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Predictors of access to and willingness to pay for climate information services in north-eastern Ghana: A gendered perspective

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ABSTRACT

Access to useful climate information is critical for adaptation needs of African smallholder farmers, yet empirical studies documenting the socioeconomic, environmental and household predictors of access to and willingness to pay for climate information services from a gendered perspective have been limited to date. This paper addresses this research need by identifying the predictors of access to and willingness to pay for climate information by smallholder farmers in north-eastern Ghana, a "vulnerability hotspot" where slight changes in rainfall often result in considerable yield losses. The study uses data collected from 193 household surveys in 2 communities across 2 districts in the Upper East region of Ghana. The logit regression was performed based on a disaggregated procedure. Our findings suggest that the majority of smallholder farmers were not willing to pay for the cost of receiving climate information. Results show that only 50% (n = 121) of the male farmers compared with just 31% (n = 72) of female farmers were willing to pay for climate information. The results from the marginal analysis suggest that access to climate information is influenced by both household and environmental factors. The marginal effects logistic regression shows statistically significant differences in the predictors of access and willingness to pay for climate information based on gender. Findings highlight that the provision of climate information should be designed and tailored to meet the needs of smallholder farmers with different socioeconomic backgrounds to enable farmers manage climate risks and build adaptive capacity. The Ghana Meteorological Agency needs to be supported through capacity building on communication to provide targeted climate information for farmers in this climate "vulnerability hotspot".

1. Introduction

Increasing evidence shows that climate change is affecting socio-ecological processes across the globe (Intergovernmental Panel on Climate Change (IPCC), 2014) with greatest adverse effects felt across sub-Saharan Africa. The region is witnessing a warming trend, with frequent incidence of extreme heat events, shifts in rainfall patterns and increases in the occurrence of droughts (IPCC, 2018). Due to the region's high level of dependence on rain-fed agriculture, any slight changes in the rainfall patterns lead to devastating

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repercussions on the livelihoods of millions of households (Serdeczny et al., 2017).

Ghana typifies the vulnerability of sub-Saharan Africa. Historical data has shown a shift in climatic conditions in all ecological zones with temperatures rising whereas precipitation levels are decreasing; and increasingly becoming erratic (Asante and Amuakwa-Mensah, 2015). Consequently, climate change presents considerable threats to food production in Ghana (Chemura et al., 2020; Kyei-Mensah et al., 2019; Asante and Amuakwa-Mensah, 2015), particularly in the Upper East region, which experiences unimodal rainfall pattern that determines the farming season and crop yield (Antwi-Agyei et al., 2012).

Agriculture contributes significantly to Ghana's Gross Domestic Product and provides employment to millions of low-income families across the country. Recognising the effects of climate change on agriculture in Ghana, smallholder farmers will need to be supported through the provision of accurate and timely Climate Information Services (CIS) to provide useable information on climate change risks affecting their livelihoods.

Climate information services can be used to direct and guide adaptation practices towards climate change effects and national development (Nkiaka et al., 2019; Vaughan et al., 2019; Singh et al., 2018). This is particularly crucial for developing countries whose economies depend on rain-fed agricultural systems. Launched in 2009, the Global Framework for Climate Services has been functional since 2012 and it is mandated to facilitate timely access to climate services (Hewitt et al., 2012). Climate information can be a useful tool in farm management and livelihood decision-making to improve food security (Vaughan et al., 2019). Recent studies (including Nyadzi et al., 2018; Ouedraogo et al., 2018) have revealed that farmers use climate information in a variety of ways including important cropping decisions such as when to plant, apply fertilizers and the varieties of crops to grow.

Farmers in northern Ghana obtain climate information from Ghana Meteorological Agency with limited number receiving some information from private providers such as Esoko and Farmerline (Nyamekye et al., 2019). Identifying what kinds of climate information farmers are accessing, using and would be willing to pay for will guide efficient delivery of effective climate information services (Vincent et al., 2020). Policymakers will need to understand the type of climate information consumers are willing to pay for, in order to guide policy decisions. This is critical for the sustainability of climate services as private sector players assume greater role in providing climate information to users.

Smallholder farmers' decision and willingness to pay for climate information is influenced by the expected benefits to be derived from the use of such information. Based on the utility maximization theory, a smallholder farmer considers how to attain the highest level of utility from the payment and utilisation of climate information (Adzawla et al., 2019; McConnell and Leibold, 2009).

Gender-based vulnerability to climate change is well documented and there is a growing research interest on gender and climate change adaptations (e.g. Gumucio et al., 2020; Partey et al., 2020; Adzawla et al., 2019; Jin et al., 2015; Terry, 2009). Several studies have reported that women are more sensitive to the effects of climate change (Goodrich et al., 2019; Van Aelst and Holvoet, 2016) due to their limited access to productive and economic assets and resources that are needed to enhance the resilience of their livelihoods. In many cases, women are also marginalised and are often constrained in decision-making, further limiting their adaptive capacities (Assan et al., 2020; Carr and Thompson, 2014). Climate information may be used as a climate smart agricultural tool in building the capacity of farmers in dryland farming systems to address climate risks. To this end, several studies have documented the need to enhance access to climate information for improved agricultural productivity in Ghana (Naab et al., 2019). However, it is not clear how the access and utilisation of climate information is influenced by gender-related factors especially in the context of rural households.

Despite the differential climate change effects on women and men, studies documenting the predictors of access to and willingness to pay for climate information from a gendered perspective in Africa has been limited to date (e.g. Diouf et al., 2019; Muema et al., 2018). This paper addresses this research gap by identifying the socioeconomic predictors of access to, and willingness to pay for, climate information by smallholder farmers in north-eastern Ghana. The paper provides answers to the following key questions: (i) what climate information are smallholder farmers in the north-eastern Ghana accessing and using? (ii) what are the predictors of access to climate information in this region? (iii) are there gender differences in willingness to pay for climate information among smallholder farmers in this region?

