Original Research Article

Analysis of~~ng~~ smallholder farmers' perceptions on~~of~~ climate change, preference and willingness-to-pay for seasonal climate forecasts information in Savelugu ~~-~~Municipality, ~~-of~~ Ghana

ABSTRACT

Aim: Agricultural production is directly affected by climate change. This means that access to climate information would help the farmers' preparedness for farming activities and the decision on the types of crops to grow when to grow them and the types of farm management activities to adopt. As such, this study analysed farmers' preference for seasonal climate forecasts and their willingness-to-pay for these information.

Place and duration: The study was conducted in the Savelugu Municipality in the Northern region of Ghana. A single year data was collected for analysis.

Methodology: A total of 300 farmers were selected through a two stage sampling procedure and used for the study. From the theory of contingent valuation, a descriptive statistic and Heckman model were used in analysing the data.

Results: From the results, the majority of farmers are willing-to-pay for seasonal climate information, especially, climate forecasts on rainfall. The farmers preferred that these seasonal climate forecasts should be disseminated to them through the radio. The farmers exhibit positive willingness-to-pay for the seasonal climate forecasts to about 20 Ghana cedis. A number of factors influenced the farmers' decision and amount they are willing to pay and these includes gender, age, perception of climate change experience, ownership of radio, off-farm activity and participation in planting for food and jobs (PFFJ) program.

Conclusions: The findings of this study highlights on the need for climate information by the farmers and how this can be effectively disseminated to them. Generally, government institutions and other private agencies should take up the challenge and opportunity to provide climate information, especially seasonal rainfall forecast, to the farmers at a fee. This fee must be determined at an optimal or at least a breakeven price considering the farmer's ability to pay. The study also recommended that climate information dissemination should be integrated into government's PFFJ program.

Key words: Contingent valuation; Climate perception; Seasonal climate forecast**,** Willingness to pay~~, Heckman two-stage~~

INTRODUCTION

In Ghana, agriculture contributes about 20% to~~of~~ the national Gross Domestic Product (GDP) (ISSER, 2017) whiles also providing 51% of the employment in the country (Stutley, 2010). Agriculture is also responsible for about 75% of foreign exchange earnings in the country

(Armah et al., 2011) with crop production making up approximately two-thirds of the sector. However, like other countries in sub-Saharan Africa, Ghana's agriculture is at risk with the changing climate and its consequences. These effects of climate change are becoming noticeable through drought or floods that affect the yield of crops especially the two major food crops of the country, maize and rice. This has been reflected into a decrease of 6.3% and 9.3% in the national value of maize and rice production respectively over the last two decades (Stutley, 2010). Ultimately, there is a strong relationship between climate change and agricultural production. The Intergovernmental Panel on Climate Change (IPCC) has predicted that, rain fed crop production could decrease by 50% by 2050 (IPCC, 2007) looking at the spate of changes in climatic conditions. According to International Food Policy Research Institute (IFPRI) (2009), Africa countries, especially, those in the sub-Saharan region are the most vulnerable group to climate change due to their high dependence on agriculture for economic growth, incomes and employment. Gradually, farmers are becoming unable to predict the patterns of rainfall in order to plan their production processes. Thus, farmers face uncertainty in their production (Loboguerrero et al., 2018). This raised the need for seasonal climate forecasts and making these information available to the farmers.

Various scholars have highlighted the importance of seasonal climate forecasting to smallholder farmers who are the central component of food production in the country (Sarpong et al., 2012). Usually, access to climatic information forms the premise upon which smallholder farmers make crucial decisions that relate to their farming activities. Accordingly, farmers are fond of using traditional means based on local knowledge to forecast rainfall patterns ahead for the crop production season. This traditional seasonal climate forecasts, operates as an endogenous system of climate information that guides farmers in making decisions relevant to the size of plots to cultivate, types of crop varieties to produce and planting dates, among others. The main factors that serve as indicators for these endogenous seasonal climate forecasts are environmental (moon, cloud, wind), biological (animals, plants), magic and religious (Phillips, et al 2002). However, according to Roncoli et al., (2008), these endogenous forecasts are becoming less reliable because of climate change over the past two decades. This can be attributed to various changes such as variation in length of rainy seasons, with variation in number of rainy days from year to year (Traore et al., 2013), massive changes in agricultural calendar due to changes in seasonal rainfall quantity and the onset and ending dates of production seasons (Marteau et al., 2011).

