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# Smallholder farmers' risk perceptions and risk management responses

## Evidence from the semi-arid region of Ghana

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Farmers' risk perceptions and risk management

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### Abstract

**Purpose** – The purpose of this paper is to identify the perceptions of farmers on the major sources of risk and to examine the effectiveness of the risk management responses of rural smallholder farm households in the semi-arid region of Northern Ghana from the socioeconomic perspective.

**Design/methodology/approach** – Both descriptive statistics and exploratory factor analysis were used on a Likert scale question to rank and identify the important risk perceptions and management strategies of the farmers. The linear regression model was used to highlight the significant factors that affect the farmers' risk perception and management responses.

**Findings** – The effects of the variations in crop yield, fertiliser prices and crop price on household income were perceived as the three most relevant sources of risk. Stabilising household income by growing different crops, storing feed/seed reserves and spreading sales were the most effective risk management strategies. Factor analysis identified market risk, production risk and human risk as major risk factors whereas diversification, financial strategy, and off-farm employment were perceived as the most effective risk management strategies. Farm and farmer characteristics were found to be significantly associated with risk perceptions and risk management strategies. Risk perceptions significantly increase the risk management strategy adopted by the smallholder rural farmers.

**Practical implications** – The findings of the paper call for the integration of farmers' risk perceptions and management strategies in the development of agricultural policies for the semi-arid regions of Ghana.

**Originality/value** – This paper deviates from the traditional technology adoption studies by modelling rural household perceptions and management strategies using, using descriptive, factor analyses, and linear regression.

**Keywords** Risk management, Factor analysis, Risk perception, Semi-arid region

**Paper type** Research paper

### 1. Introduction

Undeniably, the agriculture sector of most countries faces more risk than the industrial and service sectors (Maurer, 2014; Deressa *et al.*, 2009). In developing countries, the performance of the agriculture sector is generally uncertain (Aditto *et al.*, 2012; Di Falco and Veronesi, 2014), due to the exposure of the sector to a variety of risks and biotic and abiotic factors. Risk and uncertainty do not only impact households' production decisions but also their consumption and welfare decisions. Though numerous normative analyses have been done on how farmers should behave under risk and uncertainties (Canagarajaha *et al.*, 2001; Bergfjord, 2009), less empirical studies have been conducted on how farmers perceive these risks and how these perceptions influence their management strategies (Meraner and Finger, 2017; Bishu *et al.*, 2016).

According to Flaten *et al.* (2005), farmers' perceptions of and responses to risks are vital towards understanding their risk behaviour. The risk perceptions of farmers influence their risk-taking behaviour (Koesling *et al.*, 2004). Hence a comprehension of farmers' risk perceptions is important in helping farmers make better and informed decisions relating to the risky agriculture businesses. Added to this, an understanding of farmers' risk perceptions and risk management strategies is essential for the proper formulation of



appropriate policy to help overcome the perennial risks associated with the farming business. Most empirical studies on risk perceptions and management responses of farmers have either focussed on livestock farmers (Bishu *et al.*, 2016; Flaten *et al.*, 2005; Meuwissen *et al.*, 2001) or aquaculture (Bergfjord, 2009; Ahsan and Roth, 2010). Little studies have been conducted on rainfall dependent smallholder crop farmers (Aditto *et al.*, 2012; Koesling *et al.*, 2004) in developing countries, though these groups of farmers dominate the agricultural sector of developing countries and contribute significantly towards the GDP of their respective countries.

For instance, in Ghana, agriculture contributed 21.5 per cent to the nation's GDP in 2014 (MoFA, 2015) and it is the mainstay of the rural Ghanaian economy (GSS, 2014). In many rural communities of Ghanaian rain-dependent crop farming is the most important and only source of employment and household income (MoFA, 2015). Within the rural settings of Ghana, the semi-arid region of Ghana has almost 90 per cent of its rural population engaged in crop farming (GSS, 2014). It is noted to be the hub of legumes and cereal production, and fundamentally covers about 40 per cent of the total agricultural land of the country. The semi-arid region of Ghana is among the poorest regions, the hardest hit by climate related production risk (MoFA, 2012) and the most food insecure region.

Like other agri-businesses, crop farming in the rural semi-arid communities is associated with production, marketing, human, institutional and financial risks. Most of these risks are unknown to these rain-dependent crop farmers before the farming season but are anticipated based on their perceptions and past experiences. These perceptions influence the perceived risk management strategies and the frantic effort made to manage risk. As reiterated by Gebreegziabher and Tadesse (2014) and Legesse and Drake (2005), farmers make decisions based on what they think is likely to occur, and sometimes based on what they fear or hope is possible. Thus, the actual risk management strategy of a farmer begins with the perception of risk and the perceived risk management strategy.

In order to understand the risk behaviour of rural households, it is essential to investigate smallholder farmers' perceptions and responses to risks. As indicated by Ahsan and Roth (2010) and van Winsen *et al.* (2016), an individual's perception of risk influences his or her investment and business decisions on the farm. Despite the importance of risk perceptions and management strategies to the farming decisions of rural rain-fed smallholder in the semi-arid regions of Ghana, empirical studies are lacking. To the very best of my knowledge, no empirical studies have been explicitly conducted on the risk perceptions and risk management strategies of smallholder farmers in Ghana and more specifically the risk prone area of rural semi-arid regions of Ghana. An understanding of the risk perception and risk management strategies of smallholder rain-dependent crop farmers are essential preconditions for devising risk reducing strategies (Legesse and Drake, 2005; Hardaker *et al.*, 2004). Therefore, ignoring the risk perceptions of smallholder farmers can lead to a significant overestimation of the input demand and the output supply elasticities (Meraner and Finger, 2017; Menapace *et al.*, 2016).

Based on this gap and the relevance of risk perceptions and management strategies to smallholder households, the paper contributes to the extant empirical literature by providing empirical insight into, farmers' perceptions of the most important sources of risk and risk management through the use of an exploratory and descriptive analysis; and examine the interrelationship between farm and farmer characteristics, and household risk perceptions and risk management strategies, using the linear regression model. The succeeding sections focus on the extant literature on the risk perception and risk management strategies (Section 2), the material and methods (Section 3), analysis and methods of estimation (Section 4), results and discussions (Section 5), and the summary, conclusion and policy recommendations (Section 6).

