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Farmers' willingness-to-pay for weather information through mobile phones in northern Ghana

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Abstract

Access to climate information is one of the ways by which farmers can reduce the adverse effects of climate variability and change. However, in Ghana, and in particular, Northern Ghana there is a gap between meteorological information and farming activities. This paper examined farmers' willingness-to-pay for weather forecasts provided through mobile phone messaging. A total of 391 respondents, selected through a multi-stage sampling procedure was used. Based on the contingent valuation framework, a double-hurdle model was estimated. On average, a farmer was willing to pay GH₵ 122.15 annually for weather forecasts in the form of a text message. The results of the selection equation of the double-hurdle model show that sex, education, production aim, adaptive capacity and climate information source were significant and positively influenced willingness to pay for weather forecast while age and credit access negatively influenced same. Similarly, while dependency, extension service and adaptive capacity were significant and positively influenced the amounts farmers were willing to pay, sex and climate information access, negatively influenced the same. It is concluded that although the willingness-to-pay for weather forecast is low, especially, among male farmers, there exists a market for weather forecast that can be harnessed by the meteorological agencies. Some of the categories of farmers that may be targeted for demand and policy formulation are the following: farmers with formal education; farmers with access to extension services; market-oriented farmers; and farmers with adaptive capacity to climate change.

Keywords: *Contingent valuation; Double-hurdle model; Mobile phones; Weather forecast; Willingness-to-pay*

INTRODUCTION

Climate change and variability have been a major concern to many stakeholders globally. According to the World Meteorological Organisation (WMO) (2018), Global mean temperatures in 2017 were 1.1°C ± 0.1°C above pre-industrial levels. The organisation stressed that the world's nine warmest years have all occurred since 2005, and the five warmest since 2010. Sylla et al. (2016) also noted that since 2006, West Africa has experienced warming of about 0.3°C in the Gulf of Guinea and up to 1°C in the Sahel. Meanwhile, 80% of the world's insecure people live in countries with degraded environmental conditions than are prone to climate hazards (WMO, 2018). While excessive floods

are affecting farming in some countries, drought is affecting farming in other countries. Some studies have projected a decline in crop yield (Phiiri et al., 2016; Munang et al., 2014; Blanc, 2013; Kotir, 2011; Chijioke et al., 2011;) and welfare/livelihoods (Asfaw et al., 2016; Nkegbe and Kuunibe, 2014; Skoufias, 2012; Chijioke et al., 2011) in sub-Saharan Africa (SSA) due to climate change.
In Ghana, the Ministry of Environment, Science, Technology and Innovation (MESTI) (2019) has outlined five (5) policy messages with respect to climate change as follows: More than 30 years of climate records prove that the prevailing climatic conditions in Ghana have severely deteriorated and is more likely to worsen in the future; Events of climate hazards are on the rise and the impacts could become alarming if concrete steps are not taken to deal with the human aspects that contribute to it. Climate vulnerability due to high dependence on agriculture for livelihoods increases from the coast to the Northern savannah; Climate change can bring unbearable disruptions to electricity system, cash crops, urban migration, small-holder farmers and the seashore; and adaptation policies and investments are yielding positive returns and must be sustained.

Despite the improvements in climate projections and impact analysis (Kasei et al., 2018; Owusu et al., 2017; Amikuzuno and Donkoh, 2012), the dissemination of the needed information to the farmers remains a major drawback. Considering the seasonal nature of crop production, the availability of timely information is a primary factor to farmers. Amegnagloa et al. (2017) observed that farmers need reliable seasonal climate forecasts between one and two months before the onset of the rains. Not surprisingly, the theme of the 2018 World Meteorological Day was ‘weather-ready, climate-smart’; and this theme sought to underscore the importance of informed day-to-day planning of the weather and climate shocks and hazards. Climate forecasting and use remain crucial in the agricultural sector and the benefits have been recognized for centuries (Klemma and McPherson, 2017; Zinyengere et al., 2011; Meza et al., 2008). Farmers use climate forecast for decision making such as the time to plant and to harvest (Klemma and McPherson, 2017). Amegnagloa et al. (2017) concluded that seasonal forecasts are important in the adoption of technologies including high yielding varieties; assisting farmers in daily production decision making; efficient management or usage of input; and an overall reduction in poverty.

Evidence suggests that the resilience to climate shocks by Africa’s agriculture can be enhanced through climate forecast (Roudier et al., 2014). Roudier et al. (2014) also argued that farmers are able to maximize available opportunities when reliable forecasts are provided to them. The empirical results of Roudier et al. (2014) suggested that yields are improved through the application of climate forecast information on farms. Similarly, Onyango et al. (2014) observed that climate forecast information improves climate understanding and adaptation planning. Furthermore, Roudier et al. (2016) found that a 10-day forecast or its combination with seasonal forecasts would provide positive benefits to farmers. Roudier et al. (2016) also recommended that farmers in West Africa need to take farm decisions based on rainfall characteristics such as the onset and duration of the rains. Ouédraogo et al. (2018) stressed that access to climate information enables farmers to effectively use production inputs and technologies, reduce agricultural risks to climate shocks through managing current risks and building resilience to future risks.

One challenge of disseminating climate information and weather forecasts to farmers has always been the medium, especially, where the farmers are located in deprived communities with low access to the mass media (television and radio usage). In recent times, it appears there could be a solution through the use of mobile phones. This is because farmers are using mobile phones even in deprived communities. Obeng et al. (2019) reported that about 90% of the farmer respondents owned and used mobile phones in receiving extension messages. This means that climate forecasts can simply be transmitted to the farmers in the form of a short messaging system (SMS). However, the use of this medium requires that the telecommunication networks may place charges on sending weather forecast messages to the farmers. In this study therefore, the objectives were to: investigate farmers' willingness to pay for weather information in Northern Ghana; determine how much they were willing to pay; and identify the factors influencing same. This study is crucial at this time as farmers in the northern regions of Ghana are experiencing severer climate change and variability (Owusu et al., 2017).