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Onyango et al. (2014) reported that, one of the great problems of climate science is predicting the probability of an occurrence, severity and duration of an extreme event, as well as when and where the event will take place and also the willingness of smallholder farmers to pay for forecasted climate information. The harsh effects of climate change have continued to create massive problems among the poor households who are risk averse, leaving them more vulnerable and food insecure in many months of the year (Onyango et al., 2014). In order to help meet these challenges, more investment in disaster risk reduction is needed, including building the capacity to anticipate risks and as well as provision of relevant and accurate climate forecasting information services as an early warning strategy. Accurate seasonal climate forecasts can also help not only to reduce climatic uncertainty, but to also reduce livelihood risk to smallholder

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farmers. Studies have highlighted the significance of climate forecast. Among them is Graham et al. (2002) who suggested that the reports of natural theorists were inaccurate and that there is a need for a greater knowledge to further understand the atmosphere. Scientific weather forecasting which is more accurate, credible and reliable emerged in the mid-nineteenth century. Empirically, several studies have examined the factors influencing farmers' willingness-to-pay (WTP) for seasonal climate forecasts but the results from these studies are mixed and inconsistent (Ouédraogo et al, 2018; Amegnaglo et al., 2017; Mabe, et al., 2014; Stutley, 2010; Nakuja, 2012). This (These) suggests that the factors influencing farmer's WTP is location and time specific. Again, these studies have either overlooked the need for addressing sample selection bias or failed to understand the role of the farmer's climate perception on their WTP decisions. This study addressed these limitations of previous studies and also highlighted the influence of Government's recent policy in agriculture, planting for food and jobs (PFFJ) policy on individual farmer's WTP for climate forecasts.

The introduction of this policy is to ensure high output from farms, increase the productivity of farmers and improve the food security status of the country. Implicitly, this policy would move farming from largely subsistence to a business or nearly commercial venture. The success or failure of this policy would ultimately be determined by the production climate or environment, largely, rainfall and the availability of early warning systems. In addition to highlighting the influence of agricultural policies such as the PFFJ on WTP for scientific climate forecasts, this study would highlight policy issues around the pricing of scientific climate information. Primarily therefore, the objective of this study is to investigate smallholder farmers' WTP for seasonal climate forecasts in the Savelugu Municipality in the northern region of Ghana. Thus, the study specifically ~~seeks to~~ addressed the following research questions. (1) What are were the types of seasonal climate forecasts preferred by farmers? (2) What are the channels through which farmers want to receive seasonal climate forecasts information? (3) Are farmers willing to pay for seasonal climate forecast? (4) What factors influence farmers WTP for seasonal climate forecasts?

The remainder of the paper is structured as follows: Section two describes methodology under the subheadings of study area, sampling procedure and data collection, and analysis. Section three presents and discusses the main findings of the study. Section four concludes with policy recommendations. It is automatic that these sub sections have to be discussed. I suggest you delete this!!!!!!!!!!!!

METHODOLOGY

Study Area

The study was carried out in Savelugu Municipality. The Municipality was purposively selected, due to a report by Population and Housing Census, (2010) that demarcated farmers in this area to be smallholder farmers mainly into rain-fed maize production, and characterized with erratic rainfall. It shares boundaries with West Mamprusi District to the North, Karaga District to the East, Tolon/Kumbungu District to the West and Sagnerigu District Assembly to the South. The municipality has about 149 communities with many of the communities concentrated at the southern section. The population of Savelugu Municipal, as projected by 2010 Population and Housing Census, is 139,283 representing 5.1% of the region's total population, with 60% of the population being rural. The municipality also has a total land area of about 1790.70 sq. km. Due to the availability of arable land and limited economic opportunities, as high as 89.3% of households in the district are engage in agriculture. In the rural localities, nine out of every ten households (93.3%) are agricultural households. Most of these households (97.0%) are involved in crop farming (GSS, 2014). The area receives an average annual rainfall of 600mm, considered enough for a single farming season. The annual rainfall pattern is erratic at the beginning of the raining season, starting in April and intensifies as the season advances, raising rainfall levels to about 1000mm sometimes. The municipality finds itself in the interior (Guinea) Savanna woodland which could sustain large scale livestock farming, as well as the cultivation of food crops such as rice, groundnuts, yams, cassava, maize, cowpea and sorghum (Population and Housing Census, 2010).