## 2. Literature review

Several theories have been adopted to explain risk perception and the subsequent decisions taken to manage these perceived risks. Common theories relating to risk perceptions and management strategies are the protection motivation theory (PMT), risk compensation/risk homeostasis theory and the situated rationality theory. The PMT is one of the most cited theories in the academic literature. The main arguments of this theory is that individuals are very likely to protect themselves from any form of risks when they anticipate adverse consequences, have the yearning of avoiding these negative consequences and are capable of taking preventive measures. Thus, the perception of risk and the management of risk increases when there is a reason for concern (Gucer *et al.*, 2003; DeJoy, 1996). On the other hand, the risk compensation/risk homeostasis theory indicates that individuals take risk when they feel a greater sense of security. Consequently, safety measures or the management strategies adopted depends on the risk perceptions and risk-taking behaviour of such individuals (Wilde, 1994). The situated rationality theory also suggests that it is a flaw to assume that safe behaviours are fundamentally rational and high-risk behaviours are intrinsically irrational. In other words, there is a possible rational explanation for choosing to take risks that is more expounding than assuming that a risk-taker is simply thrill-seeking (Cafri *et al.*, 2009).

In this study, the researcher assumes that anticipated risk influences the management strategies adopted by the farm household, hence the PMT theory is adopted by this study. Empirically, the issue of risk perceptions and management strategies have been shown to have strong industry and regional connotations (Flaten *et al.*, 2005; Legesse and Drake, 2005). Other studies have identified the farm type, the operational environments of farmers, the geographical locations, institutional structures as prime determinants of risk perceptions and risk management strategies of farmers (Meuwissen *et al.*, 2001; Bishu *et al.*, 2016).

Numerous studies exist in the developed countries that have examined the risk perception and management strategies of farmers. For instance in the mid-1990s, Martin (1996) opined that price risk and rainfall variability was ranked highest by dairy farmers in New Zealand, and routing spreading, drenching and maintaining feed reserves were the strategies used to manage these risk. Dutch livestock farmers ranked price and production risks as the two most important risk sources met by the production at lowest possible costs and insurance (Meuwissen *et al.*, 2001). According to Sonkkila (2002), Finnish farmers considered changes in agricultural policy as the most important risk factor, whereas maintaining enough liquidity and solidity was ranked as the most important management response.

Ahsan and Roth (2010) empirically investigated the risk perception and management strategies of mussel farmers in Denmark using the exploratory factor analysis. Future prices, changes in public regulations and demand for mussels were highly-ranked as the perceived risks while bad weather, harmful algal blooms, oxygen depletion, E. coli, public views towards mussel culture and change in government regulations were considered as important risk factors in mussel farming. Producing at the lowest possible cost, maintaining good relations with the government, cooperative marketing, liquidity, experience sharing and adoption of new technology were perceived as the most important risk management strategies.

According to Le and Cheong (2010), Vietnamese catfish farmers perceive price and production risks as the most significant risks while farm management and technical measures were perceived to be the most effective risk management strategies for risk reduction. Despite price risk being top rated, price risk management strategies were not perceived as important measures for risk mitigation. Meraner and Finger (2017) found that higher level of risk perception, age, subjective numeracy, farm succession, farm size and the proportion of rented land significantly impact the risk management strategies of livestock farmers' in the German region of North Rhine-Westphalia.

In Sub-Saharan Africa, quite a number of studies have been conducted on risk perceptions and risk management strategies with each yielding varied results. A bulk of these studies have been conducted in Ethiopia and on livestock farming (Bishu *et al.*, 2016; Gebreegziabher and Tadesse, 2014; Legesse and Drake, 2005). Legesse and Drake (2005) found human capital, household characteristics, orientation, infrastructure, access to resources, information and environmental factors to be influential in shaping the perceptions of risks among smallholder farmers in Eastern Highlands of Ethiopia. Additionally, the authors found from the logistics analysis that locational settings, livelihood diversification strategies and asset endowments were important in determining the perceived risk management strategies of these smallholder farmers.

Bishu *et al.*'s (2016) analysis of cattle farmers in the Tigray area of Northern Ethiopia showed that the shortage of family labour, the high price of fodder and limited farm income were perceived as the most important risks. The use of veterinary services, parasite control and loan utilisation were perceived as the most important strategies for managing risks. Gebreegziabher and Tadesse (2014) also focussed on livestock farmers in the Tigray area of Northern Ethiopia. From the factor analysis, the researchers found technological, production, financial, price/market, human and institutional factor were the major sources of risks whereas diversification, disease reduction, financial management and market network are perceived as the most effective risk management strategies in Northern Ethiopia. Surprisingly, most dairy farmers considered themselves risk takers towards farm decision and hence have a positive impact on technology adoption.

In their study of the risk perception and risk management strategies of 200 smallholder farmers in the KwaZulu-Natal Province of South Africa, Kisaka-Lwayo and Ajuruchkwu (2012) found that production, price or market, and financial risks were perceived as the most important sources of risk by these smallholder farmers. The most important traditional risk management strategies used by these farmers were crop diversification, precautionary savings and participating in social networks.

According to Aditto *et al.* (2012), the increasingly worrying sources of risk to Thai farmers are the uncertainty of product prices, input prices (market risk), diseases, pests affecting plants and animals, natural disasters and excess rainfall (production risks). The Thai farmers ranked the following as important strategies to manage risk: the storing feed and/or seed reserves, having a farm reservoir for water supplies in dry the season, holding cash and easily converted cash assets and working off-farm to supplement household income. Thus, production, off-farm and financial strategies were viewed as important strategies than marketing strategies.

### 3. Materials and methods

#### 3.1 Study area and sampling technique

The research involved face to face interviews with sampled cereals and legumes smallholder farmers from Northern Ghana. The choice of the semi-arid region of Ghana was because it is the most vulnerable to climate risk and the poorest regions in Ghana (GSS, 2014). The semi-arid region of Ghana is made up of the Northern region, Upper East and Upper West region. It is the regions with the most rain-fed farmers yet the regions with the unimodal rainfall as well as the least amount of rain (900 mm).

The multistage sampling technique was used to sample 500 farmers from 12 districts and 5 communities within each of the districts. The first stage involved purposively selecting the semi-arid regions of Ghana since it is the most risk prone region in Ghana. The second stage involved using the simple random sampling technique to sample cereals and legumes farmers in the various communities. To ensure homogeneity and heterogeneity within the sample, the final stage involved using the clustering sampling technique whereby farmers were put into three clusters, that is, the upper, the middle and the lower cereals and legume cluster.