As indicated above, quite a number of developing country studies have been done in the area of willingness to pay for weather information by farmers, however some limitations associated with these studies call for new studies for more current and improved results. For instance, in Onyanago et al (2014) study, the focus was on crop farmers and fishermen in Kenya and the method of analysis was basically descriptive. Combining a study on crop farmers and fishermen can complicate the scope of the study and may not bring out clear results. Besides, the use of descriptive statistics falls quite short of econometric techniques in terms of the predictive power and for that matter policy formulation based on the results. Also, even though Kenya is an African country, climate and its impact there may be quite different from Northern Ghana. The limitation with respect to Roudier et al. (2016) is the fact that they used simulation, rather than actual survey data for their prediction. Ouédraogo et al. (2018) study was on cowpea and sesame farmers in Northern Burkina Faso. The demand for weather information relative to leguminous plants is likely to be different from that of maize, given that the former fix nitrogen on the soil and the latter rather consumes it. Furthermore, Ouédraogo et al. (2018) study estimated a Tobit model. The Tobit model is an element of the Double Hurdle model that this present study employs. Zongo et al.'s study (2016) uses Heckman's (1979) model which is quite similar to the Double Hurdle model. The difference, however, is that in the case of the latter we suspected and tested to find that the decision to pay for weather information is linked to the amount paid which suggests that the Double Hurdle model is more suitable for our data. The strength of Obeng et al. (2019) is in the fact that the study area is one of the regions in the study area of the present study. However, not only does the present study covers two more additional regions, it employs an econometric technique in addition to the descriptive statistics that Obeng et al. (2019) employed. Besides the latter study is on farmers' perceptions of ICT tools including mobile phones but does not extend to investigating farmers' willingness to pay for weather forecast. Thus, the determinants of farmers' WTP for weather information may be said to be location, time and crop-specific, it is therefore important that we carry out location, time and crop specific studies to constantly update our knowledge for more pragmatic policy formulation and implementation.

METHODOLOGY

Study area

The study was conducted in the three (former) northern regions of Ghana; Northern region, Upper East region and Upper West region (see Appendices 1-4). As shown, the area is located in the upper part of the country. It is naturally warmer and experiences a unimodal rainfall. According to Nkrumah et al. (2014), the area receives a maximum of 150-250 mm of rainfall per month in the peak months of rainfall (July-September). Several studies and reports including Derbile et al. (2016)

argued that the northern belt of Ghana is most vulnerable to climate change due to the unimodal rainfall pattern. According to Derbile et al. (2016), climate shocks such as droughts and floods are prevalent in the area. Nonetheless, agriculture, particularly for subsistence purpose, remains the primary occupation of the people. This could be due to the fact that over 70% of the population lives in rural areas where non-farm activities are limited (GSS, 2013). The major crops grown in the area include maize, groundnut, millet, yam and cassava. Compared to the other regions of Ghana, the three former northern regions have the highest prevalence of poverty in the country. This further reduces the adaptive potentials of the farmers.

Sampling procedure and data

The study targeted farming households in the (former) northern regions of Ghana. A multi-stage sampling procedure was used in selecting the respondents for the study. First, the three (former) northern regions of Ghana were purposively selected due to their high climate vulnerability. In the second stage, simple random sampling and stratified sampling were used to select four, three and two districts from the Northern, Upper East and Upper West regions respectively, totaling 9 districts. The selected districts include East Gonja, Mion, Kumbungu and Karaga in the Northern region; Bongo, Talensi, and Kassena Nankana East in Upper East; and Wa East and Nadowli-Kaleo in Upper West region. The third stage also involved the selection of twenty households from each of the 27 communities by the simple random technique giving a total of 540. However, 149 households did not have mobile phones and so they were dropped leaving 391 households for the analysis. Of these households, 258 were male-headed while 133 were female-headed.

Theoretical Framework and Data Analysis

The theory underpinning the study is the theory of consumer behaviour, where a rational consumer aims at maximising utility from any bundle of goods subject to a given constraint. In the context of this study, the farmer who is willing to pay for weather information thinks that he/she is better off with weather information than without it. The appropriate method of analysing this behaviour is the Contingent Valuation (CV) Method. This method has been widely used in willingness-to-pay studies. The CV is a stated preference approach of measuring consumer utility and was developed by Ciriacy-Wantrup (1947). It has become a major economic tool for eliciting the market value of a non-market commodity. The fundamental principle is to analyse the response of people within a hypothetical perspective. The method has been used for a wide applications including cost benefit analysis and environmental analysis (Verbicˇ et al., 2016; Venkatachalam, 2004) since some essential environmental assets are public goods in nature and also have non-use economic values. Carson and Hahnemann (2005) cited by Oerlemans et al. (2016) outlined three advantages of the CV method. These are: it provides solution to the challenge with collecting some information on consumers; the ability to design different scenarios on new or renewed goods; and its use of the Hicksian consumer surplus other than the Marshallian consumer surplus. The Hicksian consumer surplus is made up of the equivalent variation and compensating variation. This study is based on the compensating variation of a Hicksian consumer surplus, which under the objective of improving welfare, refers to the amount of money a consumer gives to obtain higher utility. Unlike the equivalent variation that is used to measure willingness-to-accept (WTA), the compensating variation method is used to measure consumers' WTP. The Hicksian and the Marshallian demand analyses are well presented in Nicholson and Snyder (2008).

