the Wald test differs from the log-likelihood test is that it examines the null hypothesis that all model parameters are instantaneously equal to 0. The degree of freedom in this test, which equals the total number of parameters in the entire model, yields a chi-square result. The null hypothesis can be rejected if the corresponding p-value is less than the significance level, showing that the coefficients of the explanatory variables are not all concurrently equal to 0 and that the inclusion of these variables results in a statistically significant improvement in the model's fit. The LR test of rho, on the other hand, tests the null hypothesis that these *rho* are all simultaneously equal to 0, i.e., the error terms are independent. Rho is the correlation coefficient between the residuals of each equation estimated in the MVP model. MVP model is deemed appropriate if the p-value associated with the chi-square value obtained in the LR test is lower than the chosen significance threshold. The general specification of the MVP model, according to Greene [75] and Sánchez-Cañizares et al. [50], is as follows;

$$Y^*_{ij} = \beta_i X_{ij} + \varepsilon_{ij} \tag{4}$$

where Y^*_{ij} $(j = 1, \ldots, \ldots m)$ is the categorical variable related to the adoption of risk management instrument j by farmer i $(i = 1\ldots, \ldots, n)$; X_{ij} is a $1 \times k$ vector of the manifest variables that affect farmer i's decision to adopt a risk management instrument (explanatory variables), β_i is $k \times 1$ parameters to be estimated; and ε_{ij} is the vector random disturbance terms normally distributed with zero mean and constant variance. It is worth noting that estimations in the MVP model are numerically intensive and may be very slow if the data set is large, if the number of draws is large, or (especially) if the number of equations is large [76]. Empirically, the model used to estimate the multivariate probit regression is specified as:

$$\begin{aligned} Risk\ management\ instrument^*_{ij} &= \beta_0 + \beta_1 Age_{ij} + \beta_2 Gender_{ij} + \beta_3 Education_{ij} \\ &+ \beta_4 Householdsize_{ij} + \beta_5 FBO_{ij} + \beta_6 Experience + \beta_7 Extension_{ij} \\ &+ \beta_8 Land\ tenure_{ij} + \beta_9 Ricefarm\ size_{ij} + \beta_{10} Total\ farmsize_{ij} \\ &+ \beta_{11} Production\ risk_{ij} + \beta_{12} Market\ risk_{ij} + \beta_{13} Financial\ risk_{ij} \\ &+ \beta_{14} Rainfall\ prediction_{ij} + \beta_{15} Drought\ frequency_{ij} \\ &+ \beta_{16} Declined\ soil\ fertility_{ij} + \varepsilon_{ij} \end{aligned} \tag{5}$$

3.3.3. Intensity of adopting risk management instruments

Ordinary least squares (OLS) regression with count variables may have issues [77]. Hence, in the literature, the Poisson and Negative Binomial Regression Models are common count models widely recommended [78–81]. The restrictive condition that the variance equals the mean in the Poisson model is relaxed in the Negative Binomial regression model, which is an extension of the Poisson regression model. The calculated coefficients for the Negative Binomial regression are likely to be estimated more accurately than those of the Poisson regression model if the count data is over-dispersed (i.e., the conditional variance exceeds the conditional mean). Also, the two models, in most instances, produce similar estimates. However, the literature recommends that the choice of Poisson regression over Negative binomial regression can be concluded using model fit indices such as the Akaike Information Criterion, Bayesian Information Criterion and Chi-square goodness of fit [81].

According to Silva and Tenreyro [82], the basic Poisson regression model relates the probability function of a dependent variable y_i (also referred to as regressand, endogenous, or dependent variable) to a vector of independent variables x_i (also referred to as regressors, exogenous, or independent variables). Let k be the number of regressors (including, usually, a constant). x_i is then a column vector of dimension (k × 1). Finally, n is the number of observations in the sample. Given this, the standard Poisson regression is expressed as:

$$\text{Prob}\ (y_i) = \frac{e^{-\lambda_i}\lambda^y}{y_i!} \tag{6}$$

Where

$$\lambda_i = e^{(x'\beta)} \tag{7}$$

Equations (6) and (7) can be combined as follows;

$$y_i = \exp\left(-exp^{(x'\beta)}\right)exp^{(yx'\beta)} \tag{8}$$

where λ_i (which denotes the intensity of adoption), in this case, is the number of risk management instruments utilised, y_i denotes the dependent variable (risk management instrument), and x denotes the explanatory variables (socioeconomic variables, perception and institutional variables).

Empirically, the model used to estimate the Poisson regression model is specified as follows;

$$\begin{aligned} Intensity\ of\ adoption = {} & \beta_0 + \beta_1 Age_{ij} + \beta_2 Gender_{ij} + \beta_3 Education_{ij} \\ & + \beta_4 Householdsize_{ij} + \beta_5 FBO_{ij} + \beta_6 Experience + \beta_7 Extension_{ij} \\ & + \beta_8 Land\ tenure_{ij} + \beta_9 Ricefarm\ size_{ij} + \beta_{10} Total\ farmsize_{ij} \\ & + \beta_{11} Production\ risk_{ij} + \beta_{12} Market\ risk_{ij} + \beta_{13} Financial\ risk_{ij} \\ & + \beta_{14} Rainfall\ prediction_{ij} + \beta_{15} Drought\ frequency_{ij} \\ & + \beta_{16} Declined\ soil\ fertility_{ij} + \varepsilon_{ij} \end{aligned} \tag{9}$$

4. Results and discussions

4.1. Summary statistics of data

Table 2 shows farmers' mean age is 44, with a maximum age of 77. This age suggests that irrigated-rice farmers are above the youthful age bracket or older, which can affect their productivity. Thus, age is synonymous with strength and the ability to work. The average years of formal education is six, with a maximum of 16 years.

At least, farmers have little formal education, which suggests that these farmers are well-aligned to understand and assimilate good production practices. Also, the average number of people in a household is 7, with a maximum of 17 people in a home and a minimum of 1 person. The considerable number of persons in a family indicates labour availability which will favour the adoption of recommended farm practices. The average farming experience is 19 years, with a maximum of 55 years. The average years of farming suggest that farmers will capitalise on the experience earned to improve their production practices. On average, farmers have a total landholding of 5.6 acres, with a maximum of 30 acres and a minimum of 1 acre. Moreover, the average rice farm size was 2 acres, with a maximum of 12 acres and a minimum of 0.5 acres. This suggests that most of the farmers interviewed are smallholders. Most farmers (77.2%) were males, with the remaining being females. It is not surprising because female access to land and other

Table 1
Description of variables used in the regression analysis.