2. Intersectionality, gender and climate change vulnerability

Intersectionality was first coined in the field of critical race theory in the 1990s in response to binary categorisation of gender as women versus men (Crenshaw, 1991). Intersectionality defines the interactions between socioeconomic characteristics such as gender, ethnicity, cultural ideologies and other social practices and how the outcomes of such interactions influence power within a particular society (Davis, 2008). As a concept, intersectionality provides opportunity to probe critical questions relating to the norms and power structures that influence interventions on climate change (Kaijser and Kronsell, 2014). Hathaway (2020) explains that the extent to which individuals and communities manifest climate change vulnerability is a function of complex, and usually, multifaceted factors.

In the climate change literature, gender is often treated as a dichotomy with no consideration to power dynamics and socio-political contexts within which climate change issues are located (Djoudi et al., 2016). The incorporation of gender perspective into global environmental research has been insufficient and fragmented (Carr and Thompson, 2014). However, a growing body of literature suggests the indivisibility of gender issues and climate change (Hathaway, 2020). The capacity to appropriately respond to climate change effects by individuals and groups is often determined by social characteristics including gender, ethnicity, nationality, age and place (Kaijser and Kronsell, 2014). Individuals and groups are located within broader socioeconomic and political structures and their ability to respond to climate risks and threats is influenced by power relations that control access to economic and productive resources and information needed by households to confront the challenges posed by changing rainfall and temperature patterns (Djoudi et al., 2013). Hence, gender and socio-economic characteristics such as age, nationality and ethnicity determine, to a large extent, the climate resilience of agricultural systems (Harris, 2010).

Inequalities are more pronounced in developing countries where the majority of women and other marginalised groups depend on subsistence agriculture and natural resource-based livelihoods that are often threatened by climate change. Kaijser and Kronsell (2014) report that, studies and political initiatives focusing on single variable (including age, gender, social class, etc.) provide valuable lessons on power relations on climate change effects. However, such studies often fail to consider how such variables are intertwined with and sometimes strengthened by various societal structures of domination. According to Kaijser and Kronsell (2014), there is a tendency to reduce the gender aspect as narrow man–woman binaries, where women are often portrayed as weaker and marginalised victims.

Intersectionality has gained prominence in studies related to gender and climate change adaptation (Goodrich et al., 2019), and this study applies an intersectionality lens to interrogate the socioeconomic factors that determine access to, and willingness to pay for climate information in dryland farming systems in north-eastern Ghana.

3. Study area and methods

3.1. Study area

The study was conducted in the Upper East region in north-eastern Ghana (Fig. 1). Previous studies have identified the Upper East region to be the most climate sensitive region in Ghana, making smallholder farmers highly vulnerable to climate factors (Antwi-Agyei et al., 2012). The region has the highest proportion of poor people depending on climate-sensitive rain-fed agriculture and is characterised by low levels of infrastructural development and adaptive capacity. Within the Upper East region, two local assemblies, the Bawku West District (semi-urban area) and Kassena Nankana Municipal (urban area) were purposefully selected (Fig. 1) because they represent climate "vulnerability hotspots" (Issahaku et al., 2016; Antwi-Agyei et al., 2012).

With an estimated population of 90,034, the Bawku West District has Zebilla as its capital town (GSS, 2014a). The district experiences a unimodal rainfall pattern with an average annual rainfall of 956 mm (GSS, 2014a). Agriculture provides employment (either as farmers or as labourers) to about 80% of the population in the district (GSS, 2014a). The Kassena Nankana Municipal has Navrongo as its political capital with an estimated population of 109,944 (GSS, 2014b). Agriculture provides employment to about 83% of the population (either as farmers or as labourers) in the municipality (GSS, 2014b). The municipal has a generally low-lying undulating landscape. The average annual rainfall in the municipality is 950 mm (GSS, 2014b).

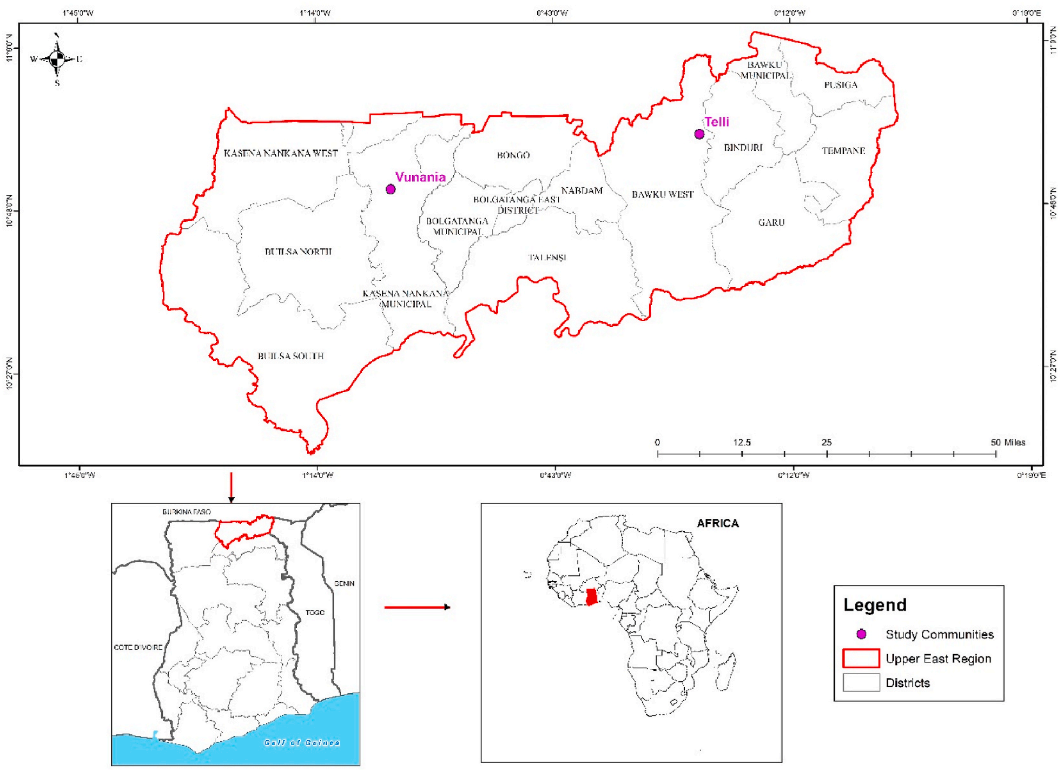

Fig. 1. The Upper East region showing study communities

Two farming communities – Vunania (from Kassena Nankana Municipal) and Telli (from Bawku West District) were selected because of their levels of climate vulnerability and advice from local district and municipal agricultural extension agents and development officers.

