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Determinants of Farmers' Climate Risk Perceptions in Agriculture—A Rural Ghana Perspective

Francis Ndamani * and Tsunemi Watanabe

School of Economics and Management, Kochi University of Technology, 2-22 Eikokuji, Kochi City, Kochi780-8515, Japan; watanabe.tsunemi@kochi-texh.ac.jp

* Correspondence: fndamani@gmail.com; Tel.: +233-242-045-268

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Abstract: This study evaluates the socio-economic predictors of farmers' perceptions about climate risk in agriculture. The levels of risk perception among different farmers' wealth groups are also investigated. A total of 100 farmers in the Lawra district of Ghana are randomly selected and interviewed. Data is obtained through the use of semi-structured questionnaires and focus group discussions. A climate risk perception index (CRPI) is derived and applied to assess the degree of perceived risk among different wealth groups of farmers. The linear regression model is also used to analyze the data. The results showed that 93% of farmers have perceived climate risk while 7% are not sure if they have perceived it. Results of the CRPI showed that resource-poor farmers are concerned about climate risk on agricultural production, while resource-moderate and resource-rich farmers are concerned about risk impacts on climatic variables, and health and socio-economy, respectively. Results of the regression model showed that education, age, a perceived increase in human disease and mortality, and a decrease in food security and incomes are predictors of risk perception. The policy implication of this study is that predictors of farmers' climate risk perception should be factored into climate change risk communication in order to boost awareness and adaptation to climate change.

Keywords: climate change; farming; predictors; risk impacts; Lawra district

1. Introduction

The agriculture sector is highly sensitive to climate change. In Africa, for instance, studies have shown that climate change embodies a significant threat to current production systems, infrastructures and markets, and therefore farmers' livelihoods [1]. Furthermore, in semi-arid Africa where many people subsist on rain-fed agriculture with limited access to safety nets, climate change can exacerbate food shortage and low income conditions of the already visibly poor in society. In Ghana, studies have shown that climate change effects (e.g., rainfall variability) have led to a decrease in volume of the annual production of staple crops [2]. The recognition that climate change-related threats to agriculture also represent threats to quality of life on a global scale has led to an increasing amount of attention to adaptation and mitigation strategies for agriculture [3,4]. Adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by the changing climate. Adaptation practices are pre-emptive in nature and are meant to lessen adverse effects and take advantage of potential benefits of an envisaged change in climatic variables [5]. Several studies have reported various adaptation practices in agriculture [6,7]. Notwithstanding the significant efforts that have been made in the development and dissemination of climate change adaptation options, these measures have not been utilized adequately and not integrated effectively into agricultural development. Studies in Ghana have shown that though majority of farmers are aware of climate change, a significant number of them still do not use adaptation practices [6,8]. This is

largely due to the fact that the proposed adaptation processes have failed to adequately addressed farmers' awareness, perceptions and concerns of climate risks.

Previous studies of agricultural conservation practice adoption have reported positive correlation between awareness of environmental problems, attitudes toward potential solutions, and willingness to adopt those solutions [9]. Furthermore, it is only when situations are perceived as problems that attitudes regarding potential ameliorative actions are more predictive of behavior change [10]. Farmer concerns about the impacts of climate change are key to successful adaptation and mitigation [3]. Farmers' willingness to implement adaptation and mitigation policies supported by public authorities and governments also depend upon their beliefs regarding climate change and their perceptions of climate change-related risks [11]. Literature has shown that appropriate risk perception can be seen as a prerequisite for choosing an effective risk-coping strategy, because a farmer that is not aware of the risks faced is clearly unable to manage them effectively [12]. Knowledge of the factors that influence farmers' perceptions of climate change-related risks is critical in developing and promoting appropriate adaptation practices in agriculture, thereby boosting the tempo of adaptation among farmers. This notwithstanding, climate risks perception in agriculture has not been adequately investigated in Ghana. This study therefore identified various climate risk phenomena and explored the degree of risk perceptions among different categories of farmers in the Lawra district of Ghana. The factors that influence farmers' risk perception are investigated. This study is essential for creating policy instruments to boost farmers' climate risk concern, and for the development of training programmes tailored to meet the adaptation needs of farmers.

