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RESEARCH ARTICLE

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Risk preferences and management strategies of farmers in Ghana: Does the type of crop grown matter?

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Abstract

This paper examined the risk preferences and management strategies of cereal and legume farmers of Ghana's savannah zones using both the exploratory factor analysis and the linear regression model. Using primary cross-sectional data and employing the multistage sampling technique made up of purposive, cluster and random sampling techniques, the paper found that cereal farmers are more risk averse than legume farmers. Rainfall variability was ranked topmost by cereals and legumes farmers. Both cereal and legume farmers employ multiple but dissimilar risk management strategies to manage these sources of risk. The commonest sources of risk to cereal and legume farmers were climate and market risk, while off-farm activities are the commonest management strategy. Production risk faced by cereal farmers was managed by both off-farm and farm production strategies whereas human risk faced by legumes farmers was managed by both off-farm and financial management strategies. The importance of market risk implies that policy initiatives should aim at reducing market-related risks by focusing on increasing off-farm opportunities for rural households.

KEYWORDS
factor analysis, Ghana, risk, risk management, risk perception, risk preference

1 | INTRODUCTION

Agricultural activities in most developed and developing countries are largely influenced by the natural and environmental conditions of these countries. Despite this, the agricultural sector of developed countries is better equipped to manage risk than the agricultural sector of most developing countries, which is fundamentally underdeveloped and rudimentary (Asravor, 2021; Di Falco & Veronesi, 2014). For a large number of developing countries, the agricultural sector is the most important contributor to National Gross Domestic Product (Asravor, 2021), food crop production for household consumption, the rural domestic market and the local economy yet arguably one of the riskiest sectors (Di Falco & Veronesi, 2014; Yesuf & Bluffstone, 2009). Among others, the sector suffers from risks associated with unpredictable weather conditions resulting in floods and droughts, disease and pest infestation and illness of household members (Dercon & Christiaensen, 2012; Deressa et al., 2009; Kurukulasurya & Mendelsohn, 2008). Since risks vary based on the geographical location and settings of the farmers (Aditto et al., 2012; Bishu et al., 2018), the type of crop grown and the characteristics of the farmers (Gebreegziabher & Tadesse, 2014; Schaper et al., 2010), it implies that the reactions and attitudes of farmers to these risks also differ.

To manage farm production risk, households first perceive the sources of these risks and then perceive the most appropriate risk management strategies before the actual implementation of these strategies. Several studies have shown that farm households vary in the importance they attach to the perceptions of sources of risks and strategies adopted to manage these risks (Aditto et al., 2012; Ahsan, 2011; Flaten et al., 2005; Koesling et al., 2004). For instance, Martin (1996) indicated that changes in input prices and product prices (market risk) were the two most important perceived sources of risk to dairy farmers in New Zealand and were met and managed by routine spraying, drenching and maintaining feed reserves. Among Dutch livestock farmers, Meuwissen et al. (2001) found price and production risks are the most important sources of risks, while producing at the lowest possible cost and using insurance services are the most important risk management strategies. Meraner and Finger (2019) identified that risk-averse German region North Rhine-Westphalia farmers prioritise on-farm risk management strategies over off-farm strategies in the management of their perceptions of risks. Additionally, higher risk perception, age, subjective numeracy, farm succession, farm size and the proportion of rented land show a significant impact on farmers' risk behaviour and management strategies (Menapace et al., 2016; Meraner & Finger, 2019).

In Africa, Bishu et al. (2018) found livestock farmers in the Tigray province of Ethiopia perceived the shortage of family labour, the high price of fodder and limited farm income as the most important source of risks, which were managed by the use of veterinary services, parasite control and loan utilisation. In the Northern Ethiopia provinces, livestock farmers were found to perceive low milk yield due to feed shortage as the top-rated source of risk while the diversification of livelihood activities and control of pests and diseases were the essential risk management strategies implemented (Gebreegziabher & Tadesse, 2014). The subject matter of risk perceptions, preferences and management strategies of smallholder farmers in sub-Saharan Africa have concentrated in East Africa, more especially in Ethiopia (Bishu et al., 2018; Gebreegziabher & Tadesse, 2014). The literature search also shows that the studies on farmers risk perceptions and management strategies have not been extensively investigated in West Africa and Ghana for that matter (Kouame & Komeman, 2012), implying that there is still quite some work to be done in this area. Added to this, the empirical literature on risk perceptions and risk behaviours has focussed on dairy and livestock farmers (Bishu et al., 2018; Gebreegziabher & Tadesse, 2014; Meraner & Finger, 2019) but very limited studies that have examined the perceptions and risk behaviour of crop farmers in both developing and developed countries (Koesling et al., 2004).

Though the livestock sector of developed and developing countries is important, in many rural sub-Saharan African provinces and villages, the crop sector is much more important since it is the dominant sector and the major employer of households (Deressa et al., 2009; Di Falco & Veronesi, 2014), especially those in rural communities. Despite the crop subsector being rain-fed and associated with high-income risk and rainfall risk has not immediately been modelled. Rather most reviewed literature points to the fact that rain-fed agriculture is not only an important source of income but also the main source of income in rural communities in developing countries (Asravor, 2018b; Deressa et al., 2009; Kurukulasurya & Mendelsohn, 2008; Di Falco & Veronesi, 2014).

Like most sub-Saharan countries, the agricultural sector of Ghana is dominated by smallholder farmers who are predominantly in the production of food crops using traditional farming practices (Akramov & Malek, 2012). Similar to most sub-Saharan countries, where maize is the most widely grown cereal and peanuts are the most widely grown tropical legumes, Ghana and, for that matter, Northern Ghana, is noted for its maize and peanut cultivation[1] (Martey et al., 2015). Tsikata and Yaro (2014) have indicated that when cultivated on a small scale, maize and peanuts are used as food crops, but generally, these crops are grown on a commercial basis. Maize and peanuts are important commercial and food crops grown in the Northern region of Ghana. Maize is Ghana's main staple crop, accounting for more than half of total cereal production (Ragasa et al., 2014). On the other hand, peanuts production is very pronounced in Northern Ghana and is the major cash crop for many households in the Northern region of Ghana (Tsikata & Yaro, 2014). According to the Millennium Development Authority (2010), maize is the largest and most widely cultivated staple in Ghana and the Northern region. Maize is cultivated by over 85% of the rural households in Northern Ghana because it has the highest potential to fight food security challenges facing rural households in Northern Ghana (Akramov & Malek, 2012). Furthermore, maize is relatively easy to cultivate, has a high yield potential and is widely adaptable to the changing climate (Akramov & Malek, 2012).