3.2. Study methods

Data for this study were collected in September and October 2019 with 193 household surveys administered in the 2 farming communities with the help of CSPro software (Ponnusamy, 2012). Data collection started with rapid rural appraisal to understand the significant ecological and socioeconomic characteristics of the study communities. The rapid rural appraisal also provided opportunity for the research team to introduce the research to the study communities. Households within the study communities were randomly selected and the head of the household or his/her representative interviewed. Interviews generally took between 45 min and 1 h 30 min. The questionnaires were pre-tested and related to background socio-economic characteristics of households, past experience of climate shocks and climate information needs at a household level. Other questions related to whether farmers were willing to pay for climate information and the types of climate information they were hoping to access and use in the future. The administration of household questionnaire was preceded by 2 regional stakeholder workshops held in Bolgatanga and Navrongo in September and October 2019 to map out the landscape of climate information services delivery in the Upper East region, Ghana. The outcomes of the workshops provided opportunity to fine-tune the final data collection instruments. A third workshop was held in Bolgatanga in February 2020 to disseminate the findings of the research and provided opportunity for workshop participants to feedback on the preliminary analyses. During this workshop, ways of improving delivery of CIS in Ghana were solicited. Study participants were assured of anonymity and made to understand that their participation in the study was voluntary.

3.3. Econometric estimation

To investigate the socio-economic predictors that influence access to, use of, and willingness to pay for receiving climate information services, the logit regression technique was applied (Deressa et al., 2009). The analysis was performed following a disaggregated procedure. Three procedures were designed. The baseline regression involved a global analysis where all the data were used in the estimation. A gendered perspective was then applied, in the second and third stages, following the global analysis. To identify the best-fit model that explains the predictors of access and willingness to pay for climate information, a number of estimations were conducted. We then employed the Hausman test to select the best-fit model for access and willingness to pay for climate information (Deressa et al., 2009). The estimation was adjusted for potential biases using the bootstrap methods with 1000 replications whilst accounting for heteroscedasticity. The cluster-adjusted standard errors robust for heteroscedasticity was used to remove any collinearity problems associated with survey data.

In the initial run, the logit estimation technique was employed to examine the factors influencing a farmer's probability of accessing climate information as well as the willingness to pay for the cost of receiving CIS. This illustrated the baseline regression, which comprised all sampled farmers of the survey. To examine the gender differences in climate information access and willingness to pay, the analysis was segmented focusing on the gender of the respective farmers. To describe the logit model, we focused on a case where the response y_i (denoting access to climate information) is a binary variable such that:

$$y_i = \begin{cases} \dfrac{1 \text{ if the ith farmer has access/is willing to pay for CIS}}{0 \text{ otherwise}} \end{cases} \tag{1}$$

It is assumed that y_i follows a Bernoulli distribution with parameter π_i, which can be written as

$$P(Y_i = y_i) = \pi_i^{y_i}(1 - \pi_i)^{1-y_i} \tag{2}$$

for $y_i = 0, 1$. Note that if $y_i = 1$ then we can obtain π_i, which is the probability of making a decision to access and pay for climate information. By denoting x as the set of independent variables illustrating the individual and environmental attributes which may determine access to climate information; then the probability that a farmer gains access or is willing to pay for CIS conditioned on the x is given by

$$P(y = 1|x) = \pi_i = \frac{\exp\{x_i'\beta\}}{1 + \exp\{x_i'\beta\}} \tag{3}$$

where *exp* is exponent and β represents the unknown parameter to be estimated.

Equation (3) is then estimated in two blocks; focusing on access to climate information and willingness to pay, respectively. As equation (3) yields parameter estimates that do not reflect the probabilities nor the magnitude of change, they are only appropriately interpreted in relation to the direction of effect of the independent variables on the dependent variables (access to CIS and willingness to pay). Since our focus is on finding out the factors that determine access to climate information as well as the extent of their use, we consider the marginal effects of the explanatory variables based on the logit model. According to Green (2000), this requires differentiating equation (3) with respect to the independent variables such that:

$$\frac{\partial P(y_i = 1|\boldsymbol{x}_i)}{\partial \boldsymbol{x}_{ij}} = \beta_j \pi_i (1 - \pi_i) \tag{4}$$

where y is the dependent variable, x is the vector of explanatory variables, π_i is the predicted probability of success, p is the probability of making a decision to access and to pay for climate information, and β represents the unknown parameter to be estimated. Equation (4) therefore gives the derivative of the probability of the outcome, y, occurring given a unit change in explanatory variables, and this generates the marginal change in the predicted probability as a result of a unit change in the explanatory variables, x. Having obtained the marginal effects, the study proceeded to investigate the factors predicting the gender differences in climate information access and willingness to pay. The differences in the impact of each explanatory variable on the dependent variables between female and male farmers were calculated using the two-proportion z-test, which is used for comparing independent samples; particularly where the outcome of interest is discrete or dichotomous.

The explanatory variables used are shown in Table 1. The explanatory variables include household characteristics (such as age, gender, marital status, and membership of a social organization or faith-based group), financial characteristics (such as access to credit, government subsidies, and receipt of remittances), and farming characteristics (such as farming experience, irrigation facilities, extension services, procedure of land acquisition, and access to labour). Other variables included asset ownership (such as land size, mobile phones, and television sets) as well as institutional or environmental factors (such as electricity, drought experience, training, seeds for sowing, internet access, access to ready market, and months household struggle to find food). We observed marginal differences in socio-economic characteristics between male and female farmers sampled; notwithstanding this, we can conclude that a fair balance exists between male and female socioeconomic characteristics (Table 1). This provides support for group invariance and engenders adequate support for group comparison of access to, use of, and willingness to pay for climate information.