Since climate information is theorised as a positive function of farm yield, farmers were asked to indicate the amount of money they were willing to pay for climate forecasts. In order to avoid different conclusions as explained by Venkatachalam (2004) and provide smart recommendations, this study used a dichotomous eliciting approach with a follow-up open-ended question in obtaining consumers' WTP. The CV has been applied in a number of studies (Ndebele and Forgie, 2017; Latinopoulos et al., 2016; Giudice and Paola, 2016; Verbicˇ et al., 2016; Guo et al., 2014; Abdullah and Jeanty, 2011).The CV method has however, been criticized on grounds of reliability and validity, especially in the aspect of questioning the respondents(Venkatachalam, 2004). In this study therefore, the researcher was objective in the questionnaire administration analyses and any potential biases avoided. Also, a detailed explanation on the framework of weather forecast provision through the mobile phone was provided to the farmers.

The Double Hurdle Model

The Double hurdle model was originally formulated by Cragg (1971) to fit consumer purchases. It involves the estimation of two separate models (hurdles). The first model represents a consumer's decision to purchase an item, and the second model represents the consumer's decision about how much to purchase. A purchase is realized only after both hurdles are cleared. Specifically, a different latent variable is used to model each decision process, with a probit model to determine the decision to purchase and a Tobit model to determine how much is purchased (Blundell and Meghir, 1987).

The Double hurdle models which are well explained in Blundell and Meghir, (1987) have wide applications in consumer and producer theories. In the context of the present study, Equation 1 is estimated by a probit model to analyse farmers' willingness to pay for weather information while equation 2 is the truncated Tobit model that will be estimated to determine the factors influencing how much farmers are willing to pay. Both equations are however estimated simultaneously by maximum likelihood estimation procedure (in STATA 16). It should be noted that the explanatory variables for both equations can be the same or different. However, at least one variable should be left out in the selection equation to avoid estimation problems such as biased estimates ((Blundell and Meghir, 1987).

WTP for Weather Information

$$D_i = 1 \ \ if \ \ Z_i\delta + u_i > 0$$
$$D_i = 0 \ \ if \ \ Z_i\delta + u_i \leq 0 \qquad (1)$$

Amount of Premium to Pay

$$Y_i^* = X_i\beta + \varepsilon_i$$
$$Y_i = Y_i^* \ \ if \ \ D_i = 1 \ \ and Y_i^* > 0 \qquad (2)$$
$$u_i \approx N(0,1); \varepsilon_i \approx N(0,\sigma^2)$$

$corr(u_i, \varepsilon_i) = \rho$ Unobserved factors that influence willingness to pay may also influence amount of premium to be paid

where

D_i is WTP

Z_i are variables believed to influence WTP.

X_i is a set of variables believed to influence the amount of premium to be paid.
Y_i^* and Y_i are the latent and observed values of the amount of premium to be paid, respectively.
u_i and ε are the error terms; and
β and δ are parameters to be estimated.
This implies that the conditional independence of distribution of the two error terms holds and that explains why the two equations must be simultaneously estimated. Following equations 1 and 2, the following equations were estimated for the first and second hurdles, respectively.

$$\begin{aligned} WTP\,decision = {} & \beta_0 + \beta_1 Sex + \beta_2 Age + \beta_3 Education + \beta_4 \Pr oduction\,aim \\ & + \beta_5 Credit\,access + \beta_6 Extension\,access + \beta_7 Adaptive\,capacity \\ & + \beta_8 C\lim ate\ perception + \beta_9 C\lim ate\ \inf ormation \end{aligned} \quad (3)$$

$$\begin{aligned} WTP\,amount = {} & \delta_0 + \delta_1 Sex + \delta_2 Age + \delta_3 Education + \delta_4 Dependency\,ratio \\ & + \delta_5 \Pr oduction\,aim + \delta_6 Credit\,access + \delta_7 Extension\,access + \\ & \delta_8 Adaptive\,capacity + \delta_9 C\lim ate\ perception + \delta_{10} C\lim ate\ \inf ormation \end{aligned} \quad (4)$$

The definition of the variables and the *a priori* expectations are contained in Table 1.

In this study a farmer is asked to state how much he or she is willing to spend in order to obtain or access specific weather forecast information per year. The average WTP is calculated using the formula below:

$$AWTP = \frac{WTP}{N} \quad (5)$$

where $AWTP$=Average Willingness to pay amount and N is the total number of sampled farmers.

Table 1: Definition of variables and *a priori* expectation.

Variable	**Definition**	**Expected signs**	
		WTP	WTP Amount
Sex	Dummy: 1 for male farmers and 0 for female farmers.	+	+
Age	The total number of years of a farmer, as at 2017.	-	-
Education	The total number of years of formal education of a farmer	+	+
Dependency ratio	The total number of inactive household members divided by the number of active members.	N/A	-
Production aim	Dummy: 1 if the primary aim for maize production is for sale or commercialization and 0 if primary aim is home consumption.	+	+
Credit access	Dummy: 1 for farmers who had access to credit (formal or informal) in the cropping season and 0 for farmers without access to credit.	+	+
Extension access	Dummy: 1 for farmers who had access to extension services in the cropping season and 0 for farmers who had no access.	+	+

Adaptive capacity	An index of the number of coping and adaptation strategies adopted by a farmer	+/-	+/-
Climate perception	Dummy: 1 for a famer who correctly predicted the directional change of both rainfall and temperature, 0 if otherwise.	-	-
Climate information	Dummy: 1 if a farmer received past information on climate change from other sources before they occurred and 0 if otherwise.	+	+

RESULTS AND DISCUSSION

Distribution of farmers based on WTP for weather forecasts

The results show that about 46% of the respondents were willing to pay for weather forecast, while 54% were unwilling (Figure 1). There were more women (about 50%) who were willing to pay than men (about 42%). This could be because women have higher vulnerability to climate change than men, to the extent that they were more willing to benefit from scientific climate information to improve upon their farming business. Some of the respondents noted that, the weather forecasts should be provided in local languages so that they can easily understand the information. This concern is legitimate, considering the low level of formal education and the inability of most of the farmers to read and understand the English language. In this study, the percentage of farmers willing to pay for weather forecast is low, compared to that of Amegnagloa et al. (2017) (82%); Ahmed et al. (2015) (67%); and Zongo et al. (2016) (71%).