Sampling procedure and data collection

The data for the study was obtained through a cross-sectional survey of farmers solely engaged in maize production in the Municipality. The study employed two-stage sampling technique, where in the first stage, the sampling frame was the list of communities in the municipality and then random sampling was used to select ten (10) communities in the Savelugu municipality. In the second stage, the sample frame was the list of farmers in each of the selected communities Pigu, Balshei, Pong Tamale, Tibala, Kpong, Kpendua, Yiworgu, Boggu, Ying and Damdu. Using the sample frame thirty (30) respondents were selected from each community randomly using systematic sampling technique. Therefore, in all, a total of 300 maize farmers were selected for this study. Also focus group discussions were employed to collect qualitative data which gave us in-depth-information on the type of seasonal climate forecasts needed by farmers and the channels that farmers want to receive their seasonal climate forecasts.

The contingent valuation method (CVM) was used to elicit respondents WTP for seasonal climate forecast because it allows us to obtain information on the value people assign to non-market goods such as climate information which are not paid for by consumer in a formal market (Pearce and Turner, 1990). A lot of studies have employed the CVM to assess farmers' WTP for climate information and these include Ouédraogo et al, (2018), Amegnaglo et al., (2017), Zongo et al., (2016), and Mabe et al. (2014). Based on focus group discussions and literature, a hypothetical market was designed and presented to respondents to elicit their WTP amount. The preamble was carved to include statements such as a firm willingness to deliver seasonal climate forecasts to respondents before the planting season. The iterative bidding mechanism was used to elicit the initial and final WTP amount from the respondents because it mimic the bargaining market that exist in developing country like Ghana (Anaman and Jair, 2001; Alhassan et al, 2017).

Data analysis

Willingness to Pay for Seasonal Climate Forecast: Contingent Valuation Method

The theoretical underpinning of CVM is the theory of consumer behavior. This is explained in this section. Given any bundle of goods, farmers are considered as rational agents who aim at maximizing their utility. It is necessary to note that utility function and attributes of the commodity under question must be critically considered in the estimation of WTP. Thus, an individual seeks to maximize utility of a good (in this case seasonal climate forecast) subject to a given constraint. However, Khuc (2013) used indirect utility function to derive WTP for drinking water in Vietnam. In equation (1), a farmer aims at maximizing utility derived from using seasonal climate forecast in agricultural production process given the quantity of the seasonal climate forecast and income.

$$U = u^*(q_1, \quad q_2 \ldots \ldots . . q_n) \qquad (1)$$

Meanwhile, utility function is a summary of one's preference and taste for a commodity with regard to purchases which affect the expenditure. Khuc (2013) indicated that an individual rather seeks to minimize his or her expenditures in order to attain a certain level of utility, u^*. Therefore, the expenditure function for a farmer when the quantity (q_o) of seasonal climate forecast is delivered by any institution without charging a fee is given as:

$$e = e(P, q_o, u^*) \qquad (2)$$

For a farmer to willingly source for specific quantity and quality (q_1) of seasonal climate forecast to meet his or her own need in production activities, that farmer is prepared to increase his or her expenditure. The WTP is then derived as the difference in the farmer's expenditure. Thus:

$$WTP = e(P, q_o, u_*) - e(P, q_1, u^*) \qquad (3)$$

Where $q_1 > q_0$

Therefore, the maximum amount of money a farmer is willing to pay for the improvement in the quality of the seasonal climate forecasts is equal to the difference in expenditure between the expenditure that prevails when the farmer uses the new seasonal climate information and the expenditure that prevails when the farmer uses pre-existing forecasts.

Determinants of willingness-to-pay for seasonal climate forecasts*: *Heckman two-stage selection model

Following Amegnaglo et al., (2015), the study employed the two-step Heckman selection model because of its ability to correct sample selection bias. The two-step Heckman selection model is instituted on the main assumption that the processes that defines a producer's decision to pay or not to pay for seasonal climate forecasts is different from the processes that decides the amount that will be paid by the producer (Heckman,1979). Based on this, to examine the factors that influence farmer's WTP for seasonal climate forecasts, the Heckman two stage sample selection model was used.

Initially (in the first or decision stage), respondents are queried if they are willing to pay to access scientific seasonal climate forecast or prefer to dwell in their traditional method of predicting. This tends to allow for dichotomous responds from respondents that is Yes (1 if willing to pay) or NO (0 if not willing to pay). Thus, the probability of responding Yes or NO is expressed in probit regression model as:

$$P_i = \vartheta + \beta_i x_i + \varepsilon_i \qquad (4)$$

where β_i= is a vector of parameters to be estimated , x_i= is a vector of observed factors such as socioeconomic factors and institutional factors (Table 1), ε_i= error term which is independently and identically distributed with a normal probability distribution function.