Variable	Description	Measurement
Dependent variables		
Risk management instrument	Type of risk management instrument used	Binary (1 = Yes, 0 = No)
Intensity of adoption	Number of risk management tools used	Count
Socioeconomic variables		
Age	Number of years	Continuous
Gender	Sex of farmer	Binary (1 = Male, 0 = Female)
Education	Level of formal education	Continuous
Household size	The total number of dependents	Continuous
FBO member	Member of a farmer group	Binary (1 = Yes, 0 = No)
Farming experience	Years of farming	Continuous
Extension access	Contact an extension agent	Binary (1 = Yes, 0 = No)
Land tenure	Rice land ownership	Binary (1 = Owned/Family land, 0 = Otherwise)
Rice farm size	Size of rice farm (acres)	Continuous
Total farm size	Total farm size (acres)	Continuous
Risk perception		
Production risk (mean score)	Farmer's perception of production risk factors	Number
Market risk (mean score)	Farmer's perception of marketing risk factors	Number
Financial risk (mean score)	Farmer's perception of financial risks factors	Number
Rainfall prediction	Difficulty in the prediction of rainfall in the past decade	0 = Don't know 1 = Easier 2 = Same 3 = Harder
Drought frequency	Frequency of droughts in the past decade	0 = Don't know 1 = Less common 2 = Same 3 = More common
Declined soil fertility	Soil fertility status in the past decade	1 = Yes, 0 = No

Table 2
Summary statistics of data.

Variable	Mean	Min.	Max.
Age	44	18	77
Level of education	6	0	16
Household size	7	1	17
Farming experience	19	2	55
Total farm size	6	1	30
Rice farm size	2	0.5	12

Variable	N	%
Gender		
Male	368	77.15
Female	109	22.85
FBO membership		
Yes	298	62.47
No	179	37.53
Land tenure		
Family/owned	300	62.89
Otherwise	177	37.11
Extension access		
Yes	210	44.03
No	267	55.97
Rainfall prediction		
Don't know	5	1.05
Easier	90	18.87
Same	9	1.89
Harder	373	78.20
Drought frequency		
Don't know	8	1.68
Less common	63	13.21
Same	9	1.89
More common	397	83.23
Declined soil fertility		
Yes	395	82.81
No	82	17.19

productive resources is very challenging among the patrilineal tribes in Ghana, especially the Northern Region [83]. Approximately 62% of the farmers belong to a farmer group. Furthermore, 63% of the farmers are cultivating on family, or owned lands, while the remaining 37% are producing on rented, vested or common lands. In addition, only 44% of the farmers had access to extension agents in the previous season. Also, 13% of the farmers indicated that drought has become less frequent in the past decade. Approximately 1% of the farmers revealed they are unaware of any changes in rainfall prediction. However, 19% of them attested that it has become easier to predict rainfall. On the other hand, 2% were indifferent about rainfall prediction; thus, it is the same as in the past decade. Most farmers (78%) asserted that rainfall prediction has become harder recently. Similarly, Zakaria et al. [84] reported that most (97%) of irrigated-rice farmers believe that rainfall keeps getting erratic, making it difficult to predict its occurrence. Nonetheless, 2% of the farmers remain indifferent about the frequency of droughts. Interestingly, 83% of the farmers attested that drought has become more frequent recently. Drought has recently become part of the weather calendar globally. Its occurrence has become rampant compared to previous decades. Therefore, it is unsurprising that most farmers attest that rainfall has become erratic recently.

4.2. Risk management instruments adopted by farmers

Table 3 summarises the risk management instruments used by irrigated-rice farmers. Inferring from the table, 398 (83%) farmers practise crop diversification. Also, none of the farmers interviewed had crop insurance. Likewise, all the farmers cultivated improved rice varieties. Similarly, all the farmers used agrochemicals (synthetic fertiliser, pesticides, weedicides, herbicides). Again, 22% participate in off-farm work, while the majority of them (78%) do not have off-farm work. Also, 26% of the farmers practise crop rotation, while a substantial proportion (74%) do not practise crop rotation. Finally, only 55 farmers practise contract farming, while the remaining 422 do not. Given that the insurance, improved varieties and agrochemicals were skewed respondents, they were dropped in the multivariate probit estimation.

4.3. Intensity of risk management instruments adopted

The bundle of risk management instruments utilised by farmers is presented in Table 4. It can be deduced that farmers combined at least two instruments simultaneously and a maximum of six. The proportion of farmers that used two instruments concurrently is 25 (5.24%). Also, 139, representing 29.14% of the farmers, utilised three instruments together. The majority (183) of the farmers combined four risk management instruments simultaneously. Further, 20.55% of the farmers used five risk instruments concurrently. Lastly, 6.71% (32) of the farmers used six risk management instruments.

Table 3
Summary of risk management instruments utilised by farmers.

Instrument	N	%
Crop diversification		
Yes	398	83.44
No	79	16.56
Insurance		
Yes	0	0
No	477	100
Off-farm job		
Yes	106	22.22
No	371	77.78
Improved varieties		
Yes	477	100
No	0	0
Agrochemicals		
Yes	477	100
No	0	0
Crop rotation		
Yes	126	26.42
No	351	73.58
Contract farming		
Yes	55	11.53
No	422	88.47
Credit access		
Yes	121	74.63
No	356	25.37

Table 4
Intensity of adopting risk management instruments.

Intensity (number of instruments adopted)	N	%
2	25	5.24
3	139	29.14
4	183	38.36
5	98	20.55
6	32	6.71

Table 5
Estimates of risk perception index.