The empirical literature also indicates that, except for studies in developing countries that have compared the risk perceptions of organic and conventional farming systems (Flaten et al., 2005; Koesling et al., 2004), most studies have not compared the risk perceptions, preferences and management strategies of smallholder crop farmers in sub-Saharan Africa. As indicated by Flaten et al. (2005), the lack of information on farmers' risk attitudes and perception of risk implies very few useful practical insights for policymakers, farm advisers and researchers. Furthermore, classifying smallholder farmers as risk averse, without identifying the crops grown by these farmers is not very informative in the design of risk mitigation policies. This study attempted to fill the research gap in the empirical literature in sub-Saharan Africa by focussing on the smallholder cereal (maize) and legume (peanut) farmers in the risk-prone villages of the Savannah Zone of Ghana, the Northern region. This study aims to empirically investigate (i) the perceptions of risk and risk management responses of cereal and legume farmers in the Northern region of Ghana, (ii) differences in risk perceptions and management responses between cereal and legume farmers in the Northern region of Ghana and (iii) socio-economic characteristics and risk attitudes related to these perceptions and strategies. In particular, the study tests whether there are differences between the risk perceptions and management strategies of smallholder cereal and legume farmers using both descriptive statistics and exploratory factor analysis. The constant relative risk aversion (CRRA) is used to examine the risk preference of the farm households, while the linear regression is used to examine the interrelationship between risk aversion, risk perception and the risk management strategies of the smallholder farm households. This article proceeds as follows. In Section 2, the material and methods are presented. Section 3 discusses the empirical results, while Section 4 presents the conclusion and policy implications.

2 | MATERIALS AND METHODS

2.1 | Study area

Prior to the collection of data for this study, northern Ghana was made up of three regions, that is, the Northern region, the Upper West region and the Upper West region, but as of December 2018, northern Ghana has been divided into five regions. Northern Ghana, which is, the savannah zone of Ghana, is the largest agricultural zone in Ghana. It covers 41% of the total agricultural land in Ghana. Approximately 80% of the population in the savannah zone of Ghana is directly or indirectly involved in agriculture. Of the three regions that make up the savannah zone of Ghana,

[1]For the cereal farmers, the study focusses on maize, while for legumes farmers, the focus is on peanut farmers.

the Northern region is the largest region in Ghana in terms of land area and occupies an area of about 70,383 km^2, which is 29.5% of the total area of Ghana. The land use pattern of the Northern region is primarily agricultural and is characterised by small-scale subsistence cereal–legume farmers. Smallholder agriculture is an important livelihood option for most rural households in the Northern region contributing significantly to household income. Despite its important contribution towards cereal–legume production, the Northern region has a unimodal rainy season and hence has only one farming season and has more than 75% of its population actively engaged in agriculture (Ministry of Food and Agricultural, 2011).

2.2 | Sampling

The smallholder farmers sampled for this study were drawn using the multistage sampling technique. This study's multistage sampling technique combined purposive, cluster and random sampling techniques into a three-stage sampling technique (for more information, see (Asravor, 2018a). The sample size was arrived at using the Cochran formula is

$$n_0 = \frac{Z^2pq}{e^2},$$

where e is the desired level of precision (margin errors), which is set at 5%. In addition, p is the estimated proportion of the population, which was set at 50%, and q is $1 - p$, which is also set at 50%.

$$n_0 = \frac{1.96^2(0.5)(0.5)}{(0.05)^2} = 385$$

Thus, the calculated sample size was 385. To avoid issues of no response and incomplete response, oversampling was done. Hence, a sample size of 500 was used for this study. The sample size of 500 farm households was made up of 260 households from the Northern region and 120 from the Upper East and Upper West regions, respectively. Purposively, the sample selection focussed on households that were either mono-cropping maize or mono-cropping peanut and not both. For the Northern region, five villages were selected in six districts (West Mamprusi, Yendi, Central Gonja, Karaga, Saboba and Bole) and except for Saboba and Bole, where eight households were sampled, the remaining villages had nine households sampled and interviewed. Out of the 260 farm households interviewed from the Northern region, 196 are maize farmers and 64 are peanut farmers. The household survey was conducted with the principal decision-maker of each household during the August–September 2015 farming season.

The paper–pencil semi-structured questionnaire was administered to obtain detailed information on the households' socio-economic characteristics, livestock and crop production and the risk perceptions and management decisions of the households. The semi-structured questionnaire also captured information on the risk preferences of the farm household using the hypothetical lottery question (see Table 2). In the hypothetical lottery choice, there are equal chances of a favourable farming season or an unfavourable farming season. The explanation of the game shows that in choice A, there is no payoff difference between favourable farming season income and unfavourable farming season income, whereas in payoff F there is a large payoff difference between favourable farming season income and unfavourable farming season income. The payoffs in Table 2 are constantly increasing in risk and return from each choice A to F. In Table 2, for instance, a respondent who chose A automatically gained 5000 Ghana Cedis (GHC) whether the season is favourable or not favourable. If the farmers choose B, in a favourable season, the farmer gets GHC5500 and GHC4600 in an unfavourable season. Compared to A, the farmer loses GHC400 but gains GHC500 in a favourable farming season.

2.3 | Risk perception and risk management strategies

2.3.1 | Measuring risk perception and risk management strategies

The climatic risk, unpredictable yields, economic fluctuation and individual-specific shocks associated with agricultural activities make identifying the perceptions and risk management strategies of the rural farm household very essential. Undoubtedly, an increase in the probability of the occurrence of risk leads to an increase in risk perception and the application of risk management strategies. Eleven questions on the perceptions of the sources of risk were presented to both cereal and legume farmers to score. The subjective risk perceptions of the two groups of farmers were measured using a five-point scale from 1 (no variation or effect) to 5 (very large variation or effect). Additionally, both cereal and legume farmers were asked to score the risk management strategies on a five-point Likert scale question using a scale from 1 (no effect) to 5 (very large effect). Twelve different risk management strategy questions were used to measure the management strategies of these two groups of farmers.

The identified perceived risk sources and perceived risk management strategies of the sampled cereal and legume farmers were calculated using the average scores and later ranked in descending order (Bishu et al., 2018; Flaten et al., 2005; van Winsen et al., 2016). The ranking was done to identify what smallholder farmers perceive as the most important risk management strategy. In addition to the ranking, exploratory factor analysis was employed to measure the underlying factors responsible for subjective risk perception and risk management strategies of the cereal and legume farmers in the Northern Region.