2. Literature Review

2.1. The Concept of Risk and Climate Risk Assessment

Risk has been defined as the result of physically distinct hazards interacting with exposed systems—taking into consideration the properties of the systems, such as their sensitivity or social vulnerability. Risk also has been described as the combination of an event, its likelihood and its consequences [13]. The perceptive approach considers risk as a set of all destructive consequences that are believed to be possible by a person who has evidence about the frequency, severity, and variability of the effects [14]. An effective climate change risk analysis in agriculture is fundamental to developing viable adaptation options to manage future anticipated risks. Literature has shown that the two important steps in climate change risk analysis include identification and assessment of current climate variability and future climate change risks and associated societal vulnerabilities [13]. These two steps form the basis for successful implementation of adaptation practices. Researchers are getting increasingly interested in risk perception, largely due to the fact that findings of scientific risk assessment are sometimes at variance with the inherent way people perceive risk [15]. Previous findings have revealed that if farmers do not believe in the occurrence of climate change and/or do not perceive it to be a threat to their livelihoods, they will not likely act to adapt to or mitigate climate change [3].

2.2. Climate Change Risk Perceptions and Concerns among Farmers

A growing body of literature exists on farmers' beliefs about the existence of climate change, their concerns, the relationship between climate change beliefs and risk perceptions, and their relationship with farmers' willingness to adapt or to support adaptation policies. Literature on adaptation to natural hazards finds that behavioral responses to hazards depend largely on risk perception, or "beliefs about the existence and characteristics of a natural hazard" [16]. As such, behavior change is influenced by perceptions of the risks associated with a given natural hazard, which are mediated by beliefs about (1) the existence of the hazard and (2) its characteristics [17]. Studies have revealed that farmer concerns about the impacts of climate change are essential to successful adaptation and mitigation [3]. As such, appropriate risk perception can be seen as a prerequisite for choosing an effective risk-coping strategy,

because a farmer that is not aware of the risks faced is clearly unable to manage them effectively [18]. Findings of studies conducted in the United States reveal that while perceptions of climate risk are central to farmer attitudes toward adaptation, concern about the potential negative impacts of climate change is an important predictor of both support for additional protective action and investment in agricultural drainage to adapt to increases in precipitation [11]. In this study, farmers are categorized into different wealth groups and their perceptions are identified and assessed.

2.3. Factors Influencing Farmers' Risk Perception

The proper perception of risk factors is the first step towards creating an effective risk management system. Literature shows that knowledge of farmers' perception of risk is essential for creating policy instruments to support agricultural risk management, and for the development of training programmes tailored to the needs of farmers [18]. Previous research studies focusing on factors determining differences in the level of risk perception have shown that farmers' perceptions are largely determined by socio-economic features of the farmers and the characteristics of their farms [19]. Previous findings have also suggested that since farmers from various countries live within different climatic and institutional conditions, differences in risk perception can be a result of either different probabilities of certain risk factors, or different farmers' mentality and awareness, or a mixture of both. [18]. Other climate risk perception predictors identified in previous studies include drought [20], yield risk and price risk for agricultural products [21–24], and weather and natural disasters [24]. It must be noted that, in the conversional approach to assessing factors influencing climate risk perception in agriculture, most investigations have used mainly demographic factors (e.g., age, education, gender, household size, farming experience and income) and climatic variables (i.e., precipitation and temperature). It appears no study, as yet, has applied variables pertaining to probability of perceived risk impacts on agricultural production, biodiversity and forestry, psychology, and health and socio-economy. This study therefore conducts a combined regression of the aforementioned risk impacts variables together with the psychological and demographic factors.

3. Materials and Methods

3.1. Survey Design and Data Collection

This study focuses on farmers in the Lawra district of Ghana. The district was chosen based on accessibility and knowledge of agricultural officers. Also, information gathered from the Upper West Regional Meteorological agency showed that the Lawra district is most prone to droughts and floods. Considering that the chosen communities are sparsely populated, a representative sample size of 100 farmer-households was randomly selected; 25 farmer-households from each community. Data is collected through focus group discussions (FGDs) and semi-structured questionnaires. For the majority of illiterate farmers, questions are translated into their local language and the responses are recorded. The questions are focused on factors and variables related to agricultural activities, climate change and climate-risk perceptions, and demographic features. Based on the literature, two main approaches have been used to assess determinants of farmers' climate risk perceptions. The first approach is qualitative, where Likert scale type questions or risk assessment scales are used to elicit responses from respondents [11]. The second approach uses quantitative scales where respondents are asked to indicate how climate change will affect the mean and variability of their yields [25]. This study applies the former approach, because it is the most ideal method to elicit respondents' concerns and views on an issue based on a range of options. Since findings of previous studies in the Lawra district already showed that farmers are aware of climate change [6], in the first stage of data collection in this current study, farmers are asked to respond to one broad question: Have you perceived any form of risk to your agricultural activities due to climate change? In the second stage, respondents are asked to score their level of climate risk perception based on a 1–4 Likert scale *(i.e., 'highly perceived', 'moderately perceived' and 'less perceived' and 'not sure')* (Table 1). Subsequently, the degree of risk perception among