### 3.2 Data description

Household and plot level data on the various farmer and farm characteristics as well as the management and agronomic practices were collected as part of the larger questionnaire on the climate change adaptation strategies of smallholder farmers in Northern Ghana. As part of the main questionnaire, a five-page questionnaire on farmers' perceptions of risk and risk management strategies was added. Almost all the questions were of the closed-ended type and were in the form of a five-point Likert scale. The 14 questions were asked on the perceptions of the sources of risk, 7 of the questions focussed on the variability associated with the various forms of risk identified and the remaining 7 was on the effect of the variability on household income. The scoring of the Likert scale was from 1 (no variation/no effect) to 5 (very large variation/very large effect). Likewise, 24 questions were asked on the various management strategies. The first 12 questions were on the effort it took to manage these risks and the remaining 12 asked questions on the income stabilisation effect of these effort. These 24 questions were scored using the Likert scale from 1 (no effort/no effect) to 5 (very large effort/very large effect). The questionnaire was administered between June 2015 and September 2015 to the smallholder farmers in the semi-arid regions of Ghana.

## 4. Analysis

### 4.1 Method of estimation

Three estimation methods were applied in this study. The first was the use of the descriptive statistics to rank the various sources of risk and risk management strategies (Flaten *et al.*, 2005; Bishu *et al.*, 2016). This was done to identify the most important risk perceptions and strategies of the rural households in the semi-arid regions of Ghana. The second estimation was the conduct of the exploratory factor analysis. The exploratory factor analysis was employed to identify the major sources of perceived risk factors and the effective risk management strategies (Ahsan and Roth, 2010; Gebreegziabher and Tadesse, 2014). Exploratory factor analysis helped in the generation of factor scores. The generated factor scores measure the deviation of an individual's score from the sample mean (Kim and Mueller, 1978). Factor scores are unique composite variables which provide reliable information about an individual's placement on the factor. It aids in the separate allotment of scores to each latent variable based on the estimates.

The third stage involved the use of the standardised factor scores to run the linear regression (Aditto *et al.*, 2012; Bishu *et al.*, 2016). The Probit model and its marginal effect were also estimated using the direct scores given by the respondents as the dependent. In order to use the direct scores from the responses gathered from the Likert scale it was recoded. The direct response was recoded to 0 where the response was 1 (no variation/no effect) and all other response was recoded 1. This made the dependent variables a dummy variable, hence the application of the limited dependent estimation technique. The detailed diagnostic checks conducted before the performance of the exploratory factor analysis is reported in the next subsections.

### 4.2 Diagnostics

Before conducting the factor analysis, the diagnostic test was carried out to assess the adequacy of the data set. The results of these diagnostic tests are reported in Tables II and IV. The overall KMO value of 0.86 for the perceived risk sources and 0.94 for the risk management strategies indicate that the pattern of correlations was comparatively compact and factor analysis was suitable (Ahsan, 2011). Additionally, the Bartlett test of Sphericity was significant at the 1 per cent for both the perceived risk sources ( $\chi^2 = 5,446.42, p < 0.001$ ) and risk management strategies ( $\chi^2 = 10,230.33, p < 0.001$ ), implying that the data come from a multivariate normal distribution with zero covariance. The overall Cronbach's  $\alpha$  values of 0.91 and 0.96 for the perceived risk sources and risk management strategies,

respectively, were above the minimum required level of 0.6 hence was acceptable (Hair *et al.*, 2006; Field, 2005). Subsequent, the eigenvalues were computed and the scree plot generated (see appendix 1 for the scree plot). The eigenvalues (eigenvalue > 1) were detailed for three factors out of the 14 sources of risk variables and 22 risk management variables for the farm household in the semi-arid region of Ghana. It is important to state here that the initial analysis using the Orthogonal (varimax) rotation was employed to ensure that the factors were independent and could be used for the linear regression (Aditto *et al.*, 2012). In accordance with the empirical literature, factor loadings greater than 0.4 were retained and interpreted (Bishu *et al.*, 2016; Gebreegziabher and Tadesse, 2014; Legesse and Drake, 2005). The value was chosen because it was considered to be above the minimum level required for the interpretation of the structure (Hair *et al.*, 2010; Bishu *et al.*, 2016). Before conducting the linear regression, the variance inflation factor was used to check for multicollinearity (see appendix 2) while the Breusch-Pagan test (bptest) was used to check for heteroscedasticity. The variance inflation factor indicated that there was no multicollinearity among the predictor variables since all the predictor variables were below 2, whilst the heteroscedasticity test using the Breusch-Pagan test (bptest) indicated that the model was not homoscedastic at 1 per cent significant level. The robust standard errors were, therefore, reported for such models since it helped avoid the heteroscedasticity problems (Cameron and Trivedi, 2005).

## 5. Results and discussion

### 5.1 Farmer and farm characteristics

Table I shows that the semi-arid region of Ghana is a patriarchy region (96.2 per cent) with older household heads (aged 48 years and above). Added to the above, majority of the household heads hardly completed the nine years compulsory basic to junior high school. Furthermore, the result confirms that farmers in the semi-arid region of Ghana are subsistence farm households cultivating an average farm size of 3.21 hectare. The average family size of 6.36 members confirmed the national statistics for the semi-arid region of Ghana (Ghana Statistical Service, 2014). On average 31.2 per cent of the households in the semi-arid region engaged in off-farm employment while the average reported annual farm income (both crop and animal income) was GHc9154 (\$2,773.66)[1].

### 5.2 Perceptions of risk sources

The summarised results of the average scores, standard deviations and the factor loadings of farmers' perception of each source of risk are presented in Table II. The results show that production risk in the form of the effect of the high variation of crop yield on income was perceived to be the most important sources of risk. This result is not surprising as most rural households in the semi-arid region of Ghana are into cereals and legumes production.

Variable	Measurement	Mean	SD	Min	Max
Age of head	Years	48.43	14.38	19	90
Gender of head	Dummy(1 = Male, 0 = otherwise)	96.2	0.19	0	1
Education head	Years	5.71	1.96	1	7
Family size	Number of members	6.36	2.12	1	10
Farm size	In hectares	3.21	2.4	0.2	20.29
TLU	Number of livestock	2.73	9.09	0	176.3
Off-farm	Dummy (1 = if engage, 0 = Otherwise)	0.312	0.46	0	1
Farm income	Ghana Cedis (GHc)	9,154	10,743	0	115,403

Source: Field Survey (2015)