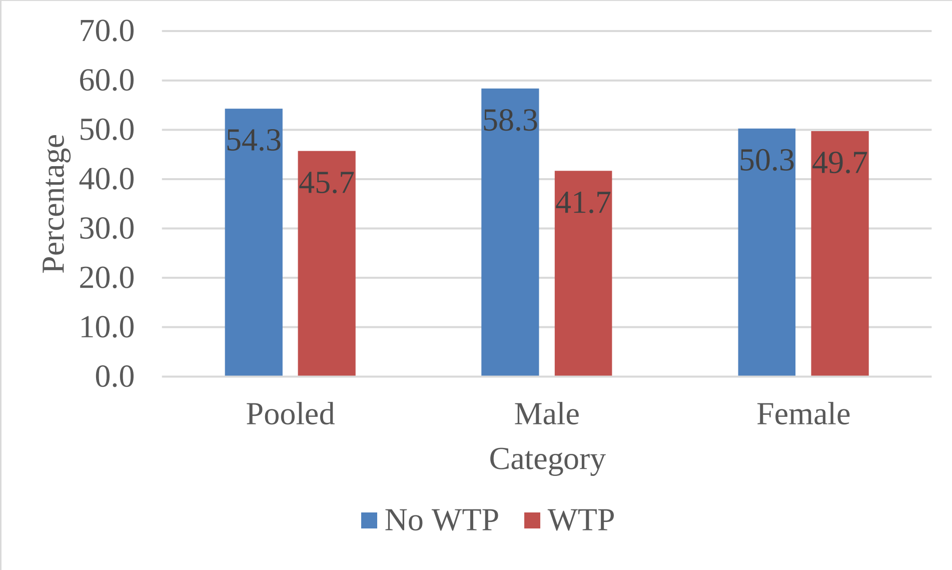

Figure 1: Percentage Distribution of farmers' WTP

Descriptive statistics of respondents

Table 2 shows the descriptive statistics of the sampled respondents. On the average, a farmer was willing to pay GH₵ 122.15 annually for weather forecasts in a form of a text message. This is an equivalent of GH₵ 0.33 (33 GH pesewas) WTP on daily basis. The least amount a farmer was willing to pay for weather forecasts is GH₵ 1 annually (GH₵ 0.003 daily or 0.3 GH pesewas) while the maximum a farmer was willing to pay was GH₵ 170 annually (GH₵ 0.47 or 47 GH pesewas daily). The analysis shows that while women were willing to pay GH₵ 134.79 annually (GH₵ 0.37 or 37 GH pesewas daily), men were willing to pay GH₵ 119.24 annually (GH₵ 0.33 or 33 GH pesewas daily).

These are higher than the annual WTP of GH₵ 41.20 also in the form of a text message estimated by Mabe et al. (2014) in the Savelugu-Nanton Municipality of Northern region.

Table 2: Descriptive statistics of the respondents

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Amount per year	122.15	185.28	1	170
Age	46.19	13.54	20	100
Dependancy	0.96	0.83	0	8
Education	4.12	5.36	0	18
Production aim	0.31a	0.46	0	1
Extension	0.41a	0.49	0	1
Credit access	0.28a	0.45	0	1
Adaptive capacity	0.25	0.06	0.11	0.42
Climate perception	0.82a	0.38	0	1
Climate information	0.53a	0.50	0	1

NB: 'a' indicates proportion and not mean

The age distribution of the farmers ranged from 20 to 100 years. However, the average age of the farmers was 46.19 years (Table 2). Dependancy also ranged from 0 to 8 with an average of 0.96. This means that, at least, one person depended on an active household member in the study area. With the high vulnerability of dependants to climate change, the maximum dependancy of 8 could be a worrying observation. The level of education was low among the respondents. Averagely, a farmer had four years of formal education. From the study, about 58% of the respondents had no formal education. However, education is very important in the adaptation to climate change and also, very crucial for the understanding or usage of weather forecasts (Zongo et al., 2016). The results also show that only 31% of the respondents engaged in crop production solely for sale or for both sale and household consumption, while the remaining 69% engaged in crop production solely for home consumption. This confirms the high subsistence level of crop production in the area.

Extension access was also low as only 41% had access to extension services in the cropping season. Access to agricultural credit input in the study area was also as low as 28%. The adaptive capacity of the farmers ranged from 0.11 to 0.42, with a mean of 0.25. This implies that the adaptive capacity of the farmers is generally low as none of them had up to half (0.5) the adaptive capacity, considering their prevailing information. Furthermore, 82% of the farmers were able to predict the directional change in climate variables correctly. For instance, the farmers perceived rainfall duration and intensity as decreasing and perceived temperatures as increasing. Access to climate information is quite high, given that more than half (53%) of the farmers had access to climate information.

Willingness to pay by region

The distribution of the WTP by region is shown in Table 3. It shows that while majority of the respondents from Upper West Region were willing to pay for weather forecasts provided as SMS through their mobile phones, less than half the farmers in Northern and Upper East Regions, were willing to pay for same. However, the average farmer in Northern Region is willing to pay GH₵1 more than the average farmer in Upper West Region and about GH₵2 more than the average farmer in Upper East Region.