Perception statements	SA (1)	A (0.5)	I (0)	D (−0.5)	SD (−1)	Mean
Production risks						
Pest and diseases significantly affect farming.	297 (62.3)	157 (32.9)	3 (0.6)	10 (2.1)	10 (2.1)	0.76
My farmland is not very fertile for production.	97 (20.3)	201 (42.1)	6 (1.3)	139 (29.1)	34 (7.1)	0.20
Encroachment of grazing animals is a serious threat.	175 (36.7)	249 (52.2)	2 (0.4)	46 (9.6)	5(1.0)	0.57
Persistent drought is a serious challenge.	226 (47.4)	226 (47.4)	2 (0.4)	18 (3.8)	4(0.8)	0.68
Erratic rainfall significantly threatens farming.	203 (42.6)	246 (51.6)	3 (0.6)	24(5)	1(0.2)	0.66
Improved varieties are not beneficial.	1(0.2)	1(0.2)	2 (0.4)	220 (46.1)	253 (53)	−0.76
Agrochemicals are not effective and useful.	2(0.4)	37 (7.8)	6 (1.3)	253 (53)	179 (37.5)	−0.60
Availability of labour is a serious impediment.	100 (21)	262 (54.9)	14 (2.9)	90 (18.9)	11 (2.3)	0.37
Conflict among irrigable field users impedes farming.	110 (23.1)	282 (59.1)	5(1)	71 (14.9)	9(1.9)	0.43
Market risks						
Market access and fear of ready market are a challenge.	190 (39.8)	236 (49.5)	1 (0.2)	47 (9.9)	3(0.6)	0.59
Prices of farm products are usually not attractive.	288 (60.4)	167 (35)	1 (0.2)	19(4)	2(0.4)	0.75
Prices of agro-inputs are currently expensive.	306 (64.2)	164 (34.4)	2 (0.4)	4(0.8)	1(0.2)	0.81
Agrochemicals are inaccessible in my area.	195 (40.9)	222 (46.5)	1 (0.2)	44 (9.2)	15 (3.1)	0.56
Financial risks						
Access to credit remains a major challenge.	213 (44.7)	241 (50.5)	5(1)	17 (3.6)	1(0.2)	0.68
High-interest rate hinders credit demand.	226 (47.4)	237 (49.7)	2 (0.4)	12 (2.5)	0(0)	0.71
Perception index	**0.43**					

Note: SA=Strong Agree, A = Agree, I=Indifferent, D = Disagree, SD=Strongly Disagree. Values in parentheses are percentages.

4.4. Farmers risk perception index

The computation of farmers' risk perceptions is shown in Table 5. However, before the perception was estimated, Cronbach's α (internal consistency coefficient) was used to examine the reliability of the risk items. The results are presented in Table 2a in the appendix. The results show that Cronbach's α for production, marketing and financial risk items are 0.65, 0.50 and 0.64, respectively, which do not meet the minimum threshold of 0.70 [85,86]. However, Taber [87] reported that Cronbach's alpha within 0.5–0.7 is acceptable. On this account, the items used to solicit farmers' risk perception can be considered reliable.

The table presents farmers' perceptions of production, marketing and financial risks. From Table 5, about 62.3% of the farmers strongly agreed that pests and diseases significantly threaten their production. Only 10 out of the 477 farmers strongly disagreed that pests and diseases threaten their rice production, while 3 of them were indifferent to the statement. Similarly, the threat of pests and diseases is also reported in related studies [88–90]. Also, the majority of the farmers (42.1%) agreed that their farmlands are not fertile for production, while 29.1% disagreed with the same. In tandem, Yahaya [91] reported that depleted farmland is a crucial reason for the decline in agricultural productivity in West Africa. Likewise, Wood [92] asserted that soil fertility management and pests and diseases are among the most significant hurdles facing farmers in northern Ghana. Again, 52.2% of the farmers agreed that encroachment of grazing animals impedes their farming, while just five persons (1%) strongly disagreed with this statement. In Ghana, crop producers and herders usually compete for the same plot of land. Accordingly, Issifu et al. [93] and Baidoo [94] noted that, in Ghana, grazing cattle easily access farm plots and destroy crops and other agricultural products, frequently leading to disputes and violent fights between farmers and herders. Mostly, this happens during the lean season when fresh vegetation is only available on cropped lands, pushing some herdsmen or uncontrolled animals, especially cattle, to invade the rice fields.

Moreover, persistent drought being a challenge in farming was strongly agreed by 47.4% of farmers, while 226 also agreed. Only a few (0.8%) strongly disagreed that persistent drought affects their production. In addition, most farmers (51.6%) agreed that erratic rainfall is a severe detriment to rice farming, while only one person strongly disagreed. It is worth stating that the adversity of perceived changes in the environment in Ghana is more witnessed in Northern Ghana, hence the farmers' agreement to this statement. Likewise, Antwi-Agyei et al. [69] reported that erratic rainfall characterises the Upper East Region. Further, only one person strongly agreed that improved varieties are not beneficial, while most farmers (53%) strongly disagreed with the statement that improved varieties are not helpful. Just 0.4% of the farmers are neutral to this statement. Due to the ever-increasing perceived environmental changes, improved rice varieties, including drought-tolerant and early maturing groups, are now considered by farmers as risk-mitigating strategies. For instance, empirical evidence shows that adopting improved rice varieties improves farmers' productivity in Northern Ghana [95,96]. Abdul-Rahaman et al. [95] found that adopting improved rice varieties was associated with a 76% increase in rice farmers' productivity. It is, therefore, not surprising that most farmers opposed the statement that improved rice varieties are not beneficial.

Further, 53% of the farmers strongly disagreed that agrochemicals are ineffective and not helpful, while the least (0.4%) strongly agreed that agrochemicals are ineffective. As expected, synthetic chemicals such as fertilisers, pesticides, weedicides and herbicides have become rampant in farming recently, and this development can be attributed to their contributions to farm productivity and efficiency [97]. Given the increase in pests and diseases, the decline in soil fertility, etc., farmers use agrochemicals to resolve these challenges. Again, most farmers (54.9%) agreed that labour unavailability seriously impedes farming. Due to the current perceived changes in the environment and the high poverty level in Northern Ghana, there is uncontrolled migration among the indigenes to the Southern part of the country [98]. Due to this, there are mostly labour shortages in the farming communities, which impede production. However, 18.9% disagreed that labour availability challenges their rice farming. In addition, 59.1% of the farmers agreed that conflicts among users of irrigable land are a hurdle to their farming. Nonetheless, 1.9% of the farmers strongly disagreed that disputes among users of irrigable land threaten farming. Due to water rationing under the irrigation scheme, there is usually some misunderstanding among farmers. Though there is a certain level of dispute among irrigable land farmers, most disagreed that it hinders their farming. It is highlighted that, when there is a conflict, water-user association leaders and other community leaders, such as assembly members and the chief, help resolve it [99].