2.3.2 | Factor analysis of risk perception and risk management strategies

Factor analysis was applied to investigate whether the number of variables of interest $Y_1, Y_2, \ldots, Y_l$ is linearly related to a smaller number of unobservable factors $F_1, F_2, \ldots, F_k$. Once these factors are unobservable, the ordinary least square regression method cannot be used (Hair et al., 2006). Under the assumption of a linear relationship:

$$Y_1 = \beta_{10} + \beta_{11} F_1 + \beta_{12} F_2 + \cdots + \varepsilon_1$$

$$Y_2 = \beta_{20} + \beta_{21} F_1 + \beta_{22} F_2 + \cdots + \varepsilon_1$$

$$\ldots$$

$$Y_n = \beta_{n0} + \beta_{n1} F_1 + \beta_{n2} F_2 + \cdots + \varepsilon_n$$

The error terms $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n$ imply that the hypothesised relationships are not exact, and $\beta_{10}, \beta_{20,} \ldots, \beta_n$ are called the loadings in factor analysis. Since these factors are unobservable, the loadings cannot be estimated. Likewise, the expectations are tested by regressing each dependent variable (Y) on the factors (Martin, 1996).

Under the assumption that the error terms are independent of one another[2] and the unobservable factor $F_1, F_2, \ldots, F_n$ are independent of the error terms and one another, then $E\left(F_j\right) = 0$ and $Var\left(F_j,\right) = 1$. If these two assumptions hold, the factors are measured in a standardised form. From these two assumptions, then

$$Y_i = \beta_{i0} + \beta_{i1} F_1 + \beta_{i2} F_2 + \cdots + (1)\varepsilon_1,$$

and the variance of Y_i can be computed as

$$Var(Y_i) = \beta_{i1}{}^2 Var(F_1) + \beta_{i2}{}^2 Var(F_2) + \cdots + (1)^2 Var(\varepsilon_i) = \beta_{i1}{}^2 + \beta_{i2}{}^2 + \cdots + \sigma_i^2.$$

[2]Similar to the assumption of regression analysis.

The variance of Y_i is made up of two parts:

$$Var(Y_i) = \underbrace{\beta_{i1}{}^2 + \beta_{i2}{}^2 + \cdots +}_{communality} \underbrace{\sigma_i^2}_{specific\ variance}$$

The communality of the variable is the part that is explained by the common factors $F_1, F_2, \ldots F_i$. The part of the variance of Y_i that is not accounted for by the common factors is the specific variance.

2.4 | Measurement of risk preference

Risk preferences of smallholder cereal and legume farmers were computed using the expected utility (EU). This method has been applied in numerous risk analysis studies (Binswanger, 1980; Kouame & Komeman, 2012). In this study, the preference of the smallholder household is measured using a hypothetical 50/50 lottery with two risky outcomes (best outcome or worst payoff), which leads to a decision problem. Thus, the switching point of the risk preferences and the degree of relative risk aversion of households was obtained by using the CRRA utility function. The CRRA function is stated as

$$U(x) = \frac{x^{1-r}}{1-r},$$

where r is the coefficient of relative risk aversion and x is the payoff in the option.

2.5 | Linear regression model

The factor scores generated from the exploratory factor analysis were used to examine the interrelation between farmers' risk attitudes, socio-economic characteristics and risk management strategies by employing multiple regression analysis. In the linear regression analysis, the standard factor scores obtained from the factor analyses on the sources of risk and risk management strategy are used as the dependent variables. The linear regression model is given as

$$Y = \alpha_0 + \beta_i x_i + \cdots + \beta_i x_n + \varepsilon_i,$$

where Y is the standardised factor scores derived from the perceptions of risk and risk management strategy, α is the intercepts, x_i is the explanatory variable (see Table 1) and ε is the error term. All the regression models are tested for possible violations of the basic assumptions of a linear regression model.

TABLE 1 Comparison of descriptive statistics of surveyed households

Variables	Definition of variables	Cereal farmers	Legume farmers
Gender of head	Gender of household head (1 = Male)	97.959	95.313
Household size	Household size	6.969	6.375
Age of head	Age of household head (years)	48.927	50.016
TLU	Tropical livestock unit	3.569	1.090
Non-farm business	Operate non-farm business(1 = Yes)	30.102	31.250
Area in hectares	Farm size of the household (hectares)	4.227	2.322
Extension services	Access to extension service (1 = Yes)	64.286	65.625

TABLE 2 Choice sets for the risk preference experiment and risk index

Choice	Payoffs [Fav:UnFav]	Classes	Cereal	Legume	EO	Open CRRA interval	CRRA mid-point
A	5000; 5000	Extreme	23.44	18.37	5000	$\alpha \leq Z \leq 2.5$	2.835
B	5500; 4600	Severe	14.06	12.76	5050	$2.49 \leq Z \leq 1.54$	2.015
C	6500; 4000	Moderate	23.44	26.02	5250	$1.53 \leq Z \leq 0.90$	1.215
D	8000; 3200	Intermediate	20.31	24.49	5600	$0.89 \leq Z \leq 0.71$	0.8
E	11 000; 2000	Slightly	10.94	12.24	6500	$0.70 \leq Z \leq 0.30$	0.5
F	16 000; 0	Neutral	7.81	6.12	8000	$0.29 \leq Z \leq -\alpha$	0.15

Abbreviation: EO, expected outcome.

3 | RESULTS

3.1 | General characteristics of respondents

All computations are conducted using R version 3.4.1. The descriptive statistics of the demographic characteristics of the cereal and legume farmers are compared in Table 1. The finding shows that approximately 98% of the cereal farmers are male, compared to 95% of the legume farmers. Thus, comparatively, there are more women in the production of legumes than cereals. This finding is not surprising as, according to Anang (2021), in Ghana, most of the activities in groundnut (peanut) production are carried out by women, and also, legumes are a major source of economic sustenance for women in rural Northern Ghana (Martey et al., 2015). The average cereal farm size was twice as much as the average legume farm size in the Northern region of Ghana. The plausible explanation is that cereal (maize) is the first food security crop grown in the savannah zones of Ghana (Nyantakyi-Frimpong & Bezner-Kerr, 2015), hence the dedication of more land to its production. Additionally, cereal farmers are somewhat younger and, relatively, have a larger household size than legume farmers. The large family size has been reported by the Ghana Statistical Service (2012) for the Northern region of Ghana and the justification for this large household is that family members provide labour for agricultural and related activities. The finding also shows that legume farmers have the most contact with agricultural extension farmers and own more non-farm businesses when compared to cereal farmers. Table 1 also shows that the average number of tropical livestock units owned by cereal farmers was thrice that of the legume farmers' survey. A probable reason for this finding could be the higher risk associated with cereal farming compared to legume farming.