At the final stage (the second or outcome stage), upon the willingness of respondents to pay for seasonal climate forecast, farmers are asked the amount they are willing to pay to access the information. The amounts expressed for those willing to pay are positive while the amounts expressed by those not willing to pay are zero. In the second stage of the Heckman's model, the outcome equation is expressed for those with the decision to pay for climate forecasts. This can be expressed as:

$$WTP_i = \varphi + \beta_i x_i + \gamma IMR + \mu_i \qquad (5)$$

WTP is the outcome variable (i.e. the amount farmers are willing to pay in Ghana cedis). The Inverse Mills Ratio (IMR) is a proxy variable for the probability of using seasonal climate forecasts and is added to the outcome equation as an additional independent variable. The IMR measures the sample selection effect. μ_i is the error term which is independently and normally distributed. Again, the vector of x_i variables is shown in Table 1.

Results and Discussions

Demographic and Socio-economic characteristics of the farmer

Based on the survey, most of the respondents (93.33%) were males and 6.67% were females. The small percentage of females could be attributed to the fact that, women do not own land as a result of the cultural discriminations that prevail in the communities, thus women are not culturally entitled to land ownership in the area. The ratio of men to women is not different from other studies in Ghana (Aidoo *et al.*, 2014). The analysis shows that the average age of the respondents in the study area was 38.71 years. Furthermore, the study area has a relatively large average household size of about 12 persons per household which is an indication of large labour available for adoption of labour intensive technologies. With regards to education, the mean years of formal education is 4.80 years which is consistent with GSS (2013). In terms of years in maize farming, 77.71% of the farmers have more than 20 years of experience in maize farming with a mean years in maize farming of 21.32 years. Finally, about 16.33% of the respondents participated in planting for food and jobs (PFFJ) program and 83.67% were non-participant. With a mean value of 4.45, for farmers' perception of the existence of climate change it suggest that majority of the farmers strongly agree that climate change exist.

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Table 1: Variable Definition and their Descriptive Statistics

Independent variables	Description	Mean	Std Dev.
Gender	1 if household head is male, 0 if female	94.56a	0.23
Age	Age of household head in years	38.71	13.17
Experience	Years of farming	21.2	13.58
Household size	Number of persons living in the household	14	10.85
PFFJ	1 if farmer participate in planting for food and job programme, 0 if otherwise	19.39a	0.40
Extension	1 if farmer has access to extension service, 0 if otherwise	39.40a	0.32
Farm size	Size of the farm in acres	5.52	7.66
Yield	Production of maize in bags per unit area (100kg bag/acre). Used as a proxy for previous year output.	3.56	6.17
FBO	1 if farmer is a member of farmer based organization (FBO), 0 if otherwise	18.03a	0.39
On-farm	1 if main economic activity is farming , 0 if otherwise	65a	0.48
Climate perception	1 if a farmer perceived there are changes in climatic conditions, 0 if otherwise.	4.45	1.20
Off-farm	1 if engaged in off-farm activities, 0 otherwise	63.44a	0.42

Radio	1 if a farmer owns radio, 0 if not	80.00a	0.40

Source: Field survey, (2018). **Note**: Mean values with ‘a’ are proportions and not means.

Perception about climate change, types and channel of receiving seasonal climates forecasts

Farmers’ perceptions on climate change are crucial in reducing the impacts of climate change. In this section, the respondent’s opinions on climate change are provided. From Table 2, the study found out that majority of the maize farmers (85.33%) perceived that there is a changing climate while the rest 14.67% perceived that there is no changing in the climate. However, those who believed it exist perceived it in diverse ways, some perceive climate change being evidence through irregular rainfall pattern (70%) and believed strongly that bush burning causes climate change (30%). The farmers who actually believed in the existence of climate change adopted certain adaptation strategies that includes the following, early planting (10%), changing of planting date (40%), short term crop planting(15%), creating fire belts around farms(5%), adopting improve seed varieties (20%) and fertilizer application (10%). Also, about 94.67% of the respondents indicated that they need seasonal climate forecast for planning farming activity while the rest 5.33% of respondents indicated no need for seasonal forecasts information. It is important to emphasize that farmers interviewed engaged in rain-fed maize farming system, and as such, the success of the agricultural season depends to a larger extent on the nature of the rainy season. Hence the central role played by rainfall in the success of the agricultural venture justifies the high interest of farmers wanting to receive seasonal climate forecasts related to rainfall (onset, distribution and amount).