For marketing risks, most farmers (49.5%) agreed that market access and fear of a ready market is a severe challenge to their farming, while 47 out of 477 disagreed. Generally, Ghana's lack of ready markets remains a severe threat to agriculture. Farmers' ability to get ready markets for their output deters most of them from production. In addition, a substantial proportion of the farmers (60.4%) strongly agreed that the prices of farm produce are not attractive, while only 0.4% strongly disagreed with this statement. In Ghana, prices for various crops are generally not appealing; hence, farmers agreed with this statement. Again, 64.2% of the farmers strongly agreed with the statement that agro-inputs are currently expensive and unaffordable. However, only one farmer strongly disagreed with this statement, while four disagreed. Similarly, Rizwan et al. [31] disclosed that high input prices are the perceived risk by rice farmers in Pakistan. Moreover, the majority of the farmers (46.5%) agreed that agrochemicals are inaccessible in their area, and 40.9% agreed with the same. In comparison, just 3.1% strongly disagreed with this statement. Likewise, Adams et al. [100] disclosed that smallholder farmers in Northern Ghana face multiple constraints in accessing the input market. Regarding financial risks, a more significant share of the farmers (50.5%) agreed that access to credit is very challenging for farmers, while just one farmer strongly disagreed. It should be underlined that lack of collateral and information asymmetry influence financial service providers to ration farmers from accessing financial services such as credit [101,102]. Interestingly, 44.7% also strongly disagreed with the statement that credit access is challenging. Lastly, 49.7% of the farmers agreed that interest rates are usually high, which impedes credit demand, while none strongly disagreed with this statement, with just 2.5% disagreeing. The cost of capital on most loans in Ghana is very high, which demotivates farmers from accessing loans. Similarly, Anang and Kabore [103] reported that interest rate deters Ghanaian poultry farmers from soliciting loans. The total risk perception index of the sampled rice farmers is 0.43, indicating that rice farmers have a favourable view of risk in agriculture and concur with the majority of risk perception statements.

4.5. Determinants of utilising risk management instruments by farmers

Table 6 illustrates estimates of the determinants of risk management instruments by irrigated-rice farmers. The multivariate probit model was estimated using simulated maximum likelihood methods through the mvprobit command in Stata version 17.0 [104]. From the table, the *p*-value of the Wald Chi^2 is significant, which indicates that the coefficients of the predictor variables are not simultaneously equal to zero. This implies that the model fits the data well. On the other hand, the probability of the Likelihood test of *rho* is significant (*p*-value less than 1%), which indicates that the error terms of the outcome variables are interdependent. Thus, there is a correlation among the risk management instruments. Hence, using the multivariate probit model is appropriate. Also, multicollinearity among explanatory variables used in the MVP was tested using the Variance Inflation Factor (VIF), as shown in Table 1a in the appendix. It is worth stating that the collinearity test was computed for only the continuous explanatory variables, as Bannor et al.

Table 6
Multivariate probit regression of factors influencing the adoption of risk management instruments.

Variables	Crop diversification	Off-farm work	Credit access	Crop rotation	Contract farming
Socioeconomic variables					
Gender	0.41(0.030)**	−0.31(0.090)*	−0.31(0.066)*	0.39(0.040)**	0.04(0.867)
Age	−0.01(0.521)	−0.00(0.825)	−0.03(0.000)***	−0.01(0.158)	−0.00(0.620)
Household size	0.02(0.456)	−0.01(0.817)	0.03(0.287)	−0.02(0.414)	0.01(0.834)
Years of education	−0.03(0.040)**	0.08(0.00)***	−0.02(0.099)*	0.00(0.854)	0.01(0.486)
FBO membership	0.18(0.290)	0.14(0.367)	0.06(0.709)	0.09(0.577)	0.06(0.734)
Farming experience	0.00(0.945)	−0.01(0.207)	0.02(0.020)**	0.03(0.003)***	0.00(0.633)
Extension access	−0.01(0.951)	−0.21(0.162)	0.29(0.049)**	0.74(0.000)***	0.51(0.004)***
Land tenure	0.22(0.170)	−0.01(0.952)	0.27(0.062)*	0.77(0.000)***	0.01(0.937)
Total farm size	0.22(0.00)***	0.05(0.045)**	−0.05(0.079)	0.04(0.103)*	0.00(0.909)
Rice farm size	−0.29(0.00)***	0.01(0.844)	0.15(0.014)	−0.06(0.398)	0.06(0.395)
Risk perception					
Mean production risk	0.48(0.232)	−0.19(0.621)	0.55(0.132)	−0.07(0.859)	0.51(0.260)
Mean market risk	−0.28(0.456)	0.50(0.139)	−0.60(0.059)*	−0.99(0.003)***	−0.35(0.358)
Mean financial risk	0.04(0.892)	−0.32(0.262)	−0.34(0.208)	0.09(0.745)	0.24(0.494)
Ecological changes					
Rainfall prediction	0.15(0.121)	0.30(0.002)***	−0.09(0.308)	0.14(0.167)	−0.12(0.267)
Drought frequency	0.07(0.513)	−0.05(0.638)	−0.05(0.601)	0.00(0.968)	−0.12(0.296)
Declined soil fertility	−0.68(0.01)***	−0.41(0.016)**	−0.08(0.638)	0.54(0.009)***	0.20(0.326)
Constant	0.99(0.161)	−1.0(0.094)*	0.91(0.107)	−2.64(0.000)**	−1.70(0.014)**
Log-likelihood	−1009.63				
Wald $Chi^2(75)$	229.35				
Prob > Chi^2	0.00***				
LR test of rho, $Chi^2(10)$	43.63				
Prob > Chi^2	0.00***				

Note: ***, **, and * represent significance at 1%, 5%, and 10% levels, respectively. Figures in parentheses are robust standard errors.

[105] recommended. The result shows the absence of multicollinearity since the mean VIF (1.69) did not exceed the threshold of 10.