3.2 | Hypothetical lottery choices

Only columns one (1) and two (2) of Table 2 were presented to the sampled household. By employing the CRRA method (Binswanger, 1980; Kouame & Komeman, 2012; Miyata, 2003), the hypothetical lottery choice responses show that cereal farmers (23%) are extreme-risk-averse compared to legume farmers (18%). Additionally, legume farmers (26%) are moderate-risk-averse compared to cereal farmers (23%), though cereal farmers (8%) in the Northern region are more risk-neutral compared to legume farmers (6%). Legume farmers (24%) were also found to be more intermediate risk averse than cereal farmers (20%). Additionally, the expected outcome, which is calculated as the average of the income from a favourable farming season and the income from an unfavourable farming season, indicates that as we move down the choices of the game, the expected outcome increases. This is an indication that a higher level of income is associated with a lower level of risk aversion whereas a lower level of income is associated with a higher level of risk aversion (see Table 2). This finding is in line with the empirical literature on smallholder farmers in developing countries being moderate- to extreme-risk-averse (Kouame & Komeman, 2012; Yesuf & Bluffstone, 2009).

TABLE 3 Mean score for cereal and legume farmers' risk sources

Variation of sources of risk		Cereal farmers Mean	SD	Rank	Legume farmers Mean	SD	Rank
Rainfall variability	Climate	4.234	1.162	1	4.198	1.145	1
Crop yield variability	Production	3.827	1.062	5	3.719	1.105	4
Crop price variability	Market	3.628	1.132	7	3.359	1.132	7
Fertiliser price variability	Market	3.745	1.055	6	3.641	1.2	6
Crop pest variability	Production	2.245	1.119	11	2.25	1.195	11
Wages paid to hired labour variability	Human	2.607	1.097	9	2.656	1.237	9
Effect of variation of crop yields on household income	Production	3.974	1.088	2	4.172	1.106	2
Effect of variation of crop prices on household income	Market	3.832	1.197	4	3.688	1.39	5
Effect of variation of fertiliser price on household income	Market	3.893	1.111	3	3.922	1.325	3
Effect of variation of crop pests on household income	Production	2.429	1.281	10	2.484	1.345	10
Effect of variation of wages paid to hired labour on household income	Human	2.837	1.25	8	2.75	1.414	8

3.3 | Perceptions of sources of risk

The third and sixth columns of Table 3 compare the average scores for cereal farmers and legume farmers. Rainfall variability was highly rated as the most important source of risk by maize (mean 4.234) and groundnut (mean 4.198) farmers. The effect of the variation in crop yields and fertiliser prices on household income stands out as the second and third most important sources of risk to both groups of farmers. The responses from the ranking further indicate that crop yield variability (mean 3.719) and the effect of the variation of crop prices on household income (mean 3.688) were ranked as the fourth and fifth most important sources of risk by legume farmers, respectively, as opposed to cereal farmers, who ranked the effect of the variation of crop prices as the fourth and crop yield variability as the fifth most important source of risk. Also, the result shows that climate, market and production risks, which are related to the variability associated with rainfall, fertiliser prices and crop yield, respectively, are the three top-rated sources of risk. This finding largely confirms the findings of most empirical literature (Bishu et al., 2018; Gebreegziabher & Tadesse, 2014). Since agriculture is the main source of income for farmers in developing countries and most of the savannah zone of Ghana, any risk associated with agricultural inputs and outputs greatly affects the livelihood of these farm families.

The exploratory factor analysis applied to the 11 risk sources using the varimax rotation indicated that three factors had an eigenvalue greater than one for both groups of farmers. The overall Kaiser–Meyer–Oklin (KMO) was 0.827 and 0.680 for cereal farmers and legume farmers, respectively, suggesting that the dataset was suitable for the conduct of factor analysis. The EFA for cereals and legumes identified three main factors, and these factors accounted for a total variance of 75.2% and 55.3% of the risk sources for cereal farmers and legume farmers, respectively. Additionally, variable loadings greater than 0.5 are interpreted and the varimax rotation shows that none of the variables had a communality of less than 0.25; hence, all variables are deemed as high and evaluated for interpretation (Hair et al., 2006).

According to Table 4, cereal farmers rate crop price variability and the effect and crop price variability highly; hence, factor 1 is labelled as market risk. Factor 2 is labelled production risk due to the relatively high loadings on crop pest effect on household farm produce and the crop yield variability. Furthermore, factor 3 is named climate risk due to the high loadings on rainfall variability. This finding confirms the literature in Northern Ghana which posits that cereals (maize) are essential for both home consumption and income source (Millennium Development Authority, 2010). Hence, its production and marketing are important to the rural cereal farmer. In addition, most studies

TABLE 4 Varimax rotated factor loadings of the risk sources of cereal and legume farmers

	Cereal farmers						Legume farmers					
Variation of sources of risk	**Market**	**Production**	**Climate**	**Communality**	**Cronbach alpha**	**KMO**	**Market**	**Human**	**Climate**	**Communality**	**Cronbach alpha**	**KMO**
Rainfall variability	**0.598**	0.094	**0.875**	0.863	0.800	0.783	**0.527**	**0.573**	**0.989**	**0.995**	**0.800**	**0.752**
Crop yield variability	0.214	**0.630**	**0.598**	0.520	0.810	0.757	0.327	−0.149	**0.614**	0.507	0.810	0.552
Crop price variability	**0.683**	0.081	0.380	0.485	0.800	0.872	0.138	0.312	**0.615**	0.495	0.800	0.661
Fertiliser price variability	0.448	0.120	0.135	0.432	0.810	0.879	**0.739**	0.286	0.155	0.425	0.820	0.585
Crop pest variability	0.251	**0.591**	0.077	0.573	0.810	0.816	0.118	**0.507**	−0.056	0.985	0.800	0.630
Wages paid to hired labour variability	0.091	**0.552**	0.138	0.566	0.820	0.798	0.281	**0.984**	1.000	0.415	0.800	0.664
Crop yield effect	**0.678**	0.228	**0.684**	0.692	0.790	0.849	**0.648**	0.239	**0.655**	0.502	0.790	0.744
Crop price effect	**0.722**	0.282	0.199	0.608	0.790	0.839	**0.733**	0.034	0.177	0.569	0.790	0.816
Fertiliser price effect	**0.644**	0.151	0.142	0.658	0.800	0.877	**0.791**	0.286	0.039	0.709	0.780	0.750
Crop pest effect	0.325	**0.652**	1.001	0.529	0.810	0.841	**0.527**	**0.571**	**0.518**	0.548	0.790	0.753
Wages paid to hired labour effect	0.066	**0.584**	**0.520**	0.558	0.820	0.755	0.411	0.221	0.122	0.432	0.800	0.536
SS loadings	2.013	1.501	1.461				2.268	1.958	1.857			
Proportion Var	0.383	0.236	0.133				0.206	0.178	0.169			
Cumulative Var	0.383	0.619	0.752				0.206	0.384	0.553			
Overall alpha					0.820						0.810	
Overall KMO						0.827						0.680
Eigenvalue	4.006	1.494	1.036				4.040	1.716	1.392			
Barlett sphericity (*p*-value)	1.33E-94						2.02E-33					

Note: Factor loadings greater than 0.50 are in bold.