Table 3: Willingness to pay by region

	Not WTP		**WTP**		**Total**		**Amount**
Region	Freq.	%	Freq.	%	Freq.	%	**(GH₵)**
Northern	86	51.2	82	48.8	168	100.0	123.17
Upper East	80	63.0	47	37.0	127	100.0	121.12
Upper West	46	47.9	50	52.1	96	100.0	122.17
Total	212	54.3	179	45.7	391	100.0	122.15

Frequency of demand for weather forecasts

Figure 2 shows the frequency at which the respondents were willing to pay for weather forecasts. Thus, the frequency at which the weather forecasts should be provided, within which they will be willing to pay for such information. From the results, the highest percentage of the respondents (49.7%) were willing to pay for weather forecast provided through the mobile phone on weekly basis, followed by 30.1% respondents who were willing to pay for weather forecasts monthly. Traditionally, weather forecasts are provided on daily basis, however, only 12% of the respondents were willing to pay for weather forecasts provided through the mobile phones on daily basis. There were a few other farmers (0.5% and 2.2%) who were willing to pay for weather forecasts provided through the mobile phones twice every year or once every year, respectively. This pattern of distribution is observed for the three regions. Considering that the study is based on farmers, it is expected that their weather forecast demand may be largely seasonal. However, this is homogenous across the study areas given that rainfall pattern is unimodal making it possible for only one farming season.

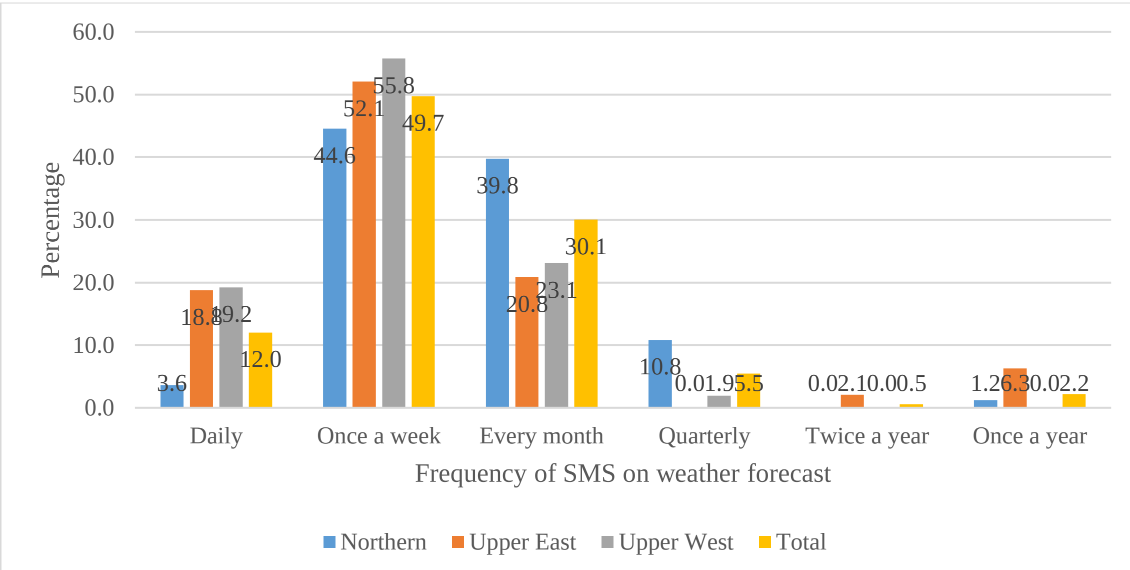

Figure 2: Frequency of Respondents' Demand for Weather Forecasts by region

Factors Influencing farmers' willingness to pay and the amount to be paid

Table 4 shows the results from the Double-hurdle model. Although the pseudo R squared is low (28.9%), the log likelihood chi square is significant at 1%, justifying the appropriateness of the model. The sigma is also significant, implying that the error terms of both the decision to pay and amount to pay are correlated (from equations 1 and 2), hence, the estimation of the Double-hurdle model was appropriate. The results show that except climate perception, all other variables have statistically significant effect on farmers' WTP decisions. On the other hand, sex, dependancy, extension, adaptive capacity and climate information have statistically significant effects on the amount farmers were willing to pay.

Sex has a positive significant (5%) effect on farmers' WTP decision but a negative significant effect on the amount they were willing to pay. The marginal effect implies that men had 0.28 higher probability of WTP for weather forecast than women; women on the other hand were willing to pay a higher amount than men. Women are more vulnerable to climate change, therefore, it can be expected that they are likely to pay a higher amount to reduce their vulnerabilities. This is consistent with the descriptive statistics on the WTP amount. The results of this study, however, are in contrast with that of Ouédraogo et al. (2018) and Mabe et al. (2014).

Age has a negative significant (5%) effect on farmers' WTP decision but a positive insignificant effect on the amount the farmers were willing to pay. This is plausible as younger farmers may be more conscious of the climatic conditions and may be willing to have up-to-date information on the weather conditions. Considering the high innovativeness of younger farmers, they may be willing to pay for climate forecasts in order to enhance their decision-making in technology adoption. This finding is consistent with that of Zongo et al. (2016) and Abebe and Bogale (2014). Abebe and Bogale (2014) explained that younger farmers are willing to pay higher amounts for rainfall-based insurance because they have less experience in predicting weather conditions and are also exposed to new technologies.

The dependancy ratio of the household was dropped from the WTP decision model. Normally, it is expected that the number of variables should not be the same in both models. It is suggested that the number of variables in the selection equation falls short by at least one (Blundell and Meghir, 1987). The dependency ratio variable is however significant in the WTP amount model. Since these farmers have more people to take care of, they may be interested in knowing the weather conditions in order to make investment decisions effectively and to avoid yield losses.

As expected, the level of education of the respondents is significant at 10% and positively influences farmers' WTP for weather forecast. The result implies that farmers with high level of education have 0.02 higher probability of WTP for weather forecast than their counterparts with low education in the study area. Educated people did not only appreciate the importance of weather forecast they were able to read the text message easily without having to depend on somebody.