different farmers' wealth groups *(i.e., resource-poor farmers, resource-moderate farmers and resource-rich farmers)* are estimated by developing a climate risk perception index (CRPI). Respondents are asked to score their level of climate risk perception based on a 1–4 Likert scale *(i.e., 'highly perceived', 'moderately perceived' and 'less perceived' and 'not sure')*. Climate risk perception index (CRPI) is estimated as follows:

$$\text{CPRI} = R_h \times 4 + R_m \times 3 + R_l \times 2 + R_n \times 1$$

where:

R_h = frequency of respondents who graded highly perceived risk;
R_m = frequency of respondents who graded moderately perceived risk;
R_l = frequency of respondents who graded less perceived risk;
R_n = frequency of respondents who graded not sure.

Table 1. Description of variables and measurements used in data collection.

Variables		Measurement
Demographic	Age	1 = 15–34; 2 = 35–54; 3 = above 54
	Gender	1 = female; 0 = male
	Education	1 = educated; 0 = illiterate
	Marital status	1 = married; 0 = single
	Average annual farm income	1 ≤ 1300; 2 = 1300–30,000; 3 > 30,000 Ghana cedi
Climate change risk perception	Risk perception	1 = yes; 0 = no
	Degree of risk perception	4 = highly perceived; 3 = moderately perceived; 2 = less perceived; 1 = not sure
Climatic variables	Perceived probability of droughts, floods and dry spell	4 = high; 3 = moderate; 2 = low; 1= not at all
	Perceived probability of increased temperature	
	Perceived probability of worsening harmattan conditions	
Health and socio-economic	Perceived severity of consequences on human diseases and mortality	
	Perceived severity of consequences on migration	
	Perceived severity consequences on food security and incomes	
Biodiversity and forestry	Perceived probability of reduction in plant and forest species	
	Perceived probability of reduction in bird and animal species	
	Perceived probability of decrease in forest area	
Agricultural production	Perceived probability of decreased crop yield	
	Perceived probability of decrease in cropping area	
	Perceived probability of increase in pests and diseases	
	Perceived probability of increase in cost of production	
	Perceived probability of decrease in soil fertility	
Psychological	Perceived ability to control risk	

The criterion for categorization of farmers into different wealth groups is developed based on discussions with farmers and agricultural officers. Findings of the discussions showed that farmers with an annual average household income of less than 1300 Ghana cedi (i.e., GHC 1300 = US Dollar 342) are generally considered as resource-poor farmers. Also, farmers whose annual average household income range between 1300 and 30,000 Ghana cedi are classified as resource-moderate farmers. The resource-rich farmers are claimed to have an annual average household income of more

than 30,000 Ghana cedi. In addition to the conversional approach to climate change risk perception analysis, this study asked farmers to score their level of risk perception with respect to four categories of climate change risk impacts. These are agricultural production, biodiversity and forestry, health, socio-economy and climatic variables (Table 1). These factors are obtained from farmers, agricultural staff and literature [26].

3.2. Empirical Approach of Determinants of Climate Risk Perception

The linear regression analysis is used to evaluate the factors that influence farmers' climate change risk perceptions. Climate change risk perception is the dependent dummy variable in this study. To determine the dummy, a value of '1' was assigned to a farmer who has perceived any form of climate related risks and '0' if he has not perceived any risks. Farmers' climate change risk perceptions are influenced by a number of factors. Most quantitative analyses use the mono-disciplinary approach and therefore any mechanisms that affect agricultural productivity other than direct climate change effects are disregarded. However, this study uses a different approach that includes indirect effects. In this study, the independent variables for climate change risk perception are classified into five categories: demographic factors (age, gender, education and farming experience), perceived impacts on agriculture production (e.g., crop yield, cropping area, cost of production, etc.), perceived impacts on biodiversity and forestry (e.g., plant and tree species, bird and animal species, forest area, etc.), perceived impacts on health and socio-economy (household incomes, food security, migration, mortality and human disease), perceived impacts on climate variables (i.e., drought, flood, dry spell, harmattan winds) and perceived psychological impacts (e.g., ability to control risk). Respondents are asked to score their responses with respect to each of the variables using a four-point scale *(i.e., 'high', 'moderate', 'low' and 'not at all')*. Prior to running the regression model, the mean scores and correlations of the independent variables were calculated to assess their relation with the dependent variable (e.g., risk perception) and with each other (Tables 2 and 3).