**Table I.**  
Distribution of  
Socioeconomic  
characteristics of  
respondents

Sources of risk	Most important risk factors							Cronbach's $\alpha$	KMO
	Mean	SD	Rank	Market risk	Prod. risk	Human risk	Communality		
Unexpected variability related to crop yields	3.85	1.1	4	0.71	0.27	-0.08	0.58	0.9	0.86
Unexpected variability related to crop prices	3.65	1.17	6	0.79	0.34	0.05	0.74	0.9	0.91
Unexpected variability related to fertilizer price	3.71	1.13	5	0.69	0.10	0.09	0.5	0.9	0.86
Unexpected variability related crop pests	2.27	1.12	14	-0.08	0.38	0.69	0.62	0.91	0.78
Variability related wages hired Labour	2.65	1.17	12	0.12	0.05	0.83	0.7	0.91	0.74
Variability related to livestock production	3.07	1.29	10	0.29	0.82	0.18	0.78	0.9	0.89
Variability related to livestock price	3.22	1.27	9	0.31	0.79	0.23	0.77	0.9	0.9
Effect of crop yield variability on income	4.14	1.09	1	0.79	0.22	0.09	0.68	0.9	0.89
Effect of crop price variability on income	3.9	1.25	3	0.82	0.28	0.12	0.77	0.9	0.91
Effect of fertilizer price variability on income	3.94	1.22	2	0.71	0.19	0.2	0.58	0.9	0.87
Effect of crop pest attack on income	2.52	1.35	13	-0.01	0.35	0.67	0.56	0.91	0.78
Effect of wages paid to hired labour on income	2.89	1.31	11	0.26	0.04	0.76	0.64	0.91	0.77
Effect of livestock production on income	3.33	1.38	8	0.36	0.77	0.19	0.76	0.9	0.88
Effect of livestock price variability on income	3.39	1.39	7	0.35	0.78	0.21	0.77	0.89	0.9
Eigenvalues				6.53	2.46	1.45			
Per cent of total variance explained				28.1	22.3	17.3			
Cumulative per cent of variance explained				28.1	50.3	67.6			
Overall Cronbach's coefficient $\alpha$								0.91	
Overall KMO									0.86
Number of variables considered for naming			4		2	2			

Notes:  $n = 500$ . Factor loadings with absolute values greater than 0.4 are in italic

Source: Field Survey (2015)

**Table II.**  
Varimax rotated factor loadings of perceived sources of risk for Northern Ghana

In addition, market risks in the form of the effect of the high variation of crop price and the effect of the high variation of fertiliser price on households were ranked as the 2nd and 3rd most important source of risk, respectively. Since inorganic fertiliser is a major input in the farming, an increase in the price of inorganic fertiliser is likely to affect smallholder farmers. The finding on market risk is consistent with previous studies by Aditto *et al.* (2012), Flaten *et al.* (2005) and Gebreegziabher and Tadesse (2014). These researchers have indicated that the variability and effect of input and product prices (market risks) are essential to smallholder farmers hence an increase in their prices affects the production processes. Table II, further, indicates that the unexpected variability associated with crop yield and unexpected variability associated with fertiliser price were ranked as the 4th and 5th most relevant sources of risk, respectively.

Additionally, the three least important perceived sources of risks are the variability of the wages paid to hired labour, the effect and the variability of crop pest on yields. Although ranked as the least important sources of risks, their averages were above 2.5. This is an indication that households in the semi-arid regions viewed these perceived risk sources as equally important. It is essential to note that most farm families hired labour for their farm activities due to the communal labour systems in the rural areas of Ghana. In the communal labour systems, known as the “nnoboa”, farmers take turns to work on each other’s farm. As indicated in Table II, three factors were selected for interpretation from the factor analysis conducted on the perception of the sources of risk since their eigenvalues and the scree plots were greater than one (see appendix). These three factors explained 67.6 per cent of the total variance which was deemed sufficient and satisfactory (Hair *et al.*, 2006). Additionally, for easy interpretation, factor loadings with absolute values greater than 0.4 were labelled.

To this end, the obtained factors were grouped named based on the identified names in the literature. The first factor is named “Market Risk” because of the relatively high loadings of the crop price and fertiliser price for both the effect and variability of the sources of risk. This finding is in line with the findings of Aditto *et al.* (2012) and Bishu *et al.* (2016). Additionally, there was a relatively high loading of livestock production variability and livestock production effect compared to livestock price variability and livestock price effective hence the second factor is labelled “Production Risk”. The third factor is labelled “Human Risk”, because of the highest factor loading of the variability of the wage paid to hired labour. Bishu *et al.* (2016) labelled this type of risk as labour risk. Similar Gebreegziabher and Tadesse (2014) found human risk to be the most important in source of risk of dairy farmers Ethiopia.

### 5.3 Relationship between the perceived risk source and farmer and farm characteristic

Consistent with studies that have used the standardised factor scores and the direct scores from the responses to the risk perception as dependent variables, the study reports a low value for the coefficients of determination ( $R^2$ ) and pseudo  $R^2$  for both the ordinary least square regression (OLS) and the probit model of the risk factor models. The low value of the  $R^2$  is an indication of the diversity among the individual farmers in the semi-arid region. This confirms the numerous literature that have used the standardized factor scores for linear regression (Aditto *et al.*, 2012; Flaten *et al.*, 2005; Meuwissen *et al.*, 2001). Dependent variables are made up of the normalised or the standardized factor score and the direct scores given by the respondents, respectively[2]. The results from the analysis of the linear regression model presented in Table III shows that the age of the household head was negative and significantly related to the perception of market risks at 10 per cent level of significance. Meaning older household heads perceived both market risks (both crop and livestock) as less important than younger household heads.

Furthermore, the number of livestock owned (TLU) was positive and significantly related to production risk at 1 per cent level of significance implying households with larger livestock perceived production risks as more important than farmers owning little livestock. This finding was consistent with the finding of Bishu *et al.* (2016) for the Tigray area of Ethiopia.

**Table III.** Multiple regression of the risk factors and the socioeconomic variables

	Market risk		Prod. risk		Human risk	
	Coef.	<i>p</i> -value	Coef.	<i>p</i> -value	Coef.	<i>p</i> -value
Intercept	-2.08E-01	0.4782	-2.35E-01	0.41344	-5.16E-01	0.0686*
Age	-5.28E-02	0.0854*	-2.78E-02	0.35599	-5.78E-02	0.051*
Gender	2.89E-03	0.8984	1.69E-02	0.44694	2.40E-02	0.2726
Education	2.33E-01	0.3015	1.39E-01	0.53028	-1.90E-03	0.9931
Family size	2.96E-02	0.2003	1.01E-02	0.65543	1.98E-02	0.3751
Farm size	-2.09E-03	0.5283	2.49E-03	0.44374	7.01E-03	0.0286**
TLU	2.07E-03	0.6632	1.22E-02	0.00925***	7.46E-05	0.987
Off-farm	7.96E-06	0.2341	-6.04E-06	0.35745	1.40E-05	0.0306**
Farm income	-8.35E-02	0.3668	-2.12E-01	0.02002**	-9.13E-02	0.3071
Adjusted <i>R</i> <sup>2</sup>	0.01371		0.04221		0.03616	
Bptest	20.483	0.008654***	20.718	0.007936***	19.693	0.01156**
<i>F</i> -statistics	2.678	0.006912***	2.279	0.02116**	1.65	0.1083

**Notes:** \*\*\*, \*\*\*, \*Statistically significant at 10, 5 and 1 per cent, respectively

**Source:** Field Survey (2015)

A probable reason for this finding is the open range nature of livestock production and the poor livestock management strategies of farmers in the semi-arid area of Ghana which makes livestock production a risky venture. Furthermore, the study found that wealthy farmers (farm income) perceived production risk to be less important compared to less wealthy farmers. This was expected since wealthy farmers in the Northern part of Ghana usually rely on diverse sources of income, hence are able to face risk relating to their production activities.