Table 1
Description of variables

Explanatory Variables	All Sample (N = 193)		Female (N = 72)		Male (N = 121)		Description
	Mean	SD	Mean	SD	Mean	SD	
Educational level	2.71	1.96	2.44	1.91	2.87	1.98	Categorical. 1 = None; 2 = Primary; 3 = JSS; 4 = Middle; 5 = SSS; 6 = Voc/Tech/Com; 7 = Post Sec; 8 = Bachelor; 9 = Postgraduate
Marital status	3.10	0.93	3.42	1.20	2.91	0.66	Categorical. 1 = Never married; 2 = Living together; 3 = Married; 4 = Divorced; 5 = Separated; 6 = Widow
Household size	6.05	3.24	5.76	3.28	6.21	3.23	Continuous
Access to extension services	0.79	0.41	0.72	0.45	0.83	0.38	Dummy takes the value of 1 if there is access and 0 if there is no access
Native of study community	0.64	0.48	0.40	0.49	0.79	0.41	Dummy takes the value of 1 if respondent comes from the community and 0 otherwise
Years in farming	3.19	1.21	2.85	1.22	3.39	1.17	Categorical. 1 = 0–4 years; 2 = 5–9 years; 3 = 10–19 years; 4 = 20–29 years; 5 = 30+
Experienced drought	0.80	0.40	0.76	0.43	0.83	0.38	Dummy takes the value of 1 if experienced it and 0 if the farmer does not
Training	0.42	0.49	0.43	0.50	0.41	0.49	Dummy takes the value of 1 if received and 0 if the farmer does not receive
Months household struggles for food	2.29	1.94	2.04	2.06	2.44	1.86	Continuous
Save seeds for next cropping season	0.91	0.29	0.86	0.35	0.93	0.25	Dummy takes the value of 1 if there is and 0 if the farmer does not save seeds
Age of respondent	49.15	14.72	48.63	15.00	49.47	14.60	Continuous
Member of a social organization	0.31	0.46	0.38	0.49	0.26	0.44	Dummy takes the value of 1 if belongs and 0 if a farmer does not belong to social organization
Member of a faith-based group	0.63	0.48	0.65	0.48	0.62	0.49	Dummy takes the value of 1 if belongs and 0 if a farmer does not belong to any faith-based group
Procedure for land acquisition	3.12	1.20	3.11	1.31	3.12	1.14	Categorical. 1 = Land purchased; 2 = Rented; 3 = Inherited; 4 = Other
Land size for farming	1.41	0.56	1.32	0.50	1.46	0.59	Categorical. 1 = less than 3 ha; 2 = 3–6 ha; 4 = More than 6 ha
Credit facilities	0.28	0.45	0.28	0.45	0.29	0.46	Dummy takes the value of 1 if there is access and 0 if there is no access to credit facilities
Ownership of livestock	0.93	0.25	0.90	0.30	0.95	0.22	Dummy takes the value of 1 if owns and 0 if the farmer does not own livestock
Receive remittances	0.37	0.48	0.38	0.49	0.36	0.48	Dummy takes the value of 1 if regular remittance recipient and 0 if the farmer does not receive
Receive government subsidies	0.77	0.42	0.72	0.45	0.79	0.41	Dummy takes the value of 1 if a recipient of subsidies and 0 if the farmer does not receive
Access to ready markets	0.49	0.50	0.44	0.50	0.52	0.50	Dummy takes the value of 1 if there is access and 0 if the farmer does not
Access to irrigation facilities	0.08	0.28	0.03	0.17	0.12	0.32	Dummy takes the value of 1 if there is access and 0 if there is no access
Electricity in the house	0.82	0.39	0.86	0.35	0.79	0.41	Dummy takes the value of 1 if there is access and 0 if there is no access
Access to television	0.67	0.47	0.71	0.46	0.65	0.48	Dummy takes the value of 1 if there is access and 0 if there is no access
Access to radio	0.85	0.36	0.78	0.42	0.89	0.31	Dummy takes the value of 1 if there is access and 0 if there is no access
Internet accessibility	0.30	0.46	0.31	0.46	0.29	0.46	Dummy takes the value of 1 if there is access and 0 if there is no access
Access to mobile phone	0.85	0.36	0.85	0.36	0.85	0.36	Dummy takes the value of 1 if there is access and 0 if there is no access
Access to labour	0.86	0.35	0.81	0.40	0.89	0.31	Dummy takes the value of 1 if there is access and 0 if there is no access

Table 2
Descriptive statistics of explanatory variables

Explanatory variables	All sample (n = 193)		Female (n = 72)		Male (n = 121)	
	%	SD	%	SD	%	SD
No formal education	44.3	0.50	51.4	0.50	40.2	0.49
Married	84.5	0.36	76.4	0.43	89.3	0.31
Native of study community	64.2	0.48	40.3	0.50	77.9	0.36
Training	42.0	0.50	43.1	0.50	41.0	0.50
Member of a social organization	30.6	0.46	37.5	0.48	26.2	0.42
Credit facilities	28.5	0.43	27.8	0.45	28.7	0.46
Government subsidies	76.3	0.42	72.2	0.47	78.7	0.46
Access to ready markets	49.2	0.50	44.4	0.50	51.6	0.50
Receive remittances	36.8	0.48	37.5	0.49	36.4	0.48
Irrigation facilities	8.30	0.28	2.80	0.17	11.5	0.32
Access to television	67.0	0.47	70.8	0.45	64.8	0.47
Access to mobile phone	85.0	0.36	84.7	0.36	84.4	0.36
Internet accessibility	29.5	0.46	30.6	0.46	28.7	0.46
Access to radio	85.0	0.36	77.8	0.42	88.5	0.31
Experienced drought	80.3	0.40	76.4	0.43	82.0	0.38
Save seeds	90.7	0.26	86.1	0.35	92.6	0.25
Age of respondent[a]	49.2	14.7	48.6	15.0	49.5	14.6
Farming experience[a]	3.19	1.21	2.85	1.22	3.39	1.17
Months household struggles for food[a]	2.29	1.94	2.04	2.06	2.44	1.86

[a] Values in means.