4.5.1. Determinants of practising crop diversification

From Table 6, variables such as gender, years of education, total farm size, rice farm size and changes in soil fertility significantly predict the practice of crop diversification. Specifically, gender and total farm size positively predicted the utilisation of crop diversification as a risk management instrument, while years of formal education, rice farm size and experience with soil fertility negatively determined the practice. In detail, the results demonstrate that an increase in total farm size increases the likelihood of farmers adopting crop diversification. Access to land as a resource is a significant factor in determining the number of crops that can be grown given a set of resources. This suggests that farmers with larger pieces of land are more likely to diversify than their counterparts. This is convincing because most households in Northern Ghana rely on staple foods such as maize, millet and rice for household food requirements [106]. Therefore, farmers with large farm sizes are expected to allocate some portions to cultivate some of these crops. Previous studies have found that utilising crop diversification as a resilience strategy is more feasible on relatively larger farms [107,108]. Contrarily, crop diversification was significantly and negatively correlated with large farm size [109]. Further, the results suggest that males are more likely to diversify their cultivated crops than females. Primarily, males have more access to resource endowment (in Ghana, particularly the Northern region), such as land, than their female counterparts. Hence, males likely have vast lands to allocate to other crops [110,111]. Earlier empirical evidence is consistent with this finding [112]. Moreover, the results demonstrate that an increase in a farmer's years of formal education decreases their likelihood of practising crop diversification. This is surprising because education was expected to influence crop diversification positively, as reported in previous studies [113,114]. These studies contend that education contributes to the household head's human capital, and enhances the ability to accept and adopt new production techniques more rapidly, seek new information on technology, and meet more complex management requirements of crop diversification. However, our results revealed otherwise. A plausible reason for our finding could be that educated farmers might have mastered the art of rice cultivation and hence have strategies to manage risks associated with rice farming. This pushes them to abhor the cultivation of other crops. Evidence from Geethu and Sharma [115] consistently indicated that the farmer's literacy level negatively influenced crop diversification. In addition, increasing the size of rice farms decreases crop diversification intention. This finding is strange but plausible because cultivating two or more crops on the same irrigable field is not advisable. Thus, integrating vegetables with rice simultaneously on the same land is impractical since these two crops' water requirements are relatively different. For instance, most of the rice varieties (AGRA, Jasmine etc.) planted in these areas are flood rice, meanwhile the vegetables (*Ayoyo, Alefo, Bla)* consumed in these areas do not perform well in floods or waterlogged areas. Hence, farmers do not usually integrate other crops with rice simultaneously. Thus, they either cultivate rice in a season or use the plot to grow vegetables in a different season. Lastly, farmers who had experienced a decline in soil fertility in the past decade decreased their probability of adopting crop diversification.

4.5.2. Determinants of participating in off-farm work

Inferring from Table 6, variables such as gender, years of education, total farm size, ability to predict rainfall, and soil fertility status in the past decade are essential determinants of farmers' participation in off-farm work to manage risk. While years of formal education, total farm size, and rainfall prediction positively affect off-farm work participation, gender and soil fertility status negatively induce farmers to engage in off-farm work. An increase in farmers' years of formal education increases their likelihood of participating in off-farm work. This finding is convincing because educated farmers can find employment opportunities in the public and other informal sectors by working part-time. Also, educated farmers can be considered well-oriented and informed about other businesses aside from farming. This stimulates their participation in off-farm work. Likewise [106,116,117], reported that education influences off-farm work participation. Also, Khanal and Mishra [116] found a negative correlation between a farmer's spouse's educational level and off-farm work participation. The author argued that most off-farm activities do not require formal education, hence the insignificance. Also, increasing total landholding significantly increases farmers' participation in off-farm work. A reason could be that farmers with large farm sizes will likely give out portions of their lands as rent and channel the capital into off-farm. Early research revealed a negative correlation between farm size and off-farm work participation [118]. In addition, when it becomes more difficult for farmers to predict rainfall, the probability of engaging in off-farm work increases. That is, the inability to predict rain increases farmers' perception of farming as a risky venture and drives their intention to find an alternative source of livelihood off-farm. Correspondingly, Bezabih et al. [119] found that variability and reduced rainfall increase farmers' likelihood of off-farm work participation in Ethiopia. Moreover, males are unlikely to engage in off-farm work relative to females. During the field visit, it was found that a group of female rice farmers have other livelihood activities, such as weaving and parboiling rice for sale. Further probing indicated that this is a typical case in the study area. Females primarily engage in other off-farm income-generating activities, while males are concentrated on the farm [111]. Also, because females have limited access to land, they are usually forced to find off-farm work to generate income. This finding is consistent with Ahmed and Melesse [120] who found in Ethiopia that female-headed households were more likely to participate in off-farm work than their male counterparts. On the contrary, Ma et al. [121] asserted that males are more likely to engage in off-farm work than females, while Ma et al. [122] reported no significant relationship between gender and off-farm work participation. In addition, farmers who experienced a decline in soil fertility are unlikely to participate in off-farm employment. The Ghanaian government's Planting for Food and Jobs has subsidized and made fertilizers readily available and accessible on the market for farmers to improve their soil conditions. Hence, soil fertility is not a factor that will deter farmers from cultivating and drive them to find off-farm work.