To reveal seasonal climate forecast needed by farmers, the study sought the respondents’ opinion on their preference for seasonal climate forecasts. Thus, the respondents were presented with various seasonal climate forecast components that theoretically farmers must have knowledge or information on in order to enhance their agricultural activities. From Table 2 it was revealed that about 94% of farmers preferred seasonal climate forecasts on rainfall, followed by temperature (3%), sunshine and lastly humidity (0.67%). This preference order by the farmers can be explained by the fact that rainfall is the primary climatic condition in crop production. It is therefore consistent that farmers would prefer seasonal information on rainfall than the other climate variables. A similar result was obtained by Mabe et al. (2014) and Amegnaglo et al. (2015). Farmers’ high interest for information about the onset of the rainy season can be attributed to the fact that maize is a weather sensitive crop, specifically during the germination. Thus, information about the onset of the rainy season aids farmers in making their choice regarding crop cultivars that are more favorably to the season. Farmers can choose late or early maturing cultivars depending on the rainfall pattern.

Table 2: Perception about Climate Change, Types and Channel of Receiving Seasonal Climates Forecasts

Variable	Frequency	Percentage

Existence of climate change		
Yes	256	85.33
No	44	14.67
Need for seasonal forecast		
Yes	284	94.67
No	16	5.33
Type of seasonal climate forecasting knowledge needed for farming		
Rainfall	282	94.00
Temperature	9	3.00
Sunshine	7	2.33
Humidity	2	0.67
Channel for receiving seasonal climate forecast		
Mobile phone	79	26.33
Radio	149	49.67
Television	72	24.00

Survey field work, 2018

One priority factor to consider is were the medium for delivering seasonal climate forecast. Therefore, three channels were provided to the respondents to indicate their preference. The communication channels used to deliver seasonal climate forecasts to end-users are vital because it can influence the use or non-use of the information and significantly reduce the verification costs (Goddard et al., 2010). As shown in Table 2, the highest percentage (49.67%) farmers preferred to receive the seasonal climate forecasts through radio, whilst 26.33% and 24% preferred receiving seasonal forecasts through mobile phones and television, respectively. This could be due to the presence of a radio channel or station in the Savelugu township. This provide a major source of information to the members of the Municipality in a local language. With the recent upsurge of mobile phones, one would expect that farmers would prefer to receive seasonal climate forecasts through the mobile phones. However, from a focus group discussion, it was revealed that information provided through the mobile phones are done in English language and most of the farmers could either not read or could read with minimal understanding. This is consistent with the low educational level of the farmers as in Table 1. Consistently, Amegnaglo et al. (2015) found that about 75% of their respondents preferred radio as medium for receiving climate information.

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Farmers' WTP for seasonal climate forecast information

Table 3 shows the result on the WTP for seasonal climate forecasts by the farmers. This involved the WTP decision, the minimum or first amount and the maximum or final amount a farmer is willing to pay for a forecast.

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Table 3: The WTP, initial and final WTP amount GH₵ (USD)

Variable	**Frequency**	**Percentage (%)**

WTP decision		
Yes	221	73.67
No	79	26.33
Amount WTP (mean)		
Initial bid	17.59 (3.53)	
Final bid	20.40 (4.09)	

Note: 1USD= GH₵ 4.99 Ghana Cedis (18th December, 2018 exchange rate)

Source: Field Survey (2018)

The survey depicts that majority of the farmers were ready to contribute financially to benefit from the seasonal climate forecast in order to reduce climate risks on agricultural productivity (Table 3). Thus, 73.67% of the farmers showed a strictly positive WTP. However, 26.33% of the farmers need climate information but were not willing to pay for it. Thus, although these farmers indicated that they need scientific seasonal climate forecasts, they are willing to pay for these forecasts, hence, would rely on indigenous knowledge in predicting the weather events.

As shown in Ttable 3, the initial mean WTP is about GH₵17.59 (USD3.53), which averagely increased to GH₵20.40 (USD 4.09) as the final amount a farmer is willing to pay for a weather forecast. Compared to the study by Amegnaglo et al., (2017) in Benin, the mean WTP value is lower than what farmers were willing to pay in Benin (USD 19).

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Determinants of smallholder farmers' WTP for seasonal climate forecasts.

As indicated in the study methodology, a two-step Heckman analysis was used to examine the factors that influence farmer's WTP decision for seasonal climate forecasts and the maximum WTP amount. The estimated results are presented in Table 4. The coefficient of the inverse Mill's ratio (IMR) was statistically significant at 10%. This depicts the presence of selection bias in the dataset and an indication that the estimates in the outcome equation appropriately explain the WTP amount of the farmers. The results of the WTP decision model indicates that gender, FBO membership, perception of climate change experience, and ownership of radio significantly influenced smallholder farmers' decision to pay for seasonal climate forecasts. Also, the WTP amount for seasonal climate forecast was significantly influenced by age, off-farm activities, participant of planting for food and jobs (PFFJ), and farmer's perception of climate change.