4. Results

4.1. Socio-demographic attributes of study respondents

Close to half of the study respondents (44%) reported having no formal education, with the majority having only basic education (Table 2). In terms of gender, 51% of the sampled female farmers have had no formal education relative to 40% of male farmers. The mean age of study respondents is about 49 years. This indicates that the majority of the study households fall outside the productive cohort. Agriculture in Ghana is labour intensive, which makes it difficult for the less able-bodied to carry out the farming practices required to ensure reasonable yield. With reference to the gender distribution, the results reveal that about 61% of the study respondents are males with an average age of 50 years. We also observed that generally 63% of the study respondents belonged to faith-based groups with only 31% belonging to some kind of social organization. Again, the distribution is similar between male and female farmer groups based on this dimension of social capital endowment.

Table 2 further shows that 80% of the respondents have experienced drought in these communities. Male farmers also have more access to irrigation facilities (12%) and radios (89%) compared to female farmers. About 3% of female farmers had access to irrigation facilities and 78% to radios. We also sampled more (78%) native male farmers (farmers who are natives of the study communities) compared to native female farmers (40%). A greater proportion of male farmers (93%) also reported saving seeds for next cropping in comparison to female farmers (86%).

4.2. Types of climate information farmers are willing to pay

The results reveal that the majority of the smallholder farmers are not ready to pay for receiving climate information (Table 3). Only 50% (n=121) of the male farmers compared with just 31% (n=72) of female farmers are willing to pay for receiving climate information (Table 3). The results further indicate that smallholder farmers' unwillingness to pay for climate information cuts across all climate information types for both male and female farmers (Table 4a).

The results further suggest that male farmers have more access to weekly and monthly forecast compared to their female counterparts (Table 4b). Regarding gender differences in access to climate information, Table 4b demonstrates that a significant percentage of male farmers received monthly and weekly forecasts relative to female farmers.

4.3. Socioeconomic predictors of access to climate information

The parameter estimates and the marginal effect results of the logit regression for predictors of access to climate information are reported in Tables 5a and 5b, respectively. It shows that socioeconomic factors including age, gender, level of farming experience, training, credit facilities, asset ownerships and membership of a social group are all predictors of smallholder farmer's access to climate information. In terms of access to climate information, the analysis shows that the age of a farmer is a key determining factor, with a level of significance at 10%. It indicates that younger farmers are more likely to access climate information than old or matured farmers. According to the marginal effect estimates, a unit increase in farmers' age is detected to lead to a decrease of 0.5% reduction in the probability to receive climate information.

Table 3
Willingness to pay for climate information in study communities

Sex	Mean	Std. Deviation	Std. Error Mean	T-value	P-value
Female	.31	.464	.055	−2.788	.006
Male	.50	.540	.046		

Table 4a
Type of climate information and willingness to pay by smallholder farmers

	All Sample (n = 193)		Female (n = 72)		Male (n = 121)		Difference (Female – Male)		
	N	%	N	%	N	%	N	%	*p*-value
Seasonal Forecast	41	21.2	13	18.1	28	23.1	−15	−5	.821
Monthly Forecast	40	20.7	13	18.1	27	22.3	−14	−4.2	.782
Weekly Forecast	31	16.1	9	12.5	22	18.2	−13	−5.7	.108
Daily Forecast	47	24.4	16	22.2	31	25.6	−15	−3.4	.365
Windstorms	16	8.3	5	6.9	11	9.1	−6	−2.2	.108
Lightning	5	2.6	2	2.8	3	2.5	−1	0.3	.985
Heavy Rainfall	37	19.2	12	16.7	25	20.7	−13	−4	.131
Onset of the Rains	27	14.0	9	12.5	18	14.9	−9	−2.4	.821

Table 4b
Gender differences in access to climate information

	All Sample (N = 193)		Female (N = 72)		Male (N = 121)		Difference (Female – Male)		
	%	N	%	N	%	N	%	S.E	*p*-value
Seasonal Forecast	18.6	36	20.5	15	17.4	21	3.2	5.9	0.582
Monthly Forecast	10.3	20	4.1	3	14.0	17	−9.9	3.9	0.027
Weekly Forecast	7.7	15	4.1	3	14.0	17	−9.9	4.1	0.016
Daily Forecast	36.1	70	9.6	7	6.6	8	3.0	7.1	0.681
Windstorms	9.8	19	34.2	25	37.2	45	−2.9	4.5	0.158
Rainfall	15.5	30	11.0	8	9.1	11	1.9	5.1	0.582

Table 5a
Logistic regression on access to climate information by smallholder farmers

	All Sample		Female		Male	
	Coefficient	*P*-value	Coefficient	*P*-value	Coefficient	*P*-value
Age	−0.030*	0.100	−0.016	0.527	−0.028	0.253
Sex	0.875**	0.029				
Farming experience	0.479**	0.015	0.172	0.658	0.576**	0.026
Experienced drought	0.997*	0.076	0.563	0.586	1.979**	0.035
Training	0.928**	0.039	2.554***	0.004	−0.169	0.951
Months household struggles for food	−0.252**	0.035	−0.345	0.201	−0.275*	0.084
Credit facilities	0.574	0.257	0.570	0.442	1.534**	0.034
Government subsidies	1.111**	0.013	1.979**	0.030	0.415	0.468
Access to ready markets	0.824**	0.037	0.031	0.899	0.949*	0.072
Access to television	0.636	0.192	1.293	0.113	−0.057	0.847
Access to radio	−0.568	0.269	−0.547	0.404	−0.322	0.726
Internet accessibility	−0.814	0.163	−1.181	0.246	−0.599	0.434
Access to mobile phone	−0.128	0.699	0.496	0.836	0.011	0.963
Member of a social organization	−0.791***	0.004	−2.303**	0.048	−0.477***	0.000
Educational level	0.347*	0.096	0.144	0.616	0.661***	0.005
Native of study community	−0.654*	0.062	−0.417	0.107	−1.281*	0.092
Save seeds	−1.089	0.126	−0.408	0.532	−1.535	0.241
Irrigation facilities	−1.346**	0.049	−1.087	0.260	−0.464	0.735
Constant	−0.444	0.785	−1.473	0.753	−0.076**	0.026
Observations	193		72		121	
−2 Log likelihood	188.755		69.383		99.886	
P-value > Chi Square	0.000		0.002		0.000	
Pseudo R-square	0.321		0.419		0.355	

*,**,*** denotes parameter estimates are significant at 10%, 5% and 1% respectively.