A similar finding was made by Zongo et al. (2016). Also, Balma et al. (2016) found education to have a positive significant influence on farmers' WTP for crop insurance. Educated farmers in Hill et al. (2013) were also more willing to purchase weather-index insurance. Quaye (2016) also found a positive effect of education on the willingness to insure agricultural assets by farmers. These findings demonstrate the need for improving climate education among the general public and farming households in particular.

The variable for production motivation has a positive effect on both the WTP decision and the WTP amount for weather forecast but significant for only the former. This is also plausible as commercially oriented farmers operate as a business and therefore, were willing to invest in assessing weather forecast in order to increase productivity.

Access to credit is important in enhancing the capital of resource poor farmers. However, those who had access to credit were less willing to pay for weather forecasts than those who did not have access. This was contrary to the *a priori* expectation. Perhaps such farmers had already committed themselves financially and so they could not commit extra funds to buy weather forecast. Amegnagloa et al. (2017), however, found that, credit has a positive effect on the amount farmers are WTP for seasonal climate forecasts.

Extension access has a positive significant effect on both the WTP decision and WTP amount for weather forecasts. This was as expected because extension officers would explain the importance of understanding the weather to the farmers. Farmers' knowledge becomes more improved through extension services and therefore would demand weather forecasts. Amegnagloa et al. (2017) found that one way through which farmers are willing to receive seasonal climate forecasts is through the extension agents, and therefore recommended the integration of seasonal climate forecasts into national extension service packages.

The adaptive capacity of the farmers also has a positive significant effect on both the decision to pay for weather forecasts and the amount to be paid for such information. Farmers with high adaptive capacity may want to have weather forecast daily and also be prepared to pay higher amounts to ensure that they maintain or improve their adaptive capacities. On the other hand, farmers with low adaptive capacity may not appreciate the importance of weather information on their ability to adapt effectively to climate change and variability.

Access to past climate information has a mixed effect on the farmers' WTP. Thus, while there is a positive relationship between climate information and WTP decision, the variable has a negative relationship with the WTP amount. Thus, farmers who had access to information on shocks prior to their occurrence had higher probability of deciding to pay for weather forecasts but willing to pay less amount for such information. With such acquaintance with climate information, farmers may appreciate the importance of weather forecasts and would be willing to pay for new information but not a high amount.

Table 3: Determinants of farmers' WTP decision and amounts WTP

	WTP Decision			**WTP Amount**		
Variable	Marginal effect	Std. Err.	P-Value	Coef.	Std. Err.	P-Value
Sex	0.276**	0.132	0.037	-0.311*	0.167	0.064
Age	-0.012**	0.005	0.011	0.001	0.006	0.878
Dependency	-	-	-	0.238***	0.083	0.004
Education	0.020*	0.012	0.094	-0.014	0.014	0.323
Production aim	0.401***	0.134	0.003	0.099	0.169	0.560
Credit access	-0.227*	0.135	0.093	0.097	0.182	0.594
Extension	0.215*	0.122	0.076	0.504***	0.159	0.001
Adaptive capacity	0.388**	0.048	0.023	0.615**	0.285	0.031
Climate perception	-0.103	0.154	0.503	0.214	0.208	0.303
Climate information	0.262**	0.119	0.028	-0.301*	0.159	0.058
Constant				3.627	0.387	0.000
Sigma	0.105**	0.047	0.025			
Pseudo R^2	0.289					
LR Chi^2	83.89***					
N	391					

****, ** and * indicates significant levels at 1%, 5% and 10%, respectively.*

CONCLUSIONS AND RECOMMENDATIONS

On the average, a farmer was willing to pay GH₵ 122.15 annually for weather forecasts in the form of a text message. More farmers were willing to pay for weekly weather forecasts than on daily or annual basis. Both socioeconomic and climate factors have significant effects on farmers' WTP decision and WTP amounts. The probability of WTP was high for the following categories of farmers: male farmers; younger farmers; educated farmers; farmers with commercial orientation; farmers who had access to agricultural extension; and farmers with high adaptive capacity. The amount farmers were willing to pay was also high for the following categories of farmers: female farmers; farmers with high dependency ration; farmers with extension access and farmers with high adaptive capacity. Against this background, the following recommendations are made.

First, relatively young farmers should be targeted for purchasing weather information, given that they have high probability of WTP. Similarly, access to extension services should be stepped up by the Ministry of Food and Agriculture (MoFA) and NGOs. Extension services should include climate discussions since some farmers have more confidence in information directly provided by extension officers. Since formal education may be too late for the farmers, education on climate change may be given to the farmers through adult education or through special training tailored to suit them. Education on climate should also be integrated into the education curriculum to improve children's knowledge on climate change who would also transmit such information to their parents with little or no formal education. There is also the need to enhance the farmers' adoption of on-farm adaptation strategies to enhance their adaptive capacity, which would ultimately lead to high probabilities of WTP and also increase WTP premiums.