3.3. Definition of Climate Change Risk Perception

This study defines climate change risk perception as the concerns or anxieties demonstrated by farmers about past, current and future occurrence of negative impacts on climatic variables, agricultural production, biodiversity and forestry, and health and socio-economy due to climate change.

Table 2. Correlations of climate change risk perception variables in the Lawra district of Ghana.

Variables	Climatic Impact			Health and Socio-Economy			Biodiversity and Forestry Impact			Agricultural Production Impact					Psychological
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Perceived probability of droughts, floods and dry spell	1.00														
Perceived probability of increased temperature	0.178	1.00													
Perceived probability of worsening harmattan conditions	0.473 **	0.074	1.00												
Perceived severity of consequences on human diseases and mortality	0.065	0.049	−0.138	1.00											
Perceived severity of consequences on migration	0.257 **	0.250 *	0.037	0.316 **	1.00										
Perceived severity consequences on food security and incomes	0.576 **	0.135	0.049	0.220 *	0.659 **	1.00									
Perceived probability of reduction in plant and forest species	0.176	0.265 **	0.048	0.472 **	0.389 **	0.142	1.00								
Perceived probability of reduction in bird and animal species	0.179	0.230 *	0.055	0.372 **	0.364 **	0.229 *	0.838 **	1.00							
Perceived probability of decrease in forest area	0.179	0.292 **	0.477 **	0.365 **	0.422 **	0.261 **	0.573 **	0.398 **	1.00						
Perceived probability of decreased crop yield	0.358 **	0.158	0.351 **	0.132	0.413 **	0.322 **	0.104	0.260 **	0.426 **	1.00					
Perceived probability of decrease in cropping area	0.154	0.014	0.365 **	0.397 **	0.19	0.017	0.122	0.114	0.414 **	0.219 *	1.00				
Perceived probability of increase in pests and diseases	0.045	0.201 *	0.142	0.537 **	0.106	0.137	0.229 *	0.273 **	0.240 *	0.355 **	0.556 **	1.00			
Perceived probability of increase in cost of production	0.376 **	0.074	0.344 **	0.108	0.392 **	0.338 **	0.079	0.117	0.270 **	0.266 **	0.228 *	0.129	1.00		
Perceived probability of decrease in soil fertility	0.02	0.116	0.076	0.529 **	0.197 *	0.206 *	0.273 **	0.152	0.314 **	0.1	0.431 **	0.720 **	0.041	1.00	
Perceived ability to control risk	0.097	0.250 *	0.138	0.484 **	0.383 **	0.034	0.358 **	0.498 **	0.365 **	0.349 **	0.695 **	0.501 **	0.05	0.393 **	1.00

Notes: ** indicates significant level at 5% and, * indicates significant level at 10%.

Table 3. Descriptive statistics of predictors and mean score of climate change risk perception.

Elements	Variables	Mean	SD	Correlation with CRP
	Climate risk perception (CRP)	0.93	0.26	1
Factors related to climatic variables	Perceived probability of droughts, floods and dry spell	2.87	0.34	0.106
	Perceived probability of increased temperature	2.74	0.44	0.163
	Perceived probability of worsening harmattan conditions	2.60	0.49	0.336
Health and socio-economic factors	Perceived severity of consequences on human diseases and mortality	2.15	0.89	0.263
	Perceived severity of consequences on migration	2.13	0.75	−0.074
	Perceived severity of consequences on food security and incomes	2.46	0.67	0.221
Biodiversity and forestry factors	Perceived probability of reduction in plant and forest species	2.25	0.61	0.273
	Perceived probability of reduction in bird and animal species	2.15	0.86	0.269
	Perceived probability of decrease in forest area	2.29	0.67	0.119
Factors related to agricultural production	Perceived probability of decreased crop yield	2.58	0.71	0.162
	Perceived probability of decrease in cropping area	1.68	1.14	0.408
	Perceived probability of increase in pests and diseases	2.12	1.04	0.234
	Perceived probability of increase in cost of production	2.22	0.71	0.086
	Perceived probability of decrease in soil fertility	2.35	0.81	0.222
Psychological factors	Perceived ability to control risk	1.64	1.13	0.156

4. Results

4.1. General Demographic Characteristics of Respondents

The results of respondents' demographic features are presented in Table 4. The majority of farmers interviewed are above thirty-five years (i.e., resource-poor = 76.4%; resource-moderate = 90.9% and resource-rich = 81.8%). Similarly, most of the respondents have more than eleven years of farming experience (i.e., resource-poor = 76.5%; resource-moderate = 78.6% and resource-rich = 81.8%). In all the wealth categories of farmers, male respondents are dominant (i.e., 82.4%, 75.8% and 87.9%, respectively). The findings also showed that the illiteracy rate is very high among farmers in Lawra district, irrespective of wealth status (i.e., 85.3%, 63.6% and 87.9%, respectively).