Table 5b
Marginal effects on access to climate information by smallholder farmers

	All Sample		Female		Male		Difference	
	dy/dx	*P*-value	*dy/dx* (M_f)	*P*-value	*dy/dx* (M_m)	*P*-value	$M_f - M_m$	*P*-value
Age	−0.005*	0.089	−0.002	0.521	−0.004	0.666	0.002	0.810
Sex	0.133**	0.024						
Farming experience	0.071***	0.009	0.022	0.657	0.075*	0.059	−0.053	0.119
Experienced drought	0.152*	0.068	0.066	0.587	0.262**	0.014	−0.196***	0.001
Training	0.155**	0.032	0.359***	0.001	−0.006	0.140	0.365***	0.000
Months household struggles for food	−0.034**	0.032	−0.040	0.216	−0.034**	0.026	−0.006	0.826
Credit facilities	0.086	0.243	0.071	0.426	0.197	0.891	−0.126**	0.018
Government subsidies	0.169***	0.009	0.257**	0.019	0.066	0.125	0.191***	0.002
Access to ready markets	0.130**	0.028	0.015	0.898	0.124*	0.099	−0.109**	0.008
Access to television	0.098	0.188	0.181*	0.082	−0.016*	0.056	0.197***	0.000
Access to radio	−0.088	0.263	−0.099	0.389	−0.034	0.208	−0.065*	0.063
Internet accessibility	−0.118	0.151	−0.142	0.219	−0.080	0.629	−0.062	0.171
Access to mobile phone	−0.034	0.699	0.034	0.837	−0.004**	0.023	0.038**	0.011
Member of a social organization	0.052***	0.002	0.316***	0.008	0.087	0.142	0.229***	0.000
Educational level	−0.097*	0.084	0.045	0.620	−0.167**	0.010	0.212***	0.000
Native of study community	−0.120*	0.061	−0.057	0.858	−0.062	0.566	0.005	0.889
Save seeds	−0.194	0.110	−0.079	0.529	−0.242	0.412	0.163**	0.005
Irrigation facilities	−0.199**	0.042	−0.203	0.257	−0.037**	0.037	−0.166**	0.000

*,**,*** denotes parameter estimates are significant at 10%, 5%t and 1% respectively.

The level of farmers' farming experience was found to significantly influence their accessibility to climate information. An increase in the number of years an individual has engaged in farming activities induces 7% increase in the probability of the farmer accessing climate information ($p = 0.009$). Farmer experience was also found to significantly predict male farmers' probability to access climate information but not female farmers. The z-test of difference shows no significant difference in the impact of farmers' experience on access to climate information among male and female farmers.

The marginal effect estimate shows that males who experience drought are more likely to access climate information (26.2%) but not females. The z-test of difference shows male farmers who have experienced drought are 19.6% more likely to access climate information relative to female counterparts ($p = 0.001$). Training shows a positive and statistically significant impact on farmers' accessibility to climate information. Undergoing a training program generally increases the probability of climate information access

Table 6a
Logistic regression on willingness to pay for climate information by smallholder farmers in study communities

	All Sample		Female		Male	
	Coefficient	*P*-value	Coefficient	*P*-value	Coefficient	*P*-value
Age	−0.024	0.421	−0.028	0.846	−0.022	0.288
Sex	1.105**	0.015				
Marital status	0.259	0.734	0.477	0.271	−0.100	0.771
Native of study community	−0.645	0.961	−1.248	0.761	−0.780	0.843
Experienced drought	0.210*	0.09	0.463	0.271	0.148	0.24
Training	0.919***	0.006	1.978***	0.007	0.532*	0.096
Months household struggles for food	−1.179**	0.018	−2.283**	0.011	−0.864	0.23
Save seeds	−0.183*	0.058	−0.225	0.695	−0.175	0.444
Credit facilities	1.186***	0.004	1.639**	0.017	0.846	0.135
Receive remittances	0.855**	0.044	0.907	0.892	0.955*	0.063
Government subsidies	−0.899**	0.045	−1.801**	0.030	−0.643	0.321
Accesss to ready markets	0.696*	0.070	1.182	0.406	0.846*	0.077
Access to television	0.736	0.155	0.389	0.630	1.110*	0.081
Access to radio	−0.949*	0.089	−1.066	0.231	−0.658	0.463
Internet accessibility	0.704	0.231	0.401	0.930	0.734	0.149
Access to mobile phone	−0.687	0.362	−0.814	0.731	−0.918	0.438
Health facility in the community	−1.302**	0.012	−1.929*	0.086	−1.466**	0.016
Access to labour	0.952	0.205	2.791*	0.094	0.544	0.617
Constant	−0.069	0.636	−1.670	0.866	2.444	0.228
Observations	193		72		121	
−2 Log likelihood	2526.204		651.212		1681.845	
P-value > Chi Square	0.01		0.002		0.002	
Pseudo R-square	0.290		0.551		0.252	

*,**,*** denotes parameter estimates are significant at 10%, 5% and 1% respectively.

by 15.5% ($p = 0.032$). However, if the farmer is a female, the probability increases by 35.9% ($p = 0.001$).

In the context of male farmers, the analysis shows that training has no significant impact. The z-test of difference reveals a 36.5% increase in the impact of training on access to climate information among female and male farmers ($p = 0.000$). The results of this study also reveal that poorer smallholder farmers who spend more time searching for food are generally less likely to access climate information. A unit increase in the average number of months the household struggle for food is associated with a 3.4% reduction in the probability of accessing climate information, for an average farmer.

The results indicate that access to credit facilities does not have a statistically significant impact on farmers' access to climate information (Tables 5a and 5b). However, it is identified that access to credit facilities increases a male farmer's probability to access climate information by approximately 12.6% compared to their female counterparts ($p = 0.018$).