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Gender of respondents had a positive influence on WTP decision and this was significant at 5%. This suggests that households headed by males have higher probability of showing a positive decision to pay for seasonal climate forecast than female heads. This can be partially due to the fact that the men are the main decision makers in the households of the Municipality. Therefore, the females may have to consult a male adult in the household before taking a decision. This could mask the females WTP declaration and could explain the insignificance of gender in the outcome model.

From the result, ownership of radio had a positive significant effect on the WTP decision but a negative insignificant effect on the WTP amount. The positive effect implies that farmers who own radio have a higher probability of WTP for climate forecasts than farmers who do not own a radio set. This result contradicts the findings by Zongo *et al.* (2016), who postulated that farmers believe that climate information should be free if they are broadcasted by radio channel thus decreasing the value the farmers should or would be willing to pay. Our findings can be explained in the sense that majority of the farmers were illiterate and as such would prefer to receive climate information by radio broadcast in their local dialect rather than phone messages which is communicated in English. This is consistent with the result in Table 2 where the farmers indicated high preference for receiving seasonal forecasts through the radio set.

Consistent with expectations of the researcher, the perception on climate change had a positive significant effect on both the decision and the WTP amount for seasonal climate forecasts. This means that farmers who perceived that climate change exist have a higher WTP than those who perceived that there are no changes in the climatic conditions. This is reasonable as perceived existence of climate change serve as a motivation for farmers to pay more to receive seasonal climate information which will enable them adapt well to the changing climate.

The result established that PFFJ have a positive effect on both the decision and the WTP amount. However, the effect is significant for only the amount WTP. This implies that farmers who are participant of the PFFJ program are willing to pay higher amounts for seasonal climate forecasts than those who are non-members of the program. This clearly demonstrates the effectiveness of agricultural program in enhancing farmers' preparedness and willingness to have relevant climate information.

The effect of off-farm activity is also positive and significant in explaining the WTP amount by the farmers. Thus, farmers who engage in off-farm activities such as trading are WTP higher amounts for climate forecasts than those engaged solely in agriculture. Possibly, farmers who engage in off-farm activities are willing to offer incomes from these non-farm activities to pay for the climate forecasts. This can be tired to the notion that farmers invest income from non-farm activities into their farms. This confirmed the results of Zongo *et al.,* (2015).

Table 4: Determinants of farmers' WTP for seasonal climate forecasts

Variable	WTP Decision (Decision model)		WTP amount (Outcome model)	
	Coefficient (Std. Err.)	P-values	Coefficient (Std. Err.)	P-values
Gender	0.2131** (0.1107)	0.054	0.4313 (0.3390)	0.203
Age	-	-	-0.0053 (0.0065)	0.409
Education	-	-	0.1111 (0.2171)	0.024
Experience	0.0005 (0.0022)	0.829	-	-
Phone	-	-	-0.5955	0.172

			(0.4356)	
Off-farm	-	-	0.4000**	0.059
			(0.2123)	
PFFJ	0.0784	0.369	0.0340**	0.024
	(0.0872)		(0.0151)	
FBO	-0.0356	0.635	-	-
	(0.0751)			
Farm size	-	-	-0.0125	0.215
			(0.0101)	
Yield	0.0022	0.602	-	-
	(0.0042)			
Climate perception	0.2814**	0.015	0.3949*	0.062
	(0.1160)		(0.2167)	
Radio	0.1959**	0.018	-0.1253	0.543
	(0.0827)		(0.2057)	
Constant	0.5507***	0.008	0.8592	0.222
	(0.2076)		(0.7038)	
Mills lambda	-0.4452*	0.084		
	(0.2575)			
Rho	-0.8825			
Sigma	0.5045			

Wald chi2 (8) = 20.27; Prob > chi2 = 0.0094; *, ** and *** denote 10%, 5% and 1% significant level.

Conclusions and Recommendations

Information such as seasonal climate forecast is known among the important information employed by farmers when making crucial decisions that relate to their farming activities. Within this consideration, this study analysed the preference for climate forecast and the farmers' WTP. This was done through cross-sectional data from 300 smallholder farmers in Savelugu Municipality. From the theory of contingent valuation, a descriptive statistic and Heckman model were used in analysing the data. The Heckman model allowed us to understand the determining factors for both the decision and the WTP amount by the farmers. THESE SHOULD BE REMOVE:!!!!!!!!!!!!!!!!!