Abbreviations: KMO, Kaiser–Meyer–Oklin; SS, sum of squared.

conducted in northern Ghana have shown that crop production, especially cereal production, is susceptible to climate change or changes in rainfall patterns (Nyadzi et al., 2021; Nyantakyi-Frimpong & Bezner-Kerr, 2015).

In the case of legume farmers, there were relatively high loadings of the fertiliser price variability, the effect of the variation of fertiliser price and crop price on household income; hence, factor 1 is named market risk, while factor 2 is called human risk because of the significant loadings on the variation in the wages paid to high labour and the effect of the high variation in the wages paid to hired labour. Also, factor 3 is labelled climate risk due to the high loadings on rainfall variability. Most legumes produced are used for commercial purposes (Technoserve, 2009); hence, fluctuations in yield prices affect farm households. A possible reason for the importance attached to human risk is that the harvesting and post-harvesting activities associated with legumes are labour-intensive, that is, the variability of the wage paid to hired labour and its effect on household income is very high (Asravor, 2018a). In addition, rainfall variation significantly affects yields and farm outputs in the northern part of Ghana because agriculture is usually rain-fed.

3.4 | Perceptions of risk management strategies

The five-point Likert scale on the most important perceived risk management strategies for both groups of farmers is presented in Table 5. On average, all groups of crop farmers top-rated the spread of sales over time as an indicator that this strategy is the most important risk management strategy for cereal and legume farmers. In agriculture, prices are subject to strong fluctuations, so spreading sales over a period helps farmers cash-in on price increases during cereal and legume shortages within the market (Assouto et al., 2020). Apart from the spread of sales over the period, the ranking of the risk management strategy varied between the cereal farmers and legume farmers in the savannah zone of Ghana. For instance, growing different crops and storing feed or seed reserves were ranked as the second and third most important risk management strategies by cereal farmers, whereas legume farmers ranked working off-farm to supplement household income and keeping livestock stock as the second and third important risk management strategy. This finding is confirmed by Asravor (2021), who indicated that farmers in Northern Ghana manage risk using off-farm strategies.

The exploratory factor analysis was further used to evaluate crop farmers' perceptions of risk management. The eigenvalue indicates that two factors were sufficient in explaining the underlying perception of both groups of farmers' risk management strategies and Cronbach alpha values of 0.93 and 0.95 for cereal and legume farmers,

TABLE 5 Mean score for cereal and legume farmers risk management strategies

		Cereal			Legume		
Stabilising household income:	**Type of strategy**	**Mean**	**SD**	**Rank**	**Mean**	**SD**	**Rank**
Spread sales over time	Farm prod.	3.643	1.291	1	3.453	1.447	1
Work off-farm as a supplement	Off-farm	3.138	1.319	8	3.188	1.511	2
Invest in a non-farm business	Off-farm	3.005	1.299	10	3.156	1.45	12
Have livestock on a farm	Diversification	3.179	1.349	7	2.906	1.466	3
Choose crop varieties with lower price variability	Diversification	3.082	1.266	9	3.031	1.414	4
Choose crop varieties with lower yield variability	Diversification	2.923	1.336	11	2.953	1.408	8
Reduce debts	Financial mgt.	3.383	1.305	4	3.422	1.445	11
Store feed or seed reserves	Farm prod.	3.434	1.407	3	3.438	1.5	7
Grow different crops	Farm prod.	3.469	1.318	2	3.266	1.461	6
Sign rainfall insurance	Insurance	2.561	1.396	12	2.641	1.505	5
Save cash	Financial mgt.	3.352	1.375	5	3.141	1.468	9
Save asset	Financial mgt.	3.347	1.419	6	3.219	1.578	10

respectively, indicated that there was internal consistency, that is, the items on a test measure the same construct very well (Table 6). Additionally, the KMO measure of sampling adequacy was found to be 0.899 for cereal farmers and 0.893 for legume farmers, and the Bartlett sphericity test result was highly significant ($p < 0.001$). The factor analysis showed that the two factors explained 61.6% and 64.5% of the total variance in the measure of the risk management strategy of the cereal and legume farmers, respectively. Table 6 shows that factors 1 and 2 of the risk management strategies of the cereal farmers should be labelled off-farm strategy and production strategy, respectively.

Factor 1 loads highly on stabilising household income by working off-farm to supplement household income and investing in non-farm businesses, while factor 2 loads highly on using stored feed or seed reserved, growing different crop varieties and spreading sales over time to stabilise household income. It is not surprising that the factor analysis revealed that cereal farmers view production strategy as an essential risk management strategy since the wider land area is used for the cultivation of legumes and households store feed or seed reserves to manage the risk that they encounter during the farming season. This finding has been confirmed by Assouto et al. (2020) for smallholder farmers in Benin and Asravor (2021) also gave similar reports for the smallholder farmers in the northern region of Ghana. For instance, Asravor (2021) suggested that off-farm activities serve as an important strategy for farmers in northern Ghana due to the falling crop yields these farmers are experiencing. According to the legume farmers, financial strategy and off-farm strategies are the two essential risk management strategies they employ to manage the risk they encounter. Factor 1 is labelled financial strategy due to the high loadings on using saved cash and savings in assets to manage the risk sources and stabilised household income. Additionally, legume farmers found working off-farm and investing in non-farm businesses to stabilise household income as essential risk management strategies; hence, factor 2 is labelled off-farm strategy. According to the MoFA (2012), legume is one of the essential commercial crops cultivated in Northern Ghana, and, by extension the Northern region, it is therefore not surprising that households in the production of legume can depend on their saved cash as a risk management strategy.

3.5 | Perceptions of risk concerning farm and farmer characteristics

Before the conduct of the linear regression analysis to assess the relationship between the range of farm and farmer characteristics, the risk attitude and perception, the diagnostic test performed showed the absence of multicollinearity among the explanatory variables. The Ramsey RESET test performed for the ordinary least square shows that there is no misspecification issue (Table 7). On the contrary, the bptest test shows the presence of heteroscedasticity in the model for production risk of the cereal farmers; hence, robust standard errors are reported for this model. The descriptive statistics of the linear regression show that the goodness of fit measure of the models is low to moderately high and all the models are statistically significant (Table 7).