Table 4. Demographic features of respondents in Lawra district (N = 100).

Features		Resource-Poor Farmers (N = 34)		Resource-Moderate Farmers (N = 33)		Resource-Rich Farmers (N = 33)		Test Statistic
		n	%	*n*	%	*n*	%	
Age distribution	15–34	8	23.5	3	9.1	6	18.2	X^2 = 4.826
	35–54	13	38.2	17	51.5	10	30.3	
	55 and above	13	38.2	13	39.4	17	51.5	
Marital status	Married	31	91.2	33	100.0	27	81.8	X^2 = 6.662
	Single	3	8.8	0	0.0	6	18.2	
Gender distribution	Male	28	82.4	25	75.8	29	87.9	X^2 = 1.647
	Female	6	17.6	8	24.2	4	12.1	
Education level	Illiterate	29	85.3	21	63.6	29	87.9	X^2 = 7.075
	Literate	5	14.7	12	36.4	4	12.1	
Farming experience	Less than 10 years	8	23.5	3	9.1	7	21.2	X^2 = 5.702
	11–25 years	11	32.4	16	48.5	8	24.2	
	More than 25 years	15	44.1	14	42.4	18	54.5	
Annual average income	Ghana Cedi (GHC)	<1300		1300 to 30,000		>30,000		
	US Dollar (USD)	<342		342 to 4300		>4300		

4.2. Farmers' Climate Change Risk Perceptions

The results of farmers' climate change risk perceptions show that 93% of respondents have perceived risk while 7% are not sure if they have perceived it. While 66% of the respondents have highly perceived climate change risk, 4% have less perceived it. Also, 23% of farmers have moderately perceived climate change risk in their farming activities (Figure 1).

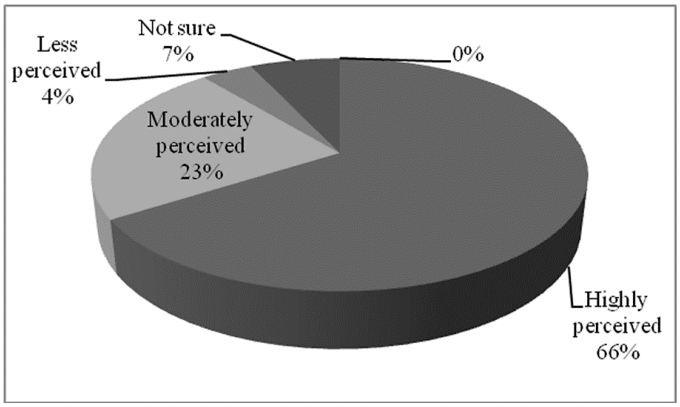

Figure 1. Levels of climate change risk perceptions of farmers in Lawra district.

Results obtained from the focus group discussions showed that farmers have perceived decreasing precipitation, rising temperatures and rainfall variability. Respondents claim that the aforementioned incidences of climate change effects have culminated in low crop production.

4.3. Climate Risk Perception among Different Farmers' Wealth Groups

The results in Table 5 show that farmers in different wealth categories have different levels of climate change risk perceptions. Generally, 91% of resource-poor farmers have perceived risk highly, while 58% and 48% of resource-moderate and resource-rich farmers have highly perceived risk, respectively. In addition, 9% of resource-poor farmers perceive moderate risk while 27% and 30% of resource-moderate and resource-rich farmers perceive moderate risk, respectively. Also intriguing is that 2% of resource-moderate and 5% of resource-rich farmers are not sure if they have perceived climate change risks or not.

Table 5. Level of climate change risk among different farmer wealth groups in Lawra district (N = 100).