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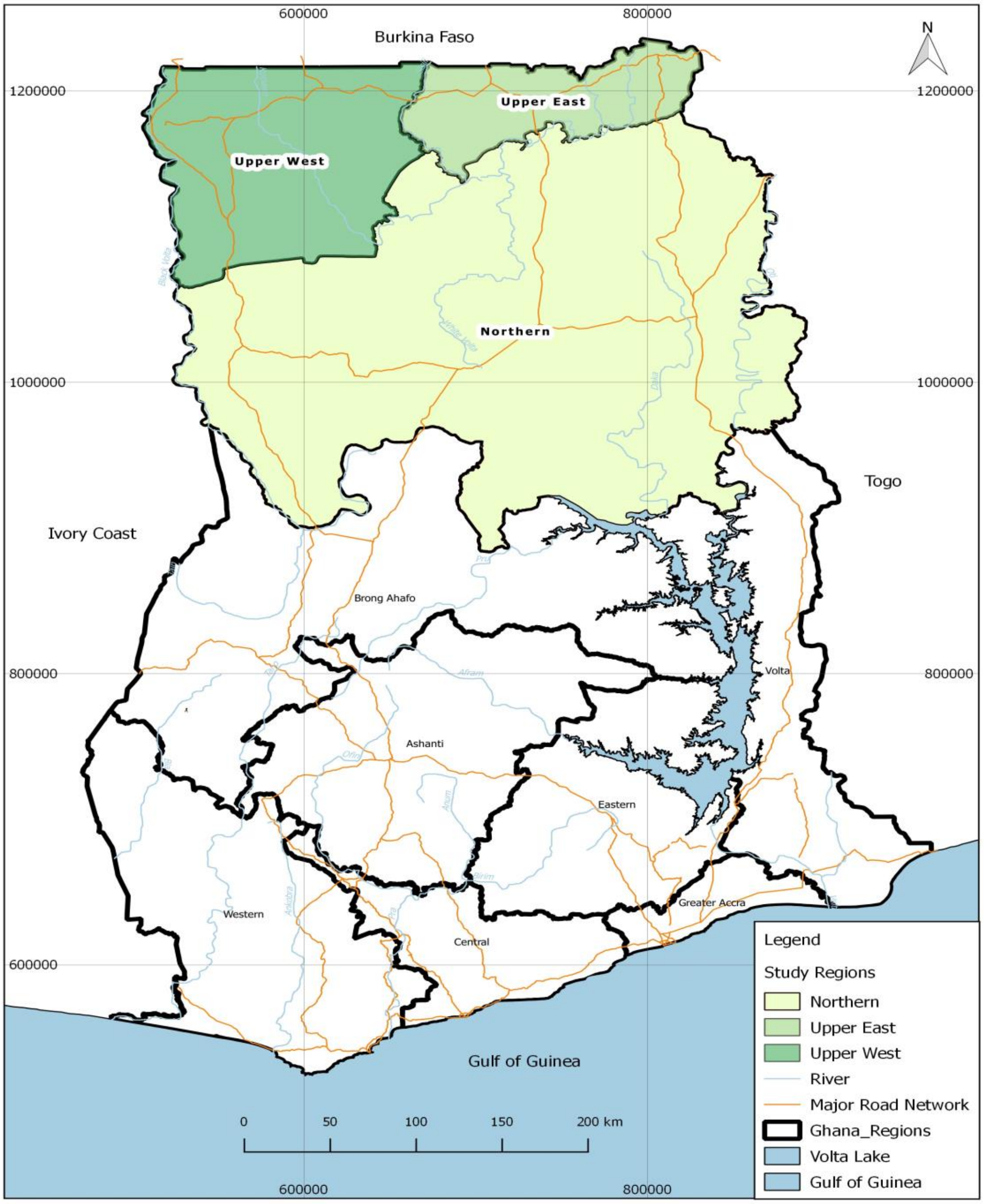
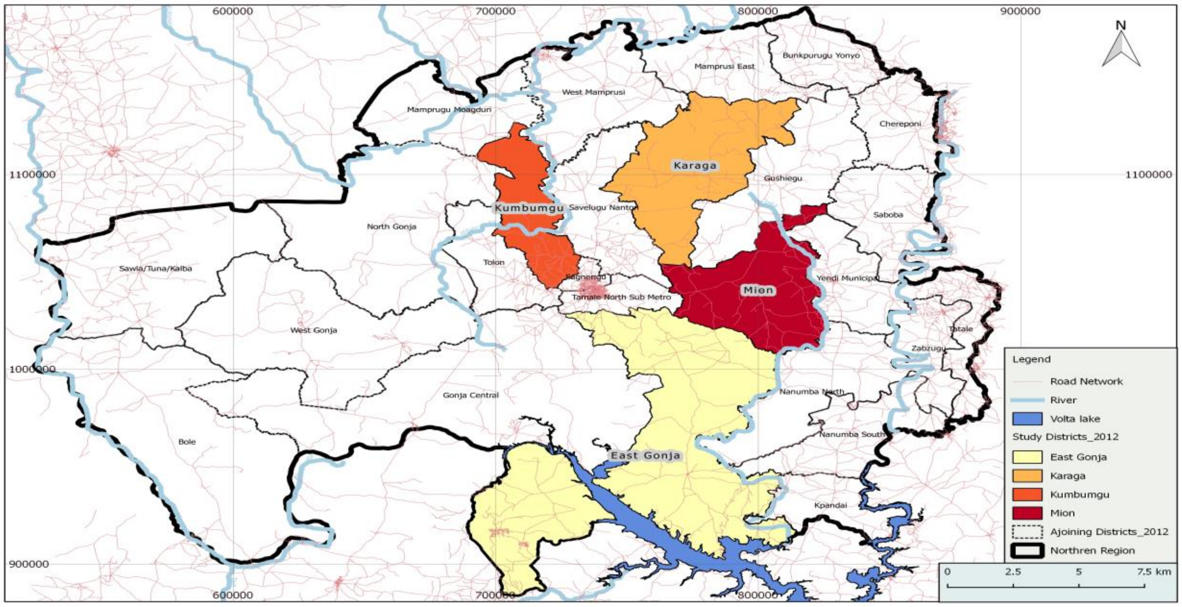
Appendix 1: Map of Ghana showing the study regions