4.5.3. Determinants of utilising credit

Inferring from Table 6, variables such as gender, age, years of education, farming experience, extension access, the land tenure system, total farm size, rice farm size and market risk significantly drive farmers to utilise credit to manage risk. Specifically, farming experience, extension access, land tenure and rice farm size positively influence the uptake of credit to hedge risk, whiles gender, age, years of formal education, total farm size and market risk negatively induce the uptake of credit. An increase in years of farming increases farmers' likelihood of credit uptake. Both formal and informal credit service providers prefer farmers with adequate experience to ensure they do not lose their investment. Even most financial service providers usually abhor start-ups or new ventures because of the risk associated with them. Hence, rice farmers with adequate years of experience can be entrusted with a loan because they are presumed to have mastered the craft of rice cultivation. Therefore, they will be able to produce and pay back their loans. This finding is in tandem with earlier studies [26,40]. Also, access to extension services augments farmers' probability of obtaining credit. In part, extension services inculcate financial advice, including loan availability and procedures to obtain the same. Also, financial institutions usually capitalise on extension agents to award farmers loans. Thus, the extension agents inform the financial institutions about farmers' creditworthiness. Hence, farmers with access to extension agents are likely to be connected to financial service providers or are educated on credits, which increases their likelihood of obtaining the same. Earlier studies concur with this finding [10,123,124]. However, Diedong [125] and Acheampong et al. [126] found conflicting results and noted that experienced farmers are unlikely to take loans. Further, farmers who own or cultivate rice on family lands are more likely to obtain credit than those who cultivate on rented land. The irrigable land area within the scheme is limited. Due to this, farmers renting irrigable plots are not assured of future extension when the rent is due. Hence, financial service providers will not want to work with farmers whose continuous production is at stake. Extending loans to these farmers becomes risky because they are not likely to access the land for subsequent production and will likely default on loan payments. Likewise, Yegbemey et al. [127] acknowledged the effect of various land tenure systems on farmers' investment and strategic decisions. Also, Sekyi et al. [128] underlined that land ownership through land registration tends to induce credit access. Contradictorily, Sanga [129] found that land registration and ownership do not guarantee farmers' credit access. Also, Missiame et al. [123] found an insignificant relationship between land tenure and farmers' credit access. An increase in rice farm size increases farmers' odds of obtaining credit. Thus, farmers with large acres on the irrigable field are more likely to be granted loans because these farmers are assumed to be commercial oriented. They can expand or increase production to pay loans when granted. Also, institutional credit agencies favour commercial farmers as they have more collateral to offer. Actually, during the field visit, it was noted that farmers with larger plots on the irrigable fields are mostly engaged in rice seed production on a commercial basis. Some even rent portions of the land to facilitate their commercial seed production business. Hence, banks and other financial service providers will likely work with these farmers. Likewise, Moahid and Maharjan [124] and Kumar et al. [130] reported a positive relationship between farm size and access to credit. In contrast, Twumasi et al. [102] discovered that farm size negatively affects farmers' credit access. Also, males are more unlikely to obtain credit relative to females. The findings contradict an earlier study which asserted that allocation of credit on a gender basis favours men more than women in the Upper East Region [131]. Thus, the proportion of credit men receive is higher than women's, and credit access is easier for men than women in the region. However, it was practically observed during the field visit that most women interviewed were in farmer groups. These groups operate as village savings and loans (VSLA) promoted by USAID and CARE International in Ghana. Hence, these women can obtain credit through revolving funds from the group. The women claim that the VSLA has been their major source of credit to finance their farming activities during financial distress. Similarly, Bannor et al. [111] noted that 62 of the 80 women participating in VSLA schemes obtained loans from their groups. Further, a unit increase in years of formal education decreases a farmer's probability of taking credit. The relationship between education and credit is inclusive in the extant literature. Thus, one strand of thought posits that education improves insight into financial services such as credit and hence has the tendency to induce the uptake of credit [103,132,133]. On the other hand, it is argued that mere formal education should not be mistaken for financial literacy [134–136]. This school of thought underline that ordinary formal education does not necessarily translate into awareness of financial services and their conditions. However, financial literacy is the key towards an individual's financial decisions, such as credit uptake and savings. The results demonstrate that a unit increase in farmers' total farm size decreases their credit uptake. It was expected that total farm size should trigger credit uptake, as found by earlier studies [26,124]. Probably, the other crops cultivated by the farmers do not require huge investments, preventing them from seeking credit though they may have a vast land. It was observed that most farmers are engaged in the cultivation of millets, maize, groundnuts, etc., on a subsistent basis. Hence, they do not channel much investment into the production of these crops. This could explain why an increase in landholding does not translate into the uptake of credit by the farmers. Further, increasing market risk decreases farmers' probability of utilising credit. Contrarily, Akhtar et al. [26] disclosed that farmers' price risk perception positively induces them to solicit credit. This study shows it is incongruous, maybe due to loan purposes, as most loans received are intended for investments to enhance or develop businesses. Because of this, a change in the price of both inputs and outputs would increase the likelihood that farmers would fail and decrease the likelihood that they will be able to repay the loan, which may cause farmers to postpone their plans and stop applying for financing. Similarly, evidence from Dang et al. [137] agrees with this result. Also, this affirms the Protection Motivation Theory that an individual's risk perception significantly predicts their management decisions. Further, the protection motivation theory is affirmed here because farmers' market risk perception predicts their decision to utilise credit.

4.5.4. Determinants of practising crop rotation

Table 6 demonstrates that gender, farming experience, access to extension services, the land tenure system, total farm size, market risk perception and soil fertility status are significant predictors of farmers' adoption of crop rotation. However, gender, farming experience, access to extension agents, total land size, land tenure system, and soil fertility status positively predict the adoption of crop rotation. At the same time, the perception of market risk negatively influences the practice of crop rotation. The results infer that an increase in total farm size increases farmers' practice of crop rotation. This outcome is in line with other research showing that farmers with larger farms are more likely to use crop rotation [138,139]. Thus, a large farm size means farmers have enough land for an effective crop rotation plan. Also, farmers who experienced a decline in soil fertility in the past decades are likely to adopt crop rotation. This result is convincing, given its agreement with previous literature that farmers regard crop rotation as the most crucial soil fertility management practice [140]. Also, Debie [141] disclosed that the soil fertility status stimulates Ethiopian farmers to practice legume-cereal crop rotation. Thus, when the soil does not support the productivity of a crop, the rational decision is to rotate the crop to help the soil regenerate nutrients. Likewise, Ghanaian farmers usually alternate their crops with leguminous crops to help the soil regenerate nutrients. An increase in farming experience increases farmers' utilisation of crop rotation. This is probable because farmers with many years of experience will likely know when to rotate their crops and the importance of crop rotation. This influences their likelihood of adopting crop rotation. Ahmed [142] reported similar findings. In contrast, Jabbar et al. [139] found that farming experience is insignificant in predicting farmers' adoption of crop rotation in Pakistan. Furthermore, farmers with contact with extension agents will likely practise crop rotation. A plausible reason could be that extension officers educate farmers on good agronomic practices such as crop rotation. As such, farmers who had contact with extension agents and were educated on crop rotation will likely practise the same. Evidence of the influence of extension agents on crop rotation is reported by Ref. [138]. Conversely, Jabbar et al. [139] reported that crop rotation is not contingent on access to extension services. Moreover, male farmers are more likely to practise crop rotation than female farmers. Generally, males have more land access than females in Ghana's Northern regions due to patrilineal inheritance. Having access to adequate farmland favours crop rotation. Similarly, Shikuku et al. [143] reported that male-headed households would likely adopt crop rotation in Ethiopia, Kenya, Tanzania and Uganda. Finally, increasing producers' perception of market risks decreases their crop rotation likelihood. For instance, the perception that buyers are only readily available to purchase a particular crop, say rice, makes it rational to focus on cultivating rice alone rather than rotating to cultivate other crops, which will become tedious to sell. Again, the Protection Motivation Theory is validated because market risk significantly, though negatively, influences farmers' decision to adopt crop rotation to manage risk.