Additionally, the result of Table III shows that the age of the household head was significant and negatively related to human risk, which implied that younger semi-arid farmers perceived human risk as more important than older farmers. Also, human risk was perceived as highly important by farmers who had off-farm work. This was an indication that farmers who have off-farm work were very apprehensive about the disruptive effect of human risk on their off-farm income and their overall household income. Households in the Semi-arid regions with larger farms were highly concerned about the human risk, because such households had hired more labour to help with their farming activities.

The results from the probit model (Table AIII) and the marginal effect (Table VII) of the risk sources using the direct responses also shows that households with higher education perceived market risk as more important than those with lower years of education. Also households with larger farm size perceived both production and human risk as important while households having off-farm employment perceive both production and human risk as less important.

#### 5.4 Perceptions of risk management strategies

Smallholder farmers in Northern Ghana encounter various forms of risk and adopt heterogeneous strategies to manage these risks. Table IV shows that the two most important risk management strategies used to stabilise household income were the growing of different crops (4.39) and the storing of feed or seed reserve (3.71). This finding is in line with that of Aditto *et al.* (2012) who found similar results for smallholder farmers in the Northern-east and the Central Thailand. Furthermore, the spreading of sales over a time period (3.67) and the reduction in debts (3.53) were ranked 3rd and 4th effective income stabilising risk management strategies adopted by the rural households in semi-arid regions of Ghana. According to the household in the semi-arid regions of Ghana, the effort of growing different crops to stabilise household income (mean of 2.62) was the least effective risk management strategy used to stabilise household income.

**Table IV.**  
Varimax rotated  
factor loadings of  
management  
strategies for  
Northern Ghana

Management strategies	Mean	SD	Rank	Divers.	Effective risk management strategies			Cronbach's $\alpha$	KMO
					Fin. Mgt.	Off-farm	Communality		
<i>Managing risk by putting effort into</i>									
Spread sales over time	3.190	1.45	10	0.31	0.47	0.58	0.65	0.96	0.96
Work off-farm as supplement	3.022	1.51	16	0.39	0.34	0.74	0.82	0.96	0.96
Invest in non-farm business	3.078	1.45	12	0.39	0.33	0.70	0.74	0.96	0.94
Have livestock on farm	2.656	1.43	21	0.19	0.71	0.43	0.75	0.96	0.96
Choose crop varieties with lower price variability	2.638	1.38	22	0.22	0.53	0.64	0.75	0.96	0.96
Choose crop varieties with lower yield variability	3.040	1.09	15	0.18	0.34	0.59	0.49	0.96	0.93
Reduce debts	2.798	1.58	20	0.18	0.86	0.21	0.82	0.96	0.94
Store feed or seed reserves	2.982	1.58	17	0.36	0.59	0.45	0.67	0.96	0.94
Grow different crops	2.622	1.51	24	0.23	0.79	0.22	0.73	0.96	0.93
Sign rainfall insurance	2.974	1.6	18	0.31	0.11	0.62	0.49	0.96	0.94
Save cash	3.068	1.52	13	0.3	0.71	0.36	0.73	0.96	0.93
Save asset	2.848	1.58	19	0.21	0.9	0.15	0.87	0.96	0.9
<i>Stabilising household income through</i>									
Spread sales over time	3.668	1.39	3	0.73	0.22	0.14	0.46	0.96	0.94
Work off-farm as supplement	3.320	1.42	7	0.63	0.14	0.21	0.6	0.96	0.92
Invest in non-farm business	3.200	1.43	9	0.66	0.21	0.4	0.65	0.96	0.94
Have livestock on farm	3.206	1.43	8	0.65	0.2	0.39	0.62	0.96	0.97
Choose crop varieties with lower price variability	3.154	1.39	11	0.74	0.11	0.26	0.62	0.96	0.92
Choose crop varieties with lower yield variability	3.066	1.42	14	0.71	0.14	0.2	0.56	0.96	0.91
Reduce debts	3.532	1.44	4	0.70	0.28	0.33	0.69	0.96	0.95
Store feed or seed reserves	3.706	1.44	2	0.68	0.13	0.02	0.48	0.96	0.88
Grow different crops	4.386	1.55	1						
Sign rainfall Insurance	2.626	1.47	23						
Save cash	3.490	1.47	5	0.77	0.3	0.31	0.78	0.96	0.95
Save asset	3.466	1.46	6	0.72	0.32	0.38	0.77	0.96	0.96
Eigenvalues				11.92	2.53	1.31			
Per cent of total variance explained				26.7	22.2	18.1			
Overall Cronbach's $\alpha$ coefficient				3	3	3			
Overall KMO				26.7	48.9	67			0.94
Cumulative per cent of variance explained				3	3	3			
Number of variables									

**Notes:**  $n = 500$ . Factor loadings with absolute values greater than 0.4 are in italic

**Source:** Field Survey (2015)

After the ranking, the factor analysis was conducted using the 24 risk management variables. The first varimax orthogonal rotation indicated that stabilising household income by growing different crops and signing rainfall insurance to stabilise household income had to be dropped due to the lower communalities than the required minimum of 0.4. A second rotation was therefore performed with the 22 risk management variables.

For the first factor, the study reports high loadings on choosing crop varieties with lower yield variability, having livestock on the farm and choosing crop varieties with lower price variability, hence factor one is described as "Diversification strategy". Furthermore, factor two loaded highly on the effort at using savings in the form of cash, the ease of converting an asset into cash and the debt reduction strategies hence it was referred to as "Financial strategy". The last factor, factor three, was construed as "off-farm strategy" because it loaded highly on the effort at using the non-farm business and working off-farm as risk management strategies. Additionally, the factor also loaded highly on investing in a non-farm business to stabilise household income. The finding of this study is largely consistent with those of Kisaka-Lwayo and Ajuruchkwu (2012), Aditto *et al.* (2012) and Gebreegziabher and Tadesse (2014).