The impact of government subsidies on access to climate information is also detected to be positive. Access to government subsidies increases farmer's probability of accessing climate information by 16.9% ($p = 0.009$). The influence of government subsidies on access to climate information is, however, identified to be strong among female farmers than their male counterparts. The z-test of difference shows that female farmers who benefit from government subsidies are 19.1% more likely to access climate information relative to their male counterparts ($p = 0.002$).

The analysis shows that on the average, the presence of a ready market increases a farmer's probability of accessing climate information by 13% ($p = 0.028$). When compared to the female counterparts, the analysis shows that the probability of accessing climate information due to the presence of ready market increases by 11% when the farmer is a male rather than a female ($p = 0.008$). The marginal influence of assets such as mobile phones, radio, televisions and internet were investigated. There was no evidence to suggest that ownership of these assets have any statistically significant influence on a farmer's probability of accessing climate information. Nonetheless, it is identified that access to television, enhances female farmers access to climate information ($p = 0.082$).

4.4. Socioeconomic predictors of willingness to pay

The parameter estimates and the marginal effect results of the logit regression for predictors of willingness to pay for climate information are reported in Tables 6a and 6b, respectively. Tables 6a and 6b show that there are gender differences in smallholder farmers' willingness to pay for receiving climate information services in north-eastern Ghana. The probability that a smallholder farmer will be willing to pay for the cost of receiving climate information will increase by 18.1% points ($p = 0.005$) when the farmer is a male rather than a female (Table 6b). The z-test of difference shows that access to labour, marital status, training, struggle for food, government subsidies, ready markets and television predict the differences in willingness to pay among male and female farmers. Struggle for food reduces the probability that a farmer will be willing to pay for climate information; however, the z-test of difference shows that the probability that a farmer is ready to pay for climate information reduces by 16.4% when she is a female ($p = 0.008$).

The results also show that for male famers, access to credit facilities increases probability of being willing to pay for climate information by 15.4% ($p = 0.022$). The implication is that access to credit facility is a strong predictor of male farmers' readiness to pay for climate information services compared to female farmers. Again, regular remittances were generally observed to increase a farmer's willingness to pay for climate information by 14.9%. In terms of male farmers, the results show an increase of 17.4% in the probability of being willing to pay for climate information. However, the results from the test of difference suggest that this is not significantly different from its effect on female farmers' readiness to pay for climate information (4.7%, $p = 0.384$).

Table 6b
Marginal effects on willingness to pay for climate information by smallholder farmers in study communities

	All Sample		Female		Male		Difference	
	dy/dx	*P*-value	*dy/dx* (M_f)	*P*-value	*dy/dx* (M_m)	*P*-value	$M_f - M_m$	*P*-value
Age	−0.004	0.800	−0.004	0.846	−0.004	0.280	0.000	0.957
Sex	0.181***	0.005						
Marital status	0.045	0.530	0.067	0.260	−0.018	0.771	0.085***	0.000
Native of study community	−0.112	0.110	−0.175	0.761	−0.142	0.843	−0.033	0.531
Experienced drought	0.037	0.152	0.065	0.259	0.027	0.230	0.038	0.200
Training	0.160	0.543	0.278***	0.001	0.097	0.183	0.181***	0.000
Months household struggles for food	−0.206***	0.001	−0.321***	0.003	−0.157*	0.071	−0.164***	0.008
Save seeds	−0.032*	0.064	−0.032	0.694	−0.141	0.440	0.109**	0.015
Credit facilities	0.207***	0.008	0.230***	0.007	0.154**	0.022	0.076	0.209
Receive remittances	0.149***	0.001	0.127	0.892	0.174**	0.049	−0.047	0.384
Government subsidies	−0.157**	0.026	−0.253**	0.016	−0.117	0.315	−0.136**	0.014
Access to ready markets	0.121**	0.040	0.166	0.400	0.154*	0.052	0.012	0.826
Access to television	0.128	0.198	0.055	0.628	0.202*	0.100	−0.147***	0.005
Access to radio	−0.166*	0.084	−0.150	0.217	−0.120	0.460	−0.030	0.549
Internet accessibility	0.123	0.684	0.056	0.930	0.134	0.136	−0.078*	0.087
Access to mobile phone	−0.120	0.211	−0.114	0.731	−0.167	0.434	0.053	0.317
Health facility in the community	−0.227***	0.000	−0.271*	0.068	−0.267***	0.009	−0.004	0.952
Access to labour	0.166	0.722	0.392*	0.097	0.099	0.616	0.293***	0.000

*,**,*** denotes parameter estimates are significant at 10%, 5%t and 1% respectively.

5. Discussion

The results indicate that the majority of the study respondents have experienced drought (Table 2). This finding concurs with other studies (e.g. Adzawla et al., 2019; Kumasi et al., 2019; Armah et al., 2010), suggesting that smallholder farmers in northern Ghana have experienced climate shocks including droughts and floods. The study communities are characterised by drought and high levels of poverty rates and climate vulnerability (GSS, 2014a) and this presents considerable challenges to the livelihoods of thousands of households within the region. Additionally, farmers across northern Ghana are often confronted with non-climatic stressors that interact with climate stressors to wreak havoc on food production systems, leading to food insecurity (Antwi-Agyei et al., 2017). Results further suggest that majority of the male farmers sampled are natives of the study communities compared to their female counterparts (Table 2). This has implications for access to productive resources including land, which can constrain a female farmer's efforts at implementing climate change adaptation practices in northern Ghana (Nyantakyi-Frimpong, 2020; Meinzen-Dick et al., 2019; Antwi-Agyei et al., 2015). A study by Bhadwal et al. (2019) highlighted that the lack of access to natural capitals was a predominant factor driving gendered vulnerabilities in the Eastern Himalayan region in India.