4.5.5. Determinants of participating in contract farming

Table 6 highlights that only extension access significantly and positively stimulates farmers' decision to practise contract farming. Thus, farmers who had contact with extension agents are more likely to participate in contract farming. Extension officers provide production and marketing education to farmers. Therefore, extension agents can potentially educate farmers on the merits associated with contract farming. In this sense, farmers who had contact with extension officers will likely be oriented towards contract farming. On the other hand, some contractual arrangements come with private extension service delivery [52,144], which could explain the positive and significant relationship between contract farming and extension service. Similarly, Mishra et al. [145] reported that private extension visits increase participation in contract farming.

4.6. Determinants of the intensity of adopting risk management instrument

The argument from Martey & Kuwornu [81] is that the factors influencing the probability of adoption may differ from the intensity of adoption. Therefore, the intensity of adoption, measured by the number of risk management instruments adopted, was analysed to complement the determinants of adoption. The output is presented in Table 7. The estimation was done with STATA version 17 software. The goodness-of-fit indicators reveal that our model is robust to various specifications. Generally, the probability of Wald Chi^2 is significant in both models, meaning the coefficients of the variables are not simultaneously equal to zero, and the model fits the data well. The Pseudo R^2 infers that the explanatory variables jointly explain about 0.8% of farmers' decisions to utilise risk management instruments. However, the extremely insignificant probability of alpha, Prob($chibar^2$), in the Negative Binomial regression affirms that the data exhibit no overdispersion. Also, the Pearson goodness-of-fit value was extremely insignificant, informing that the Poisson regression model suits the data better than the negative binomial model. Further, the AIC value from the Poisson regression is lower (3.865) than that of the Negative Binomial regression (3.869). The Poisson regression has a BIC value of −1027.424 and −1021.256 for the Negative Binomial regression. In essence, there is lower information loss in the Poisson regression model relative to the Negative Binomial regression considering the AIC and BIC values. This further affirms that the Poisson regression model is appropriate for the analysis. However, for comparison and robustness check, the results of both models are presented in Table 7. Nonetheless, though both models yielded similar results, for conciseness without loss of generalization, the discussion is centred on the Poisson regression model.

Inferring from the table, age, farming experience, land tenure system, extension access, total farm size, and difficulty in predicting rainfall are the significant factors influencing the intensity of adopting risk management instruments. The results demonstrate that a unit increase in farmers' age decreases the number of risk management instruments adopted by 1.6%. Thus, aged farmers lack the strength to carry out many farm activities. Hence, utilising a couple of management techniques by farmers becomes challenging. In other settings, old age is aligned with poverty [46]. Hence, aged farmers are likely less endowed with resources to facilitate their uptake of many risk management instruments. Also, Manda et al. [146] argued that younger farmers are more innovative and willing to take risks, unlike older farmers, which increases their tendency to adopt new technologies like risk management instruments. Contrarily, Kassie et al. [147] contend that older farmers might have accumulated enough physical and social capital, which is likely to augment their adoption decision. Martey and Kuwornu et al. [81] uncovered that age does not explain farmers' intensity of adopting technologies. Further, a unit increase in years of farming increases the intensity of risk management instruments adopted by 1.8%. Experience is generally said to be the best teacher. Hence, experienced farmers are knowledgeable of available risk management instruments and the need to combine several of them to manage risks. Likewise, Martey and Kuwornu [81] asserted that farming experience significantly predicts the intensity of adopting soil fertility management practices. On the contrary, Ayenew et al. [148] disclosed that experienced farmers are unlikely to adopt new practices and the intensity of adoption. They explain that experienced farmers are usually reluctant to change because they find it comfortable with their old ways of production. Also, farmers with access to extension agents are more likely to increase the number of risk management instruments used by 30%. Similarly, Bashiru et al.

Table 7
Determinants of the intensity of adopting risk management instruments.

Variables	Model 1 (Poisson regression)			Model 2 (Negative Binomial regression)		
	Marginal effect	Std. error	p-value	Marginal effect	Std. error	p-value
Socioeconomic variables						
Gender	−0.032	0.020	0.790	−0.032	0.020	0.790
Age	−0.016	0.000	0.003***	−0.016	0.001	0.003***
Household size	0.003	0.003	0.849	0.003	0.003	0.849
Years of education	0.004	0.001	0.674	0.004	0.001	0.674
FBO membership	0.047	0.016	0.626	0.047	0.016	0.626
Farming experience	0.018	0.001	0.003***	0.018	0.001	0.003***
Extension access	0.302	0.016	0.002***	0.302	0.016	0.002***
Land tenure	0.390	0.016	0.000***	0.390	0.016	0.000***
Total farm size	0.041	0.007	0.039**	0.041	0.003	0.039**
Rice farm size	0.031	0.005	0.523	0.031	0.008	0.523
Risk perception						
Mean production risk	0.308	0.042	0.218	0.308	0.042	0.218
Mean market risk	−0.252	0.351	0.228	−0.252	0.035	0.228
Mean financial risk	−0.022	0.316	0.908	−0.022	0.032	0.908
Ecological experience						
Rainfall prediction	0.138	0.010	0.021**	0.138	0.010	0.021**
Drought frequency	−0.019	0.011	0.784	0.019	0.011	0.784
Declined soil fertility	−0.166	0.021	0.189	−0.166	0.021	0.189
Log-likelihood	−904.817			−904.817		
Wald $Chi^2(16)$	98.08			98.08		
Prob > Chi^2	0.000***			0.000***		
Psuedo R^2	0.008			0.008		
Deviance goodness of fit	74.463					
Prob > $Chi^2(460)$	1.000					
Pearson goodness of fit	74.350					
Prob > $Chi^2(460)$	1.000					
AIC	3.865			3.869		
BIC	−1027.424			−1021.256		
Inalpha				−31.186		
Alpha				2.86e-14		
LR test of alpha = 0: chibar2(01) = 0.000 Prob(chibar2) = 1.00						

Note: ***, **, and * represent significance at 1%, 5%, and 10% levels, respectively.