Variables	Farmers' Wealth Groups		
	Resource-Poor Farmers	**Resource-Moderate Farmers**	**Resource-Rich Farmers**
Highly perceived	91	58	48
Moderately perceived	9	27	30
Less perceived	0	13	17
Not sure	0	2	5
Total	100	100	100
X^2		14.611	

4.4. Farmers' Perceived Climate Risk Impacts and Phenomena

The findings show that farmers in Lawra district generally perceived climate change risk impacts in terms of agricultural production, biodiversity and forestry, health and socio-economy and climatic variables (Table 6). The results show that farmers have inherent concerns and apprehensions about the occurrence and consequences of climate change. Results of the FDGs reveal that perceived occurrence of drought, dry spell, floods, rising temperatures and worsening harmattan winds are risk impacts on climatic variables. Perceived increase in human diseases, mortality, migration and decrease in food security and incomes were classified under the health and socio-economic risk impact domain. The respondents identified decreasing crop yield, cropping area, soil fertility, and increasing pests and diseases and cost of production as risk impacts on agricultural production. In addition, decreasing forest area, and reduction in plant, tree, bird and animal species are classified under biodiversity and forestry risk impacts. Previous studies have also identified similar risk phenomena perceived by farmers [20–24].

Table 6. Climate risk impacts and phenomena.

Climate Risk Impacts	Climate Risk Phenomena
Agricultural production	Low crop yield, increase in crop diseases, increase in crop pests and insects, decrease in cropping area, increase in production costs, reduction in water quality, hardening of seed bed and reduction in soil fertility
Biodiversity and forestry	Reduction in plant and forest species, reduction in bird and animal species, decrease in forest area, extinction of certain plant and forest species and extinction of certain bird and animal species
Health, socio-economy and culture	Increase in disease infection, increase in mortality, increase in poverty, reduction in household incomes, increase in migration, increase or decrease in belief in God and widening of gap between rich and poor
Climatic variables	Increase in drought, increase in dry spells, increase in floods, worsening of harmattan conditions and rainfall variability, rising temperature

The results of climate change risk impacts perceived by different wealth categories of farmers are presented in Table 7. The findings show that resource-poor farmers are very concerned about climate change risk impacts on agricultural production (i.e., CRPI = 130), while resource-moderate and resource-rich farmers are concerned about risks on climatic variables (i.e., CRPI = 129) and health and socio-economy (i.e., CRPI = 132), respectively. For resource-poor farmers, climate change risk impacts on climatic variables, biodiversity and forestry, and health and socio economy are ranked second, third and fourth respectively (i.e., CRPI = 124, 115 and 111). In the case of resource-moderate farmers, risk impacts on agricultural production, health and socio-economy and biodiversity and forestry are ranked second, third and fourth respectively. (i.e., CRPI = 123, 107, 101). Regarding resource-rich, farmers perceived climate change risk impacts on climatic variables was ranked second (i.e., CRPI = 120) while impacts on biodiversity and forestry (i.e., CRPI = 113) and agricultural production (i.e., CRPI = 99) are ranked third and fourth respectively. The findings obtained from the FGDs confirmed the results of the analysis. Resource-moderate and rich farmers are more able to meet the financial demands of adaptation to climate change and are therefore unlikely to perceive the full impacts on climate change risks on farming activities.

Table 7. Risk perception on impact variables by different wealth categories of farmers in Lawra district (N = 100).

Variables	Climate Change Risk Perception Index (CRPI)		
	Resource-Poor Farmers	**Resource-Moderate Farmers**	**Resource-Rich Farmers**
Agricultural production	130*(1)*	123*(2)*	99*(4)*
Biodiversity and forestry	115*(3)*	101*(4)*	113*(3)*
Health, socio-economy and culture	111*(4)*	107*(3)*	132*(1)*
Climatic variables	124*(2)*	129*(1)*	120*(2)*
Chi-Square	21.852	24.953	25.704
DF	3	3	3
Pr > Chi-square	0.036	0.002	0.001

4.5. Determinants of Climate Change Risk Perception

Results of the regression model of determinants of climate change risk perception are presented in Table 8. Two demographic variables (i.e., age and education) are significant predictors of climate change risk perception. Also, gender, income and marital status are not predictors of climate change risk perception in agriculture. The perceived probability of increased droughts, dry spells and floods is also a significant predictor of farmers' climate change risk perceptions. Similarly, perceived likelihood of increasing temperatures and worsening harmattan winds are supported by the analytical results as significant determinants of climate change risk perception.