In terms of access to climate information, the age of a farmer was found to be a key determining factor, with younger farmers more likely to access climate information than older farmers. This finding is consistent with previous studies conducted in Kenya (Muema et al., 2018; Kirui et al., 2014) and Bangladesh (Uddin et al., 2014), suggesting that older farmers are less likely to use climate information because they might have accumulated a wealth of agro-ecological knowledge through years of farming that could help them to adapt their farming operations to climate change and variability. Farming experience, which is related to age, was also found to be a predictor of access to climate information, particularly for male farmers. Li et al. (2016) observed that income, education, age and gender, as well as public awareness and concerns about climate change were significant factors influencing willingness to pay for climate change mitigation in China.

Additionally, our analysis reveals that male farmers are more likely to access climate information in the study communities. This can be attributed to the gender roles played by women and the greater ease with which men can access climate information using radios and mobile phones compared to women-headed households. This finding is confirmed by other studies that have shown that men tend to be more responsive in adopting climate information partly because of access to communication devices and control over financial resources to purchase mobile phones (Partey et al., 2020). In a study conducted in the Upper West region of Ghana that shares similar ecological and climatic characteristics with the communities in the present study, Partey et al. (2020) observed that men demonstrated a higher tendency to use climate information services than women. This is because socio-cultural norms sometimes preclude female farmers from being invited to periodic, formal and informal meetings where farmers interact and exchange relevant information (Nyadzi et al., 2018). In Bangladesh, Ferdous and Mallick (2019) observed that women's access to and ownership of resources were shaped by the patriarchal norms that often limit their possibilities in accessing alternative opportunities that could increase their assets portfolio to address climate risks.

Training was found to be critical in accessing climate information in the study communities. In any process of change, willingness to act is key. The willingness to take action when confronted with climate risks involves change in beliefs and attitudes, and in Senegal Diouf et al. (2019) observed that, training and sensitizing women on the utility of climate information services is critical. Women in the northern region including the Upper East region have received considerable training and capacity building from government and development agencies aimed at building their resilience to climate stressors including erratic rainfall.

Our analysis demonstrates that poorer smallholder farmers who spend more time searching for food are generally less likely to access climate information. Interestingly, the impact on female farmers was revealed to be insignificant but not different from the impact on male farmers. This contrasts a priori expectation, as it was expected that the family roles performed by women would make them more susceptible to food supply shocks; influencing their decision to seek for environmental information including information on the climate.

Furthermore, the effect of membership of a social organization was detected to be stronger for female farmers compared to their male counterparts. This is consistent with earlier research findings in Senegal (Diouf et al., 2019) and Kenya (Muema et al., 2018) suggesting that farmers belonging to social organisations have higher likelihood of employing adaptation practices. In the study communities, women form cooperatives based on their common interests and these enable them to discuss their problems relating to agriculture, take collaborative action and access credit facilities for farming operations. This is sometimes being deliberately encouraged by Ghana's Ministry of Food and Agriculture to strengthen the capacity of women farmers to address climate change effects on their livelihoods. Being a member of an organization facilitates awareness of agrometeorological advisories that can be accessed to build women's resilience to climate change (Gumucio et al., 2020; Antwi-Agyei et al., 2013). Social organizations represent safety nets and informal insurance that farming households can use to address the risks posed by climate change on their livelihoods (Fraser, 2007).

Although membership of social organisations offers possibilities for safety nets in cases of difficulties, most women focused organisations tend to lack funding and capacities. In India, Venkatasubramanian et al. (2014) observed that farmers' group annual membership fees can be costly for resource-poor farmers and can limit womens opportunity to participate in such groups. There should be conscious effort by policy makers including agricultural and environmental planning bodies to institute measures including capacity building workshops for women-based organisations in order to improve their efficiency and sustainability.

The results suggest that government subsidies, presence of a ready market and the ownership of a radio predict farmer's readiness to pay for climate information. Such results are in consonance with previous studies conducted in the Savelugu Nanton Municipality in northern Ghana (Mabe et al., 2014), indicating that socioeconomic factors including age, sex, and on-farm income significantly and positively affect the willingness of farmers to pay for weather forecast information. In Burkina Faso, Ouédraogo et al. (2018) observed that various socioeconomic factors including level of education, gender and age all greatly influence readiness to pay for climate information. In terms of planned adaptation programmes, Ahmed et al. (2015) reported that farmers with high levels of income, household size and farm size were more willing to pay for the cost of implementing planned adaptation programmes.

6. Conclusions and policy implications

This study identified the socioeconomic factors influencing access to and willingness to pay for climate information by smallholder farmers in north-eastern Ghana. Findings show that access to and the willingness to pay for climate information by smallholder farmers have been detected to be influenced by both individual and environmental specific factors. The marginal effects logistic regression shows statistical significant differences in the predictors of climate information access as well as willingness to pay by smallholder farmers. It can be concluded that climate information accessibility and the willingness to pay for climate information among male farmers are predicted by factors such as drought experience, food insecurity and farming experience. For female farmers, the results indicate that access and willingness to pay for climate information are motivated by factors such as, government subsidies, membership of a social group and training.

The implication of the findings is that agricultural and environmental planning bodies need to avoid one-size fit all climate policies and climate information service provision systems. Climate services delivery should be tailored to meet the needs of different socioeconomic groups including male and female smallholder farmers that may need such information for adaptation purposes. It is suggested that interventions such as gender-specific agricultural training workshops could be instituted to improve training for women in agriculture. This will ensure greater participation of female farmers in such training workshops in this agricultural setting where socio-cultural barriers often preclude women farmers from attending important training workshops.

Local information centres could be provided as part of national climate change policy to enable female farmers access climate information. Women's accessibility to climate information is enhanced when agro-meteorological advisories are provided within the local communities. As part of a National Framework on Climate Services, tailored climate information needs to be provided to smallholder farmers with different socioeconomic backgrounds to enable farmers manage climate change effects. The Ghana Meteorological Agency needs to be supported and adequately resourced to provide targeted climate information for farmers in this climate "vulnerability hotspot".

Author contribution

Philip Antwi-Agyei: conceptualization; methodology, data analysis; funding acquisition; writing – review and editing. Kofi Amanor: methodology, data analysis, writing. Jonathan N. Hogarh: writing-reviewing and editing. Andrew John Dougill: conceptualization, writing-reviewing and editing.

Declaration of competing interest

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

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