[149] disclosed that extension service positively influences the intensity of risk management adoption. Likewise, Mensah-Bonsu et al. [79] and Danso-Abbeam and Baiyegunhi [97] contend that extension services significantly and positively influence farmers' adoption intensity. The result is justified since extension agents are mostly responsible for disseminating good agronomic and marketing practices to farmers. Hence, farmers' awareness of diverse risk management through extension education is more likely to combine multiple of them to manage risk. On the contrary, Awuni et al. [150] unravelled that extension service reduces the intensity of adopting technologies by farmers. Moreover, farmers cultivating on family or owned lands are more likely to adopt a bundle of risk management instruments than those cultivating on rented lands. Studies have disclosed that the land tenure system has great implications for farm investment decisions, including adopting good agronomic practices and risk management techniques [127,147,151]. Further, increasing total farm size increases the likelihood of adopting multiple risk management techniques by 4.1%. Thus, farmers with larger farm sizes are exposed to more risk, which explains the likelihood of adopting multiple risk management instruments. Also, consistent with theory, large farm size means there is adequate land to allocate for experimenting practices like diversification, crop rotation, etc. Hence, farmers with larger farm sizes are more likely to adopt multiple practices to manage risk. Likewise, Bashiru et al. [149] and Kwawu et al. [152] found that larger farm size induces farmers to utilise more risk management tools. Nonetheless, empirical results from Awuni et al. [150] indicate a negative effect of farm size on the intensity of adopting technologies. Thus, Martey and Kuwornu [81] argued that most farmers are resource-poor; hence, they adopt few practices that they can manage, notwithstanding their farm size. Further, an increase in the difficulty of predicting rainfall increases the intensity of adopting risk management tools by 13.8%. This result is plausible because when rainfall becomes erratic, the obvious decision by farmers is to adopt strategies to nullify rainfall repercussions. Some strategies farmers usually utilise include cultivating drought-tolerant and early maturing varieties [58,153]. It is worth stating that the factors influencing the adoption of risk management instruments differ from those affecting the intensity of adoption. For instance, the perception of declining soil fertility was a significant predictor of adoption but was insignificant in the intensity of adoption. Market risk perception was significant in the intensity of the adoption model but insignificant in the adoption decision. This presupposes that the drivers of adopting technologies by farmers should not be mistaken as the same factors that induce the intensity of adoption. This decision follows a two-stage rationality and must be studied cautiously.

5. Conclusion and recommendation

The study investigated risk perception, adoption of risk management instruments, and the intensity of adoption among irrigated-rice farmers in the Upper East Region. The Tono and Vea irrigation schemes were selected purposively via a simple multistage sampling approach. Further, the Kassena-Nankana East and Builsa North districts under the Tono irrigation scheme were purposively chosen. Also, the Bolgatanga and Bongo municipals were selected from the Vea irrigation scheme. Proportionally, 318 farmers were selected from the Tono irrigation scheme and 159 from the Vea irrigation scheme through Yamane [70]'s sampling technique. The perception index, multivariate probit regression and Poisson regression models were used to measure farmers' perception of risk, determinants of adoption of risk management instruments, and the extent of risk management techniques, respectively.

The perception index score was 0.43, implying that farmers agreed with the risk questions. Thus, they agreed that risks affect their farming. Further, results from the multivariate probit analysis revealed that gender, years of education, total farm size, rice farm size, and soil fertility status in the past decade significantly predict the practice of crop diversification. Also, gender, years of education, total farm size, and ability to predict rainfall, and soil fertility status in the past decade are essential determinants of a farmer's participation in off-farm work to manage risk. Moreover, gender, age, years of education, farming experience, extension access, the land tenure system, total farm size, rice farm size and market risk significantly drive farmers to utilise credit to manage risk. In addition, gender, farming experience, access to extension services, the land tenure system, total farm size, market risk perception and soil fertility status are significant predictors of farmers' adoption of crop rotation. Finally, extension access significantly and positively stimulates farmers' decision to practise contract farming. The results from the intensity of adopting risk management techniques demonstrate that age, farming experience, the land tenure system, extension access, total farm size and difficulty in predicting rainfall are the significant factors influencing the intensity of adopting risk management instruments. It is worth mentioning that this study is not without limitations. Notably, although most rice farmers have similar features, expanding the study area to cover rice farmers in other geographical regions can provide insightful findings. Thus, this study was limited to only irrigated-rice farmers in the Upper East Region. Further studies could be conducted in different ecological settings and socioeconomic statuses, like the Asutuare irrigation scheme and rain-fed rice farmers, to validate the current findings.

5.1. Recommendation

Practice: Given that none of the sampled farmers had crop insurance, the authors recommend that insurance companies extend their marketing and services to cover farmers within the irrigation scheme. Increasing awareness and farmers' knowledge and access to insurance companies can help their utilisation. Further, males should be encouraged to participate in village savings and loans since it has the potential to offer credit facilities in times of need. Thus, the women attested that VSLAs are their primary source of credit. Hence, extension agents and other developmental partners, such as CARE International and USAID, should encourage male VSLAs to facilitate credit access by men. Moreover, stakeholders should consider farmers' risk perception when designing risk management policies since it informs their adoption decision.

Theory: The study re-enforces the Protection Motivation Theory in risk management that perceived risk explains risk management adoption by farmers. Thus, the study unravelled that farmers' market risk significantly predicts their decision to adopt risk management instruments. However, perception is insignificant in predicting the intensity of adoption. Therefore, it is not supported under the Protection Motivation Theory.

Policy: Government policies and investment plans should be focused on assisting with enhanced extension services, offering training through on-farm demonstrations, and disseminating information on risk management techniques, especially for Ghana's smallholder farmers, including rice farmers. Investment in organisations like extension services, research centres, and ICOUR is crucial for development because it may persuade farmers to use the right risk management tools. At the moment, all farmers are growing improved rice varieties. To facilitate the dissemination of new and improved rice varieties and technologies for the farmers to embrace, long-term collaboration is still needed between organisations like the Savanna Agricultural Research Institute, the Ministry of Food and Agriculture, and ICOUR.

Further studies: Further studies investigating farmers' binary decisions (adopt or otherwise) of technologies should consider the intensity of adoption since factors that augment the decision to adopt might vary from those influencing the intensity of adoption.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jafr.2023.100593.

Appendix

Table 1a
Multicollinearity test of continuous explanatory variables

Variable	VIF	Tolerance (1/VIF)
Age	2.28	0.44
Household size	1.04	0.96
Years of education	1.19	0.84
Farming experience	2.20	0.46
Total farm size	2.06	0.48
Rice farm size	1.99	0.50
Production risk perception	1.54	0.65
Market risk perception	1.57	0.64
Financial risk perception	1.37	0.73
Mean VIF	**1.69**	

Table 2a
Reliability test results

S/No	Sub-scale	Items	Scale Mean	Range	Cronbach Alpha
1	Production risk	9	5.02	1–5	0.65
2	Market risk	4	2.72	1–5	0.50
3	Financial risk	2	1.39	1–5	0.64

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