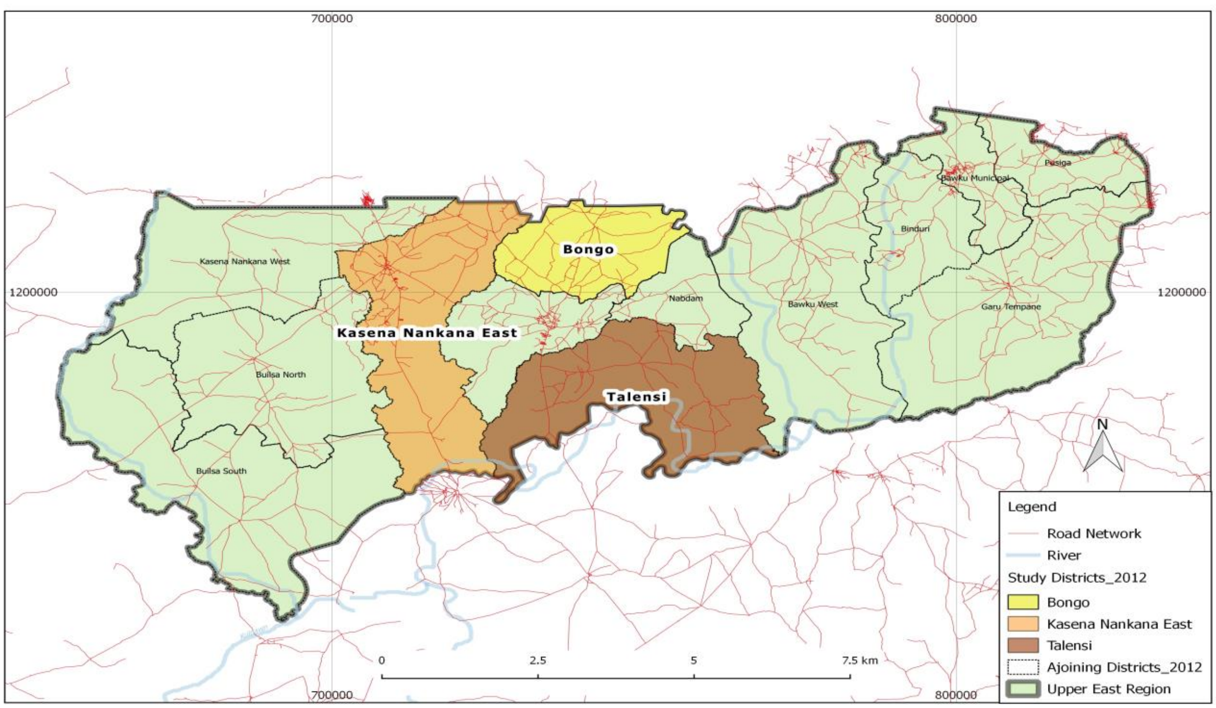


Appendix 2: Map of Northern Region showing study districts



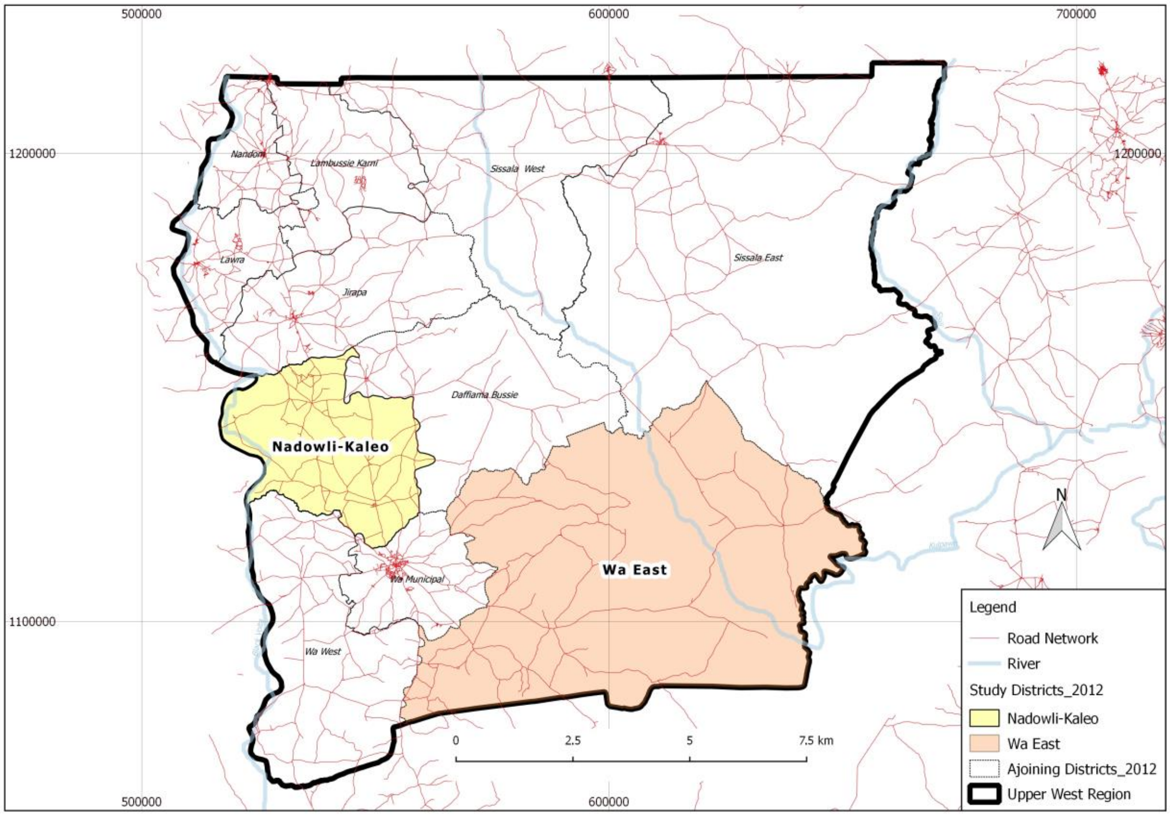
Source: Author's construct

Appendix 3: Map of Upper East Region showing study districts



Source: Author's construct

Appendix 4: Map of Upper West Region showing study districts



Source: Author's construct