The study established that the majority of farmers are willing to pay for seasonal climate information. However, the most preferred seasonal climate forecast by the farmers is on rainfall (onset, distribution and amount). Again, the study concluded that for the farmers to accept to pay for seasonal climate forecasts, especially on rainfall, it must be communicated through the radio. This ultimately offers a greater opportunity for the dissemination of climate forecasts to a large group of farmers within a short possible time. On the average, farmers are were willing to pay about 18-20 Ghana cedis for climate forecast. The study also established a number of factors that influenced both the decision and WTP amount for seasonal climate forecasts. These factors

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include gender, FBO membership, perception of climate change experience, and ownership of radio. Furthermore, the factors determining WTP are age, trading, participant of planting for food and jobs (PFFJ), and perception of climate change. This study highlighted a number of policy implications.

Firstly, there is was ~~the~~ need for government institutions and other private agencies to take up the challenge and opportunity to provide climate information, especially seasonal rainfall forecast, to the farmers. Farmers indicated WTP for such services. Therefore, these agencies must determine an optimal or at least a breakeven price to charge the farmers for the forecasts. This should be done considering the farmer's ability and WTP. For example, national extension packages must make it a priority to integrate seasonal forecast via radio stations available whiles making emphasizes on such issues during visitation to such farmers. Secondly, it must be emphasized that numerous of farming activities depend greatly on climate events hence the role of climate information in farming cannot be underestimated, since the farmers are willing to pay to have such information. Thus, when such vital information is at their disposal it will help in the management of on-farm and non-farm risk which increases farm productivity thus increasing farmers welfare as a whole. Lastly, climate information dissemination can be integrated into government's PFFJ program. This is essential since the production climate can have a negative effect on the success of the program and the fact that membership of the program enhances farmers WTP decision and amounts for seasonal climate forecasts.

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Declaration of interest

Authors have declared that no competing interests exist

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REFERENCES

Alhassan, H., Asante, A.F., Oteng-Ababio, M. and Bawakyillenuo, S. (2017). Do socio-psychological factors influence households' willingness to pay for improved solid waste management services? Evidence from Ghana. *International Journal of Green Economics*, 11(3/4), 183-203.

Amegnaglo, C.J., Mensah-Bonsu, A., (2015). Are agrometeorological forecasts useful or harmful for smallholders in Africa: what does the literature say? In: Paper Presented at the 16th Global Development Conference. Agriculture for Sustainable Growth – Challenges and

Opportunities for a New Green Revolution. Global Development Network, Casablanca (Morocco).

Amegnaglo, C.J., Anaman, K.A., Mensah-Bonsu, A., Onumah, E.E. and Gero, F.A. (2017). Contingent valuation study of the benefits of seasonal climate forecasts for maize farmers in the Republic of Benin, West Africa. *Climate Services*, 6, 1-11.

Armah, A.F., J.O. Odoi, G.T. Yengoh, S. Obiri, D.O. Yawson and E.K.A. Afrifa. (2011)**.** Food Security and climate change in drought-sensitive savanna zones of Ghana. *Mitigation and Adaptation Strategies for Global Change,* 16, 291–306.

Ghana Statistical service (2014). 2010 Population and Housing Census: District Analytica Report, Savelugu-Nanton District. Republic of Ghana.

Ghana Statistical Service. (2014). Poverty Profile in Ghana (2005-2013). Ghana Living Standards Survey, Sixth Round Report (GLSS 6). Accra, Ghana.

Ghana Statistical Service. 2013. Poverty Profile in Ghana (2005-2013). Ghana Living Standards Survey, Sixth Round Report (GLSS 6). Accra, Ghana.

Goddard, L., Aitchellouche, Y., Baethgen, W., Dettinger, M., Graham, R., Hayman, P., Kadi, M., Martínez, R., Meinke, H., Conrad, E., (2010). Providing seasonal-to-interannual climate information for risk management and decision-making. *Procedia Environmental Science,* (1), 81–101

Graham, S., Pakinson C., and Chain M. (2002). Weather forecast through the ages. EOS project science, NASA.

Heckman, J., (1979). Sample specification bias as a selection error. *Econometrica,* 47 (1), 153–162 http://www.jstor.org/stable/1912352.

Ingram, K. T., Roncoli, M. C., & Kirshen, P. H. (2002). Opportunities and constraints for farmers of West Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. *Agricultural Systems, 74*(3), 331-349.