### 5.5 Correlation between perception and management

The correlation results using the standardised factor scores are presented in Table V. The results generally show a positive and statistically significant relationship between the risk factors and the effective risk management. For instance, the relationship between production risk and diversification and between human risk and diversification were positive and significant at one per cent meaning that farmers perceive diversification as a very important strategy for managing both production and human risk. Furthermore, financial strategy was perceived by farmers as an important strategy to adopt in the mitigation of all the three risk sources identified in the study. Additionally, off-farm strategy was positive and significantly related to both production risk and human risk, which is an indication that farmer in the semi-arid region of Ghana perceived off-farm strategy as an important strategy for managing human and production risk. The finding showed that the relationship between market risk and diversification, and market risk and off-farm strategies were statistically not significant. Probably most households in the rural setting are subsistence farmers and are not market focussed, hence the limited relationship between these variables.

### 5.6 Relationship between perceived risk management strategies, socioeconomic characteristics and the perceived sources of risk

The results from Table VI show that the gender of the household head was negatively related to "diversification strategy", an indication that that female household heads perceived diversification management strategy as a more relevant strategy than male household heads. In the semi-arid regions of Ghana female farmers are more diversified in their farming activities since most are in-charge of growing different types of vegetables (Hesselberg and Yaro, 2006). In contrast, male farmers perceived off-farm strategy as a more important risk management strategy than their female counterpart. Since men are usually in-charge of the upkeep of their homes, it is expected that more male heads engaged in wage employment than female heads.

Risk sources	Risk management strategies		
	Diversification	Financial Mgt.	Off-farm
Market risk	0.06088092	0.5245043***	-0.04756402
Production risk	0.340463***	0.5355763***	0.457862***
Human risk	0.2820308***	0.07991187*	0.08343481*

**Notes:** \*,\*\*\*Indicate pairwise correlation statistically significant at 10 and 1 per cent, respectively

**Table V.**  
Correlation between perceived risk sources and risk management strategies

**Table VI.**  
Linear regression of  
the effective risk  
management  
strategies, risk factors  
and the socioeconomic  
characteristics

	Diversification		Financial. Mgt.		Risk management Off-farm	
	Coef.	<i>p</i> -value	Coef.	<i>p</i> -value	Coef.	<i>p</i> -value
Intercept	4.26E-01	0.0354**	-9.67E-03	0.9714	-1.29E-01	0.60244
Age	-1.71E-03	0.9356	2.56E-02	0.3659	-7.73E-02	0.00317***
Gender	-2.58E-02	0.0988*	1.20E-02	0.5649	4.75E-02	0.01356**
Education	-1.98E-01	0.2025	1.10E-03	0.9958	-1.52E-01	0.42783
Family size	1.03E-02	0.5181	-3.22E-02	0.1308	4.61E-02	0.01876**
Farm size	-3.40E-03	0.137	3.26E-03	0.2861	-3.09E-03	0.27252
TLU	3.53E-03	0.284	-8.77E-03	0.0466**	-1.03E-03	0.79986
Farm income	1.15E-01	0.0739*	-1.39E-01	0.1041	9.02E-02	0.25214
Market risk	4.89E-01	< 2e-16***	4.45E-02	0.2871	-8.50E-02	0.02733**
Production risk	5.07E-01	< 2e-16***	3.35E-01	2.37E-14***	4.42E-01	< 2e-16***
Human risk	6.90E-02	0.0332**	2.67E-01	1.35E-09***	4.45E-02	0.26283
Adjusted R <sup>2</sup>	0.5395		0.2033		0.2516	
Bptest	23.245	0.01632	112.57	2.20E-16	12.156	0.352
F-statistics	51.44	2.20E-16***	11.21	2.20E-16***	14.76	2.20E-16***

**Notes:** \*, \*\*, \*\*\* Statistically significant at 10, 5 and 1 per cent, respectively

**Source:** Field Survey (2015)

As expected older farmers were found to be less involved in off-farm strategy, hence they perceived this risk management strategy as not important. In contrast, farmers who had higher household incomes perceived the “diversification strategy” as relevant than farmers who had lower income. In addition to the above, households with larger family members perceived the use of off-farm strategy as an important strategy to manage risk. This is because family members can supply more labour both on and off-farm in order to gain more income to supplement income from the farm. Furthermore, the study reported that household with larger livestock holding perceived as unimportant the financial strategy. Thus, households with larger livestock holding could easily convert their livestock to cash hence might give less attention to debt management than households with smaller livestock holdings.

Almost all the risk factors were positive and significantly associated with the effective risk management strategies in the regression model. Production risk was found to be positive and significantly associated with diversification strategy, financial management, and off-farm strategy. This was an indication that farmers focus on these risk management strategies to curb production risk.

Furthermore, human risk had a direct and statistically significantly related to both diversification and financial strategies, implying that farmers emphasised on the diversification and financial strategies when confronted by human risk. The study further reported that the perception of market risk had a larger influence on the diversification and the off-farm management strategies of adopted by these farm households (Table VII).

It is important to note that with the exception of the usage of financial strategy to mitigate market risk and the usage of an off-farm strategy to mitigate the effect of human risk which was statistically not significant, almost all risk management strategies were perceived as important in the mitigation the effect of the perceived risk. Additionally, the study shows that production risk is the commonest risk reported by most farm households in Northern Ghana whereas diversification strategy was the dominant management strategy applied by households to manage the negative effects associated with production, human and market risk. Generally, the findings of the study showed that many rural households in Northern Ghana employ multiple risk management strategies to manage risk hence are diversified. This finding confirms Senadza (2014) who indicated that many rural households in Ghana to be diversified.