In the case of variables relating to risk impacts on agricultural production, perceived probability of increase in pests and disease is found to be a significant determinant of climate risk perception. In addition, perceived probability of decrease in crop yield, cropping area, soil fertility and increase in cost of production are all found to be predictors of farmers' climate risk perception. The variables pertaining to climate risk impacts on biodiversity and forestry (i.e., perceived probability of decrease in forest area, reduction in bird and animal species and reduction in plant and forest species) were all found to be predictors of farmers' risk perceptions, but not statistically significant.

With regards to health and socio-economic factors, perceived severity of consequences on human diseases and mortality, and on food security and incomes are significant predictors of farmers' climate risk perception. Perceived severity of increased migration is found not to be a predictor of risk perceptions in Lawra district. Under psychological factors, farmers' perceived probability to control risk was found not to be a predictor of climate risk perception.

Table 8. Estimated results of determinants of climate risk perception of farmers in Lawra district (N = 100).

	Variables	B	SE B	β	VIF
Demographic features	Age distribution	0.086	0.155	0.388 **	1.708
	Gender distribution	−0.022	0.207	−0.054	5.094
	Marital status	−0.042	0.187	−0.220	2.306
	Education level	0.072	0.205	0.015 **	4.294
	Income	1.221	0.084	0.458 **	5.442
Factors related to climatic variables	Perceived probability of droughts, floods and dry spells	0.015	0.217	0.185 **	0.024
	Perceived probability of increased temperature	0.096	0.112	0.113 *	0.255
	Perceived probability of worsening harmattan conditions	0.016	0.072	0.011 *	0.039
Health and socio-economic factors	Perceived severity of consequences on human diseases and mortality	0.268	0.104	0.056 *	0.524
	Perceived severity of consequences on migration	−0.125	0.069	−0.042	0.469
	Perceived severity of consequences on food security and incomes	0.125	0.069	0.188 *	0.469
Biodiversity and forestry factors	Perceived probability of reduction in plant and forest species	0.221	0.095	0.144	0.645
	Perceived probability of reduction in bird and animal species	0.433	0.169	0.199 *	0.665
	Perceived probability of decrease in forest area	0.046	0.079	0.213 *	0.129
Factors related to agricultural production	Perceived probability of decreased crop yield	0.155	0.447	0.413 *	1.123
	Perceived probability of decrease in cropping area	0.265	0.096	0.131 *	1.608
	Perceived probability of increase in pests and diseases	0.128	0.036	0.100 *	0.688
	Perceived probability of increase in cost of production	0.081	0.045	0.204 **	0.434
	Perceived probability of decrease in soil fertility	0.281	0.077	0.132 *	0.799
Psychological factors	Perceived ability to control risk	−0.262	0.055	−0.017	0.736
	R square			0.832	
	F for change in R square			7.702	

Notes: ** indicates significant level at 5% and, * indicates significant level at 10%.

5. Discussion

Farmers have concerns and anxieties about climate change considering that about 93% of respondents have perceived climate risks. The obtained results are in line with previous findings that a significant number of farmers believed that temperature had already increased and precipitation had declined for eleven African countries [27]. The results of focus group discussions (FGDs) also showed that there was an increase in out-migration for greener pastures in Southern Ghana. Similar results were obtained in India, where migration and poverty were identified as perceived farmers' climate change risks [26]. Other climate change risks perceived by farmers include: increase in human diseases (e.g., fever), decrease in cropping area, worsening harmattan winds, increase in cost of production, decrease in food security and incomes, decrease in forest area (i.e., due to deforestation), reduction in plant, tree, bird and animal species and decrease in soil fertility.

Also, the results show that resource-poor farmers perceive climate risks more highly than resource-moderate and resource-rich farmers. This finding is likely the case because results of the FGDs showed that resource-moderate and -rich farmers have alternative sources of income (e.g., trading, artisan jobs, etc.), and as such some of them were unlikely to pay attention to climate change risk impacts. Since rain-fed agriculture is the main source of livelihood for resource-poor farmers, they are more likely to observe and feel the impacts of extreme climate change events. Findings of similar studies have also shown that poor farmers are more concerned about climate change risks [28].

Generally, resource-poor farmers are very concerned about climate-risk impacts on agricultural production, while resource-moderate and resource-rich farmers are concerned about risk impacts on climatic variables and health and socio-economy, respectively. The findings obtained from the FGDs confirmed the results of the analysis. Resource-moderate and -rich farmers are more able to meet the financial demands of adaptation to climate change and are therefore unlikely to perceive the full impacts of climate change risks on the farming activities. This finding is consistent with the results of previous studies [28].