Intergovernmental Panel on Climate Change, IPCC (2007). Summary for Policymakers. In Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of National Development Planning Commission [NDPC].

International Food and Policy Institute (IFPRI) (2009). Climate change: Impact on agriculture and costs of adaptation. Washington, DC.

ISSER (2017). The state of the Ghanaian economy 2016. Legon, Accra.

Khuc, V. Q. (2013). Household's Willingness-To-Pay Estimation for Safe Drinking Water: A Case Study in Vietnam. A Thesis Submitted to Department of Agricultural and Resource Economics, Colorado State University in Partial Fulfilment of the Requirements for the Degree of Master of Science.

Loboguerrero A. M., Boshell F., León G., Martinez-Baron D., Giraldo D., Mejía . L. R., Díaz E. and Cock J. (2018). Bridging the gap between climate science and farmers in Colombia. *Climate Risk Management*, 22, 67-81, https://doi.org/10.1016/j.crm.2018.08.001.

Mabe, F., N., Nketiah, P., Darko, D., (2014). Farmers' willingness to pay for weather forecast information in Savelugu-Nanton Municipality of the Northern Region. *Russian Journal of Agricultural and Socio-Economic Sciences*, 36(12), 34-44.

Marteau, R., Sultan, B., Moron, V., Alhassane, A., Baron, C., & Traoré, S. B. (2011). The onset of the rainy season and farmers' sowing strategy for pearl millet cultivation in Southwest Niger. *Agricultural and Forest Meteorology, 151*(10), 1356-1369.

Nakuja, T., Sarpong, D. B., Kuwornu, J. K. M. and Ashante F. A. (2012). Water storage for dry season vegetable farming as an adaptation to climate change in the upper east region of Ghana. *African Journal of Agricultural Research*, 7(2), 298-306.

Onyango, E., Ochieng, S., Awiti, A. (2014). Weather and climate information needs of small-scale farming and fishing communities in western Kenya for enhanced adaptive potential to climate change. Proceedings of Sustainable Research and Innovation Conference, 4, 187-193.

Ouédraogo ,M Barry,S.,Zougmoré, R.B.,Partey.S.T., Somé, L. and Baki, G.(2018). Farmers' willingness to pay for climate information services: Evidence from cowpea and sesame producers in Northern Burkina Faso. *Sustainability*, 10(611), 1-16.

Pearce, D. and Turner, R.K.(1990). Economics of Natural Resources and the Environment; The Johns Hopkins University press: Baltimore, MD, USA; 378p.

Phillips, J., Deane, D., Unganai, L., & Chimeli, A. (2002). Implications of farm level response to seasonal climate forecasts for aggregate grain production in Zimbabwe. *Agricultural Systems, 74*(3), 351 369.

Roncoli, C. (2006). Ethnographic and participatory approaches to research on farmers' responses to climate predictions. *Climate Research, 33*, 81-99

Roncoli, C., Jost, C., Kirshen, P., Sanon, M., Ingram, K. T., Woodin, M., & Hoogenboom, G. (2008). From accessing to assessing forecasts: An end to end study of participatory climate forecast dissemination in Burkina Faso (West Africa). *Climatic Change, 92*, 433-460

Sarpong, B., D., Anyidoho, N., A., (2012). Climate Change and Agricultural Policy Processes in Ghana. IFPRI working papers, 045.

Shankar, K.R., Nagasree, K., Venkateswarlu, B., Maraty, P., (2011). Constraints and suggestions in adopting seasonal climate forecasts by farmers in South India. *Journal of Agricultural Education and Extension,* 17 (2), 153–163

Stutley, C. (2010). Innovation Insurance Product for the Adaptation to Climate Change (IIPACC) Project Ghana, Crop Insurance Feasibility Study 2010.

Traore, B., Corbeels, M., Van-Wijk, M. T., Rufino M. C., & Giller, K. E. (2013). Effects of climate variability and climate change on crop production in southern Mali. *European Journal of Agronomy*, 49, 115-125. http://dx.doi.org/10.1016/j.eja.2013.04.004

Zongo B., Diarra1 A., Barbier B., Zorom M., Yacouba H., & Dogot T. (2016). Farmers' Perception and Willingness to Pay for Climate Information in Burkina Faso. *Journal of Agricultural Science,* 8 (1)

Zongo, B., Diarra, A., Barbier, B., Zorom, M., Yacouba, H., & Dogot, T. (2015). Farmers' practices and willingness to adopt supplemental irrigation in Burkina Faso. *International Journal of Food and Agricultural Economics,* 3(1), 101-117.