	Market		Production		Human risk	
	dF/dx	SE	p >  z	dF/dx	SE	p >  z
Age	-9.66E-05	1.76E-03	0.95622	-4.33E-04	1.78E-03	0.80795
Gender	-1.86E-01	1.16E-01	0.10933	-1.08E-01	1.21E-01	0.36945
Education	2.18E-02	1.22E-02	0.07314*	-7.31E-03	1.22E-02	0.5484
Family size	8.58E-03	1.23E-02	0.48613	-1.47E-02	1.25E-02	0.23768
Farm size	5.01E-03	6.62E-03	0.44918	1.58E-02	6.99E-03	0.02396**
TLU	1.25E-03	2.76E-03	0.65152	-8.41E-03	5.56E-03	0.13044
Off-farm	-5.26E-02	4.93E-02	0.28566	-1.24E-01	4.94E-02	0.0123**
Farm income	-1.25E-06	3.59E-06	0.72748	-1.40E-07	3.78E-06	0.97043
				dF/dx	SE	p >  z
				-2.63E-03	1.80E-03	0.14364
				1.84E-01	1.06E-01	0.0837*
				-1.29E-02	1.21E-02	0.28625
				-2.55E-02	1.25E-02	0.04217**
				1.17E-02	6.89E-03	0.09098*
				2.05E-03	2.69E-03	0.44642
				-1.02E-01	4.97E-02	0.04033**
				-8.86E-06	4.02E-06	0.02741**

Notes: \*,\*\*Statistically significant at 10 and 5 per cent, respectively

Table VII.  
Parameter estimates  
of the risk sources:  
marginal effect

The results from the probit model (Table AIV) and its marginal effect (Table VIII) also show similar results to the OLS result on the risk management strategies. For instance, off-farm strategy and financial strategy was perceived as important management strategies to manage both production risk and human risk according to the results of both OLS and the marginal effect of the probit model. Diversification management strategies was perceived as important strategies for managing the human and production risk as depicted by the results of the OLS and the marginal effect of the probit model. The result shows that larger families perceived the use of off-farm management strategies to manage risk as important (similar to the OLS results) while household heads with greater number of years of education and those who cultivated larger farm size perceived the use of diversification risk management strategies and off-farm management strategies as less important risk management strategies, respectively. The probable reason could be that households with alternative income source (off-farm income) due to the higher level of education and ownership of off-farm business might not see agricultural as a very important source of income.

## 6. Conclusion and implications

Unlike existing literature in Sub-Saharan African that have focussed on livestock farmers, this study investigated the risk perception and risk management strategies of a sample of 500 rain-fed smallholder farmers from the semi-arid regions on Ghana. The study applied the descriptive statistics to identify the most important risk sources and the most effective risk management strategies; and the factor analysis to investigate the risk factors and effective risk management strategies of smallholder farmers in the semi-arid region of Ghana. The linear regression and the probit model were used to examine the relationship between farm and farmer characteristics, the effective risk management strategies and the risk perceptions of these farmers. The results from the descriptive statistics showed that the rain-fed smallholder farmers viewed the effect of the variation in crop yields, fertiliser prices and crop prices as the three most important perceived sources of risks. To manage the negative impact of these risks on household income, income stabilising strategies such as growing different crops, storing feed/seed reserves and spreading of sales over time are implemented.

The factor analysis on the perceived sources of risks identified three interpretable risk factors: market risk, production risk and human risk. Households in the semi-arid regions of Ghana managed these three risk factors by using three interpretable effective risk management strategies: diversification strategy, financial strategies and off-farm strategy. The study finds an uphill relationship between the risk factors and the effective risk management strategy. The results of the study suggest a statistically significant positive relationship between the risk factors and the effective risk management strategies. Risk is diverse and different among individual farm households in the semi-arid region as indicated by the low value of the coefficient of determinant in both the regression and probit model. The results from the linear regression using the standardised factor scores and the probit model indicated that age and education were the only major determinant of market risk whereas farm income, TLU, and off-farm employment were important determinants of human risk. Production risk was determined by TLU, farm size and farm income. Additionally, the linear regression and the probit model results for the risk management strategies indicated that farmers who prioritised diversification strategy were those concerned about market risk, human risk and production risk. In addition, farmers who were apprehensive about production risk and human risk prioritised financial strategy while off-farm strategy was prioritised by farmers most affected by production risk. The findings generally confirm the PMT on risk, which show that risk perception influence the management strategies adopted. The finding showed that socioeconomic variables were important determinants of the risk management strategy. Gender was not an important determinant of diversification, though it was an important determinant of the off-farm strategies of the smallholder farmers. Furthermore, TLU was not perceived as an important determinant of the use of financial strategy.

	Diversification		Financial		Off-farm				
	dF/dx	SE	p >  z	dF/dx	SE	Pr(>  z )	dF/dx	SE	Pr(>  z )
Age	-1.92E-03	2.14E-03	0.36888	8.89E-04	2.14E-03	0.6781	-9.79E-04	2.02E-03	0.6278
Gender	-8.91E-02	1.52E-01	0.55727	1.00E-02	1.45E-01	0.9449	-1.23E-01	1.33E-01	0.35509
Education	-3.86E-02	1.56E-02	0.01352**	1.79E-02	1.48E-02	0.2288	1.87E-02	1.41E-02	0.18409
Family size	8.04E-03	1.51E-02	0.59374	-1.59E-02	1.48E-02	0.2824	2.67E-02	1.43E-02	0.06172*
Farm size	-2.40E-03	8.65E-03	0.7811	1.14E-02	8.29E-03	0.1676	-1.92E-02	8.03E-03	0.01671**
TLU	4.41E-03	5.74E-03	0.44184	1.65E-01	5.85E-02	0.0047***	-2.10E-03	2.66E-03	0.42929
Farm Income	-2.15E-06	4.71E-06	0.64756	-6.30E-06	4.76E-06	0.1854	3.59E-06	4.34E-06	0.40764
Market risk	2.91E-01	4.00E-02	6.42E-11***	3.83E-02	3.44E-02	0.265	-1.18E-03	3.00E-02	0.9687
Production risk	1.56E-02	3.54E-02	0.65893	2.64E-01	3.48E-02	3.99E-15***	5.52E-02	3.01E-02	0.06669*
Human risk	3.35E-01	3.66E-02	2.20E-16***	3.04E-01	3.57E-02	2.20E-16***	3.16E-01	3.55E-02	< 2e-16***

Notes: \*\*\*, \*\*, \* Statistically significant at 10, 5 and 1 per cent, respectively

**Table VIII.**  
Parameter estimates of the risk management strategies: marginal effect

Household size was perceived as an important determinant of the usage of off-farm strategy. Wealthy (farm income) were more diversified than less wealthy households. The study recommends that apart from the socioeconomic characteristics, attention should be paid to understanding market, production and human when designing policies targeted at improving the welfare of smallholder rain-fed farmers in the semi-arid region of Ghana.

### Notes

1. Using the 2015 rate of 1 GHc = 0.303.
2. The direct scores or the nominal variables given by the respondents were treated as dummies and also analysed using probit model.