The regression model of the cereal farmers indicates that compared to farmers with a lower number of livestock, the cereal farmers who owned a higher number of livestock perceived market risks to be greater. This finding was similar to that finding of Bishu et al. (2018) for the Tigray area of Ethiopia. A plausible reason for this finding is that cereal farmers having larger livestock are able to hedge against market risk compared to those with little livestock. Furthermore, extreme and severe risk aversions have a positive and significant market, production and climate risk effect for cereal farmers, suggesting that compared with risk-neutral cereal farmers, extreme- and severe-risk-averse cereal farmers perceive market, production and climate risks to be greater. Also, compared with risk-neutral cereal farmers, moderate-risk-averse cereal farmers consider production and climate risks to have a larger significant effect on them than risk-neutral cereal farmers. Similarly, intermediate risk aversion is positively associated with market risk, while larger household size is associated with higher production and climate risks.

Furthermore, compared with female household heads, male household heads perceived production risk as less important. Possibly, male cereal farmers have multiple sources of income compared to female cereal farmers. Additionally, older cereal farmers perceived production and climate risk as more important than younger cereal farmers.

TABLE 6 Varimax rotated factor loadings of the risk management strategies of cereal and legume farmers

	Cereal					Legume				
	Off-farm	Production	Communality	Alpha	KMO	Finance	Off-farm	Communality	Alpha	KMO
Stabilising household income										
Spread sales over time	0.324	**0.642**	0.518	0.92	0.928	0.529	0.418	0.454	0.94	0.899
Work off-farm as a supplement	**0.668**	0.412	0.615	0.92	0.92	0.315	**0.91**	0.928	0.94	0.853
Invest in a non-farm business	**0.745**	0.319	0.657	0.92	0.9	**0.52**	**0.775**	0.87	0.94	0.876
Have livestock on a farm	**0.645**	0.472	0.639	0.92	0.966	**0.578**	0.475	0.559	0.94	0.978
Choose crop varieties with lower price variability	**0.615**	**0.529**	0.658	0.92	0.895	**0.643**	0.389	0.565	0.94	0.884
Choose crop varieties with lower yield variability	**0.541**	0.48	0.523	0.92	0.875	**0.6**	0.3	0.45	0.94	0.863
Reduce debts	**0.582**	**0.56**	0.652	0.92	0.899	**0.655**	0.418	0.604	0.94	0.915
Store feed or seed reserves	0.11	**0.882**	0.79	0.92	0.849	**0.509**	0.433	0.447	0.94	0.887
Grow different crops	0.232	**0.823**	0.731	0.92	0.885	**0.724**	0.35	0.647	0.94	0.878
Sign rainfall insurance	**0.552**	−0.062	0.309	0.94	0.871	**0.638**	0.348	0.528	0.94	0.906
Save cash	**0.646**	**0.524**	0.692	0.92	0.898	**0.887**	0.306	0.88	0.94	0.914
Save asset	**0.625**	0.472	0.614	0.92	0.886	**0.817**	0.378	0.81	0.94	0.876
SS loadings	3.71	3.687				4.829	2.913			
Proportion Var	0.309	0.307				0.402	0.243			
Cumulative Var	0.309	0.616				0.402	0.645			
Overall alpha				0.93					0.95	
Overall KMO					0.899					0.893
Eigenvalue	6.88318	1.29062				7.58625	1.866209			
Barlett sphericity	2.116342e-312					6.00E-94				

Abbreviations: KMO, Kaiser–Meyer–Oklin; SS, sum of squared.

TABLE 7 Results of multiple regressions for risk sources

	Cereal farmers						Legume farmers					
	Market risk		Production risk		Climate risk		Market risk		Human risk		Climate risk	
	Estimate	Std. error	Estimate	Robust std. error	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
Intercept	−0.636	0.489	0.466	0.436	0.068	0.353	−1.175*	0.643	0.184	0.947	0.807	0.974
Sex of the head	0.198	0.350	−0.646***	0.228	0.223	0.167	0.588*	0.313	0.301	0.664	0.690	0.683
hhSize	0.026	0.035	0.057*	0.030	0.071*	0.037	−0.032	0.075	−0.054	0.068	0.087	0.070
Age of the head	0.002	0.005	0.015***	0.005	0.017**	0.004	−0.026**	0.011	−0.019**	0.007	−0.002	0.012
TLU	0.086**	0.043	0.065	0.070	−0.026	0.069	−0.058	0.171	0.161	0.188	0.536***	0.194
Non-farm	−0.138	0.120	0.050	0.111	−0.107	0.136	0.620**	0.275	−0.346	0.280	−0.846***	0.288
Farm size	−0.026	0.018	−0.010	0.017	0.042*	0.025	−0.074	0.088	0.028	0.102	0.096	0.105
Agric. extension	0.096	0.131	0.121***	0.023	0.168***	0.040	0.842***	0.249	1.168***	0.193	−0.236	0.282
Risk aversion												
Slight	0.385	0.290	0.350	0.322	0.205	0.250	1.384***	0.469	−0.022	0.517	1.600***	0.457
Intermediate	0.023	0.257	0.593**	0.279	0.033	0.234	1.237**	0.521	0.678	0.514	0.979**	0.391
Moderate	−0.036	0.263	0.779***	0.283	0.271***	0.087	1.196**	0.468	1.319**	0.509	0.710**	0.341
Severe	0.574**	0.241	0.654**	0.312	0.414***	0.071	1.021*	0.434	1.041**	0.423	1.244***	0.262
Extreme	0.206***	0.068	0.593**	0.292	0.026***	0.005	1.153***	0.482	0.020**	0.008	1.572***	0.295
R-squared	0.273		0.213		0.295		0.388		0.492		0.478	
F-stat. (*p*-value)	3.734(8.643e-07)		4.176(1.48e-05)		4.602(8.771e-08)		4.257(4.519e-07)		4.750(2.212e-08)		5.094(1.368e-11)	
Bptest (*p*-value)	12.85(0.380)		24.977(0.014)		24.865(0.016)		16.35(0.231)		7.513(0.874)		18.282(0.147)	
RESET (*p*-value)	1.261(0.286)		0.057(0.945)		0.454(0.636)		0.839(0.441)		0.299(0.7438)		0.761(0.475)	

Abbreviation: TLU, tropical livestock unit.

Variables and models are significant at.