In addition, the findings showed that education and age are significant predictors of risk perception. The positive coefficient for age indicates that older farmers are more concerned about climate change risk on agriculture than their younger counterparts. With regards to education, the results imply that educated farmers are more likely to be concerned about climate change risk because they are more knowledgeable due to their ability to access global, regional and country-level information and discussions about the risks and impacts of climate change. The results are consistent with findings of farmers' climate change risk perceptions in Mexico and India that showed that age, farming experience and education were significant determinants of risk perception [28,29]. However, gender, marital status and income status are not predictors of climate change risk perception in agriculture.

Also, farmers' anxieties about increased droughts, dry spells, floods, temperatures and worsening harmattan winds are identified as factors influencing climate change risk perception. These findings are in line with results obtained from the focus group discussions. Farmers claim that they have apprehensions and concern about abnormal variability in precipitation and temperature trends because these factors constitute the most immediate and noticeable effects of climate change [26].

Farmers' concerns about an increase in pests and disease, perceived probability of a decrease in crop yield, cropping area, soil fertility and increase in cost of production are all found to be determinants of climate risk perception. These results are consistent with previous findings in Mexico, which showed that farmers' experience with coffee pests is a significant predictor of climate risk perception [29]. The results of the FGDs confirmed that farmers have perceived a decrease in crop yields and soil fertility and are concerned about the severity of future consequences of climate risk on their farm activities.

Furthermore, the results show that farmers' apprehensions about a decrease in forest area, reduction in bird and animal species and reduction in plant and forest species are predictors of farmers' risk perceptions. These results are likely the case, taking cognizance of the level of deforestation and desertification in the district. Further probing during the FGDs showed that farmers relied on deforestation as alternative income source (e.g., from firewood or charcoal) since recurrent droughts and dry spells constantly cause low crop yields. Also, the farmers claimed they are worried and concerned about a decrease in plant species and migration of certain birds and animal species due to adverse climatic effects.

The results also show that severity of increased migration is not a predictor of farmers' risk perceptions. This finding is quite intriguing considering the level of out-migration occurring in the district. Further probing during the FGDs showed that farmers believed out-migration for greener pasture in urban towns was purely for brighter economic opportunities rather than due to climate change.

Farmers' perceived ability to control risk is also not a predictor of climate risk perceptions in agriculture. This finding is consistent with results obtained from the FGDs. Farmers' concerns and apprehensions about the effects of climate change are reduced with increased ability and skills to control or adapt to the risk. Similar findings, such as that the long experience accumulated for generations by winegrowers in fighting powdery mildew under varying weather conditions provides a sense of confidence (controllability and manageability), show that that managerial skills tend to reduce risk perceptions [30].

6. Conclusions

Generally, farmers have perceived climate change risk. It is observed that farmers in Lawra district generally perceive climate risk impacts in terms of agricultural production, biodiversity and forestry, health and socio-economy, and climatic variables. Resource-poor farmers are concerned about climate risk on agricultural production, while resource-moderate and resource-rich farmers are concerned about risk impacts on climatic variables, and health and socio-economy, respectively. Factors related to impacts on climatic variables and agricultural production are significant determinants of farmers' climate change risk perception. The psychological factor (i.e., perceived ability to control risk) is not a predictor of risk perception. Biodiversity and forestry related factors are also found to be predictors of climate change risk perception. In terms of impact on health and socio-economy, only perceived increase in human disease and mortality, and decrease in food security and incomes are predictors of

risk perception. Finally, demographic features such as education and age are significant predictors of risk perception while gender, marital status and income status are not. Based on the results, it is essential for governments and policy makers to make climate risk communication and awareness an integral part of climate change policy. The risk impacts of climate change on human health, migration and other socio-economic factors need to be adequately identified and mainstreamed into climate risk communication policy. This will improve farmers' concerns about, and ensure enhanced adaptation to climate change. In addition, considering that the majority of farmers in Lawra district are resource-poor and are concerned about climate risk impacts on their farming activities, it would be appropriate for government and development partners to establish and promote irrigation in the area. Further, research scientists and agricultural staff could collaborate to develop and promote appropriate climate change adaptation alternatives (e.g., drought-tolerant and early maturing crop varieties). The finding that farmers have perceived decreasing tree, plant, bird and animal species requires that the government, forestry commission, plant protection agency, environmental protection agency and other development partners take steps to restore and protect the ecosystem against climate change impacts. These findings are worth further investigation to identify how perceptions of the different wealth categories of farmers are influenced by the various climate risk phenomena and impacts. The outcome of such an investigation will further enhance the formulation of appropriate climate risk communication models and policies to meet different target groups.

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