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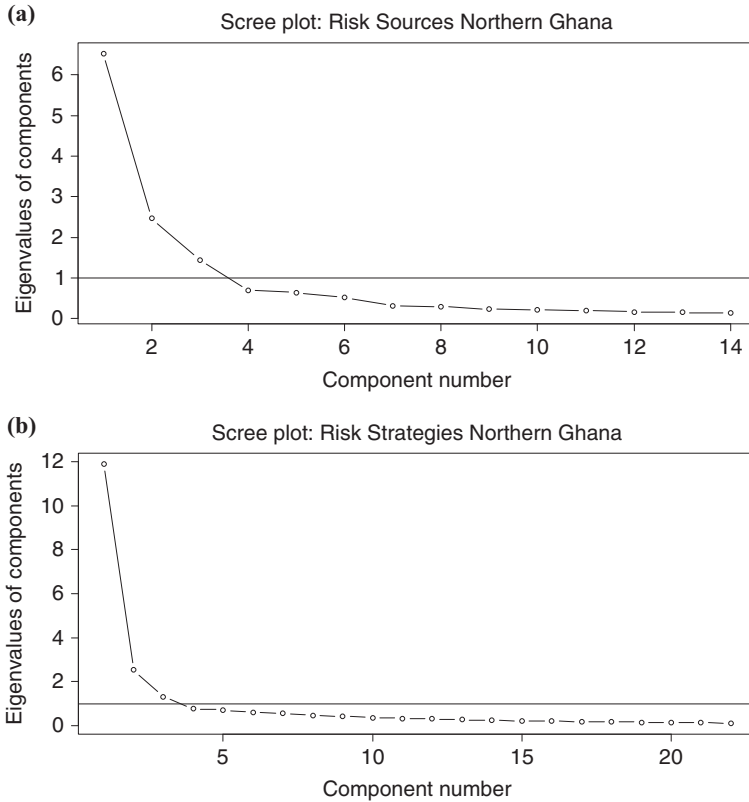


Figure A1.  
Scree plots

Appendix 2. Variance inflation factors (VIF)

Variables	Northern Ghana VIF	Sqrt(VIF)
Age	1.195316	1.09330508
Gender	1.031338	1.01554813
Education	1.599787	1.26482687
Family size	1.367319	1.16932416
Farm size	1.214669	1.10212023
TLU	1.160878	1.07744049
Off-farm	1.516538	1.23147797
Farm income	1.128381	1.06225279

Table A1.  
VIF: Risk perceptions

Variables	Northern Ghana VIF	Sqrt(VIF)
Age	1.214457	1.102024
Gender	1.034975	1.017337
Education	1.622703	1.273854
Family size	1.375942	1.173006
Farm size	1.236414	1.111942
TLU	1.190337	1.091026
Farm income	1.521884	1.233647
Market risk	1.01769	1.008806
Production risk	1.066298	1.032617
Human risk	1.025988	1.012911

Farmers' risk  
perceptions  
and risk  
management

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**Table AII.**  
VIF: risk management  
strategies

**Table AIII.**  
Parameter estimate of  
the probit model of  
the risk sources

	Market risk		Production risk		Human risk	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	-9.58E-02	3.89E-01	4.86E-01	3.89E-01	4.68E-01	3.98E-01
Age	-2.86E-04	4.43E-03	-1.01E-03	4.46E-03	-6.71E-03	4.48E-03
Gender	-4.71E-01	3.06E-01	-2.70E-01	3.03E-01	4.91E-01	3.16E-01
Education	5.45E-02	3.05E-02	-1.82E-02	3.05E-02	-3.24E-02	3.04E-02
Family size	2.14E-02	3.09E-02	-3.71E-02	3.12E-02	-6.33E-02	3.12E-02
Farm size	1.29E-02	1.66E-02	3.86E-02	1.72E-02	2.87E-02	1.70E-02
TLU	3.30E-03	6.74E-03	-2.04E-02	1.35E-02	5.25E-03	6.61E-03
Off-farm	-1.32E-01	1.24E-01	-3.09E-01	1.24E-01	-2.55E-01	1.24E-01
Farm income	-3.32E-06	9.00E-06	-9.71E-07	9.29E-06	-2.21E-05	9.72E-06
Pseudo $R^2$	0.015207		0.0355097		0.03857573	
log pseudo likelihood	-335.4979		-328.5812		-328.3936	
df	9		9		9	
Prob > $\chi^2 =$	0.2405713		0.002125595		0.000913853	
<b>Notes:</b> **Statistically significant at 10 and 5 per cent, respectively						

## Appendix 4. Probit model of risk management strategies

Farmers' risk perceptions and risk management

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	Diversification			Financial			Off-farm		
	Estimate	SE	Pr(>  z )	Estimate	SE	Pr(>  z )	Estimate	SE	Pr(>  z )
Intercept	8.98E-01	4.58E-01	0.05**	-3.67E-01	4.48E-01	0.41284	1.64E-01	4.30E-01	0.7028
Age	-4.31E-03	5.06E-03	0.3944	2.25E-03	5.06E-03	0.65702	-2.31E-03	4.82E-03	0.6311
Gender	-2.72E-01	3.54E-01	0.4423	2.65E-02	3.41E-01	0.93808	-2.72E-01	3.37E-01	0.4199
Education	-9.21E-02	3.63E-02	0.0111**	3.82E-02	3.50E-02	0.27513	4.49E-02	3.34E-02	0.1786
Family size	1.52E-02	3.55E-02	0.6686	-3.99E-02	3.50E-02	0.25448	6.07E-02	3.39E-02	0.073
Farm size	-1.27E-03	2.01E-02	0.9497	2.80E-02	1.97E-02	0.1537	-4.52E-02	1.90E-02	0.0172**
TLU	1.03E-02	1.31E-02	0.4322	3.78E-01	1.42E-01	0.00781***	-5.01E-03	6.52E-03	0.4421
Farm income	-6.74E-06	1.10E-05	0.5387	-1.54E-05	1.12E-05	0.17066	8.35E-06	1.03E-05	0.4158
Market risk	6.84E-01	9.07E-02	4.89E-14***	1.02E-01	7.80E-02	0.19106	1.48E-02	6.99E-02	0.8321
Production risk	5.18E-02	8.01E-02	0.5185	6.39E-01	7.87E-02	4.68E-16***	1.28E-01	7.03E-02	0.0679*
Human risk	7.94E-01	8.06E-02	< 2e-16***	7.24E-01	7.92E-02	< 2e-16***	7.52E-01	7.86E-02	< 2e-16***
Pseudo $R^2$	0.3024257			0.2797149			0.2060768		
log pseudo likelihood	-239.3256			-246.4358			-272.0475		
df	12			12			12		
Prob > $\chi^2 =$	2.05E-38			4.50E-35			9.16E-25		

Notes: \*\*, \*\*\*, \*\*Statistically significant at 5 and 1 per cent, respectively

Table AIV. Parameter estimate of the probit model of the risk management