*$p < 0.10$,

**$p < 0.05$,

***$p < 0.01$.

This is plausibly because older cereal farmers might not have other sources of income-generating activities and hence are worse affected by production risk compared to younger cereal farmers. This finding reaffirms those reported by Asravor (2021), who suggested that older farmers do not have the energy to pursue other livelihood options aside from farming and hence might perceive production risks as very important. Access to agricultural extension services was found to have a positive and significant effect on production and climate risk. This suggests that compared with cereal farmers who have access to extension services, cereal farmers who have access to extension services perceive production risk as more important.

The model on the risk perception of legume farmers indicates that compared with younger farmers, older legume farmers perceive market and human risk as less important. This may be because older legume farmers usually produce for home consumption in the market when compared to younger legume farmers who grow leguminous crops with commercialisation in mind. The results of this study also suggest that extreme, severe and moderate risk aversions are positively and significantly related to market, human and climate risks for risk-neutral legume farmers. This is an indication that intermediate-risk-averse legume farmers perceived market risk as more important than risk-neutral household heads. Likewise, compared with risk-neutral households, slight- and intermediate-risk-averse households view market and climate risks as more important. Households with non-farm businesses value market and climate risks more compared with those who do not own a non-farm business, whereas legume farmers with more livestock value climate more compared with legume farmers with fewer livestock. Finally, legume farmers who have access to agricultural extension services are found to perceive human risk as more important compared with legume farmers who do not have access to agricultural extension services. This finding shows that agricultural extension services provide farmers with the opportunity to reduce the amount of money spent on hiring labour for legume cultivation.

3.6 | Perception of risk management strategies concerning farm and farmer characteristics

Similar to the previous analysis, the linear regression model was used to assess the relationship between risk perceptions, risk attitudes and farm and farmer characteristics. The diagnostics test suggests the absence of multicollinearity. Aside from farm production management strategies under cereal production, all models did not show the absence of heteroscedasticity (Table 8). The coefficient of the Ramsey RESET test is not significant, implying that evidence of model misspecification is not found (Table 8). Like the regression model on risk perception, a number of socio-economic variables had significant effects on risk management strategies. In spite of this, the risk management strategies had more significant variables than the risk perception models. Similar findings have been reported by Flaten, Lien, Koesling, Valle and Ebbesvi (2005) among organic and conventional dairy farming from Norway.

The results of the model for cereal farmers showed that the slight-, intermediate-, moderate-, severe- and extreme-risk-averse cereal farmers perceived production management strategies and off-farm management strategies as more relevant than risk-neutral farm households and off-farming related risk management strategies. This implies that as risk aversion of the cereal farm households increases these households tend to increase their engagement in production-related risk management strategies. This finding is consistent with Meraner and Finger (2019), who identified risk averse livestock farmers in Germany to be actively engaged in an on-farm management strategy. Furthermore, this result also confirms (Flaten et al., 2005; Hellerstein et al., 2013; Menapace et al., 2016) that risk-averse farmers are more likely to apply on-farm risk management strategies than market-based risk management strategies.

Market, human and climate risks were also found to be highly associated with production risk management strategies and off-farming management strategies. This finding contradicts the finding of Meraner and Finger (2019) who found a high perception of market risks to be associated with a decreased probability of farmers focussing on on-farm agricultural risk management strategies compared to off-farm strategies. In the case of this study, most cereal-producing farm households view the production of cereal as an important food security staple, hence the

TABLE 8 Multiple regression analysis for the perceived risk management strategies

	Cereal				Legume			
	Farm production		Off-farm		Financial mgt.		Off-farm	
	Estimate	Robust std. error	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
Intercept	0.876*	0.471	1.132*	0.605	1.136*	0.643	−0.697	0.846
sexHeadMale	−0.218	0.363	−0.606	0.521	−0.537	0.605	1.478*	0.759
hhSize	0.003	0.034	−0.006	0.033	−0.041	0.037	0.159**	0.065
ageHead	0.018***	0.005	−0.010***	0.002	0.004	0.006	0.008	0.009
asinh (TLU)	0.080	0.071	0.019	0.078	0.141**	0.067	−0.040	0.210
Non-farm business	−0.065	0.146	0.076**	0.036	−0.022*	0.136	0.464***	0.138
areaHectare	−0.038	0.023	−0.103***	0.018	−0.029**	0.014	0.068	0.100
Extension	−0.137	0.128	0.038	0.135	−0.148**	0.070	−0.033	0.332
Risk aversion								
Slight	0.172**	0.071	0.077***	0.013	−0.165	0.260	0.567***	0.126
Intermediate	0.192***	0.011	0.279***	0.103	0.434**	0.215	0.474***	0.168
Moderate	0.155***	0.026	0.426***	0.112	0.283	0.217	0.157***	0.012
Severe	0.254**	0.110	0.277***	0.031	0.664***	0.249	0.090	0.422
Extreme	0.212***	0.032	0.040***	0.007	−0.003	0.006	0.440**	0.163
Risk sources								
Climate risk	0.357**	0.080	0.287***	0.077	0.678***	0.226	0.358**	0.148
Market risk	0.193**	0.074	0.160**	0.080	0.152*	0.087	0.133**	0.050
Human risk					0.165**	0.082	0.315**	0.123
Prod. risk	0.180***	0.050	0.253***	0.071				
Multiple *R*-squared	0.316		0.352		0.325		0.412	
F-statistic (*p*-value)	3.301(7.076e-05)		2.986(0.0002)		4.81(2.212e-08)		4.356(2.928e-07)	
Bptest (*p*-value)	33.674(0.004)		14.802(0.539)		18.927(0.217)		18.276(0.308)	
RESET (*p*-value)	1.478(0.231)		1.168(0.314)		2.093(0.135)		0.139(0.871)	

Abbreviation: TLU, tropical livestock unit.
Variables and models are significant at
*$p < 0.10$,
**$p < 0.05$, and
***$p < 0.01$.

possibility of increasing its cultivation (Ministry of Food and Agricultural, 2012). Further, climate risk affects farmers in northern Ghana due to their over-dependence on the weather, hence the higher management strategies.

Furthermore, compared with younger cereal farmers, older cereal farmers perceive off-farm management strategies as less important ($p < 0.01$) but perceive farm production as more important than younger cereal farmers. This finding is consistent with numerous empirical studies (Flaten et al., 2005; Meraner & Finger, 2019; van Winsen et al., 2016). Younger cereal farmers are more energetic and hence are more likely to apply off-farm risk management strategies compared to older farmers who prefer on-farm agriculture-related risk management. Additionally, engagement in non-farm activities is positively and highly significantly associated with the off-farm strategy. This suggests that cereal farm households that own a non-farm business perceived an off-farm strategy as an important source of income. Table 8 also shows that cereal farmers who own larger farms perceive off-farm management strategies as highly unimportant ($p < 0.01$). Possibly having a larger farm implies that a household devotes much attention to the activities on the farm, hence the limited importance attached to off-farm risk management strategy.

Off-farm risk management strategies are found to be more important risk management tools for slight-, intermediate-, moderate-, severe- and extreme-risk-averse cereal farmers than risk-neutral cereal farm households. This implies that compared to risk-neutral cereal cultivating farm households, slight-, intermediate-, moderate-, severe- and extreme-risk-averse cereal farmers view extra income sources from off-farm risk management strategies as very essential. Additionally, cereal farmers who perceived climate, market risks and production as important emphasised off-farm risk management strategies as important risk management strategies ($p < 0.01$).

From the legume farmers' perspective, the two main factors identified are financial management and off-farm management. The finding shows that households who own non-farm businesses perceive managing risk by using a financial risk strategy as less relevant but managing risk using an off-farm business strategy as very important or relevant. Additionally, an increase in the area cultivated by the household is associated with increasing financial management strategies. This implies that legume-cultivating households view financial risk management strategy as highly important because legume cultivation (harvesting and post-harvesting) is labour-intensive; hence, households involved in legume cultivation are more likely to rely on their personal funds.

The results in Table 8 also show that legume farmers perceived financial management as an important strategy to manage human risk ($p < 0.001$), market risk ($p < 0.05$) and climate risk ($p < 0.10$). This suggests that as human and market risk perceptions of legume farming households increase, these households tend to increase their effort at managing these risks using financial management strategy. Off-farm management strategies were also used by legume farmers to manage climate, market and human risks. Furthermore, legume farmers who have access to agriculture extension perceived financial management strategies as unimportant risk management strategies. Possibly, agricultural extension services provide legume farmers with the knowledge that helps reduce the risk associated with legume cultivation and the funds needed, hence the decrease in the risk. Financial management is perceived as a more relevant risk management strategy by intermediate- and severe-risk-averse legume farm households than by risk-neutral legume farm households, according to the study.

Table 8 also shows that male household heads and larger farm households manage risk using off-farm strategies. Similar to the result of the cereal-producing farm households in the Northern region, legume farm households owning non-farm businesses perceive the utilisation of off-farm management strategies as very important. Additionally, except for severe-risk-averse farmer households, extreme-, slight-, intermediate- and moderate-risk-averse households perceive off-farm management strategies as important strategies for managing risk. This finding is consistent with the findings of Menapace et al. (2016) and Meraner and Finger (2019). The regression model also indicates that the perception of human risk and market risk was significantly associated with the utilisation of an off-farm management strategy.

Among cereal and legume farmers, an increase in climate risk increases the risk management strategies adopted for all strategies. Interestingly, climate risk had the highest coefficient compared to the other risk sources (market risk, human risk and production risk), as indicated in Table 8. This points to the fact that risk related to rainfall variability greatly affects the farm practices of the farmers in the northern region of Ghana. Consistent with this study, Nyadzi et al. (2021) and Asravor (2021) found that rainfall variability is a problem for Ghanaian farmers, particularly rainfed farmers in the northern part of the country who are impacted by these changes, hence the adoption of various management strategies.

4 | CONCLUSION

An understanding of smallholder farmers' risk perceptions, risk preferences and risk management strategies is important in the design of policies that are targeted at helping smallholder farmers. In this paper, the hypothetical lottery choice question was used to measure the degree of cereal and legume farmers' risk aversion, while the five-point Likert scale was used to identify the most important perceived sources of risk and risk management strategies for both groups of farmers. The findings of the study provide new insight into the different relationships between the risk sources of cereal farmers (market, production and climate risk) and legume farmers (market, climate and human risk) and risk management strategies adopted by these two groups of farmers, hence extending and adding to the existing empirical literature. The study shows that the main sources of risk to both farmers are those related to the market, such as price variations in crops and fertiliser and those related to the climate, such as rainfall variability.

The results suggest that cereal farmers are more risk-averse (extreme to severe) than legume farmers. Both groups of farmers perceived rainfall variability, the effect of the variation in crop prices and fertiliser prices on their household income as the three primary sources of risk faced in their cereal farming activities. Spreading of sales over time was perceived as the most important risk management strategy. Aside from the spread of sales over time, cereal farmers perceived the growing of different crops, the storing of feed or seed reserves and the reduction of debts as more important risk management strategies, while legume farmers perceived working off-farm to supplement household income, having livestock on-farm and choosing crop varieties with lower price variability as more important. Both groups of farmers apply multiple risk management strategies to combat the perceived risk sources identified.

The factor analysis shows that three out of the 11 perceived risk sources are important to both cereal and legume farmers. Also, two out of 12 risk management strategies are important to both groups of farmers. Apart from market risk, cereal farmers perceived production risk as an important factor, while legume farmers perceived human risk as an important risk factor. The factor analysis revealed that the off-farm strategy was the common risk management strategy to both groups of farmers, aside from the production management strategy, which was important to cereal farmers, and the financial management strategy, which was essential to legume farmers.

The findings show that a number of socio-economic variables and risk aversion characteristics have significant effects on risk perceptions and management strategies of both cereal and legume farmers. More importantly, all categories of risk aversion, climate and market risks positively and highly significantly affect the management responses of both cereal and legume farmers in the Northern region of Ghana. Production risk positively and significantly affects the off-farm strategies of cereal farmers, while human risk significantly affects the financial and off-farm strategies of legume farmers.

The study recommends that to reduce risk, strategies formulated should separately target the specific socio-economic characteristics and the risk attitudes of each group of farmers. The importance attached to market and climate risks by both groups of farmers implies that policy design for the alleviation of poverty among both groups of farmers should be focussed on reducing climate and market risks associated with crop farming activities. That is, policies targeting market risk should focus on how to make inorganic fertiliser affordable to both groups of farmers while adopting management strategies against the variability of the weather should be encouraged. Additionally, the importance of the use of the off-farm management strategy for risk management implies that policymakers can create more income-generating opportunities for rural households by targeting the off-farm sector. In order to help farmers, overcome the risk associated with crop price variation, it is suggested that government can introduce a price floor such as a guaranteed minimum. Furthermore, policymakers can introduce a market price stabilisation scheme, such as price support as this will guarantee stable prices for these farm households and ensure reasonable income. Finally, the provision of timely weather information will let farmers know when to plant their legumes and cereals.

DATA AVAILABILITY STATEMENT

Due to commercial embargo data cannot be shared.

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