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RESEARCH ARTICLE

Willingness to pay for weather index-based insurance in semi-subsistence agriculture: evidence from northern Togo

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ABSTRACT

The effects of climate change on agricultural production are pushing countries to reconsider risk management policies in their development plans. Opportunities exist to increase agricultural production and improve the policy environment. However, policymakers lack local empirical evidence to provide local solutions to agricultural development in many developing countries, including Togo. This paper assesses farmers' willingness to pay for weather index-based insurance (WII) as a market option for sharing climatic risks. A choice modeling approach is used based on data collected from 704 randomly selected households in northern Togo, West Africa. Statistical analysis of the data shows that dry spells are the major concern of farmers and maize is perceived as the most affected food crop. Results also indicate that respondents are willing to participate in a WII market and would prefer insuring crops, such as maize over sorghum and rice against drought by paying on average about $14.5 per hectare. The results show that WII should not be offered standalone, but interlinked with other factors such as providing drought tolerant and high yielding varieties; loans to organized farmers' groups; and weather information through TV, radio and mobile phones in local languages, while encouraging education to enable the diffusion of more advisory services. These factors are likely to influence positively farmers' preferences in participating in a WII market.

Key policy insights

- Very often, insurance is seen as a magic bullet in agricultural risk management policy discussions.
- A standalone WII could suffer from low adoption, a problem that calls for other policy options.
- As a climate change adaptation policy, WII could be bundled with other risk-reducing options for a better uptake and to improve farmers' welfare.
- WII can be an effective channel for farm credit facilities and advisory services, as well as other agricultural risk management interventions.

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Agriculture; climate change; adaptation policy; weather index-based insurance

1. Introduction

The impact of climate change on agricultural productivity is widely recognized (Doelle & Seck, 2019; Mendelsohn et al., 1994; Nordhaus & Yang, 1996). Besides positive impacts predicted in some regions (Deschênes & Greenstone, 2007; Hossain et al., 2019), negative effects of climate change on agricultural production are also projected, and these are more pronounced in developing countries (Davenport et al., 2018; Di Falco, 2014; IPCC, 2014; Rosenzweig & Parry, 1994). In Sub-Saharan Africa, variability in temperature and precipitation, the shortening of growing seasons, flooding, drought and erosion are frequently observed and are becoming real challenges for agricultural production leading to an increase in food imports (Deressa et al., 2009; Di

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Falco et al., 2011; Egbendewe et al., 2017; Wossen et al., 2017). Climatic risks can escalate poverty levels, especially given the proportion of the population involved in the agricultural sector and its contribution to welfare of households in low income and developing countries. Moreover, people in low-income countries who heavily depend on agriculture tend to be more vulnerable, because of their low adaptive capacities (Fisher et al., 2015; Hönle et al., 2018; IPCC, 2014; Rosenzweig & Parry, 1994).

There is, therefore, the need for intervention, not only of the public and private sectors in climate risk management, but also at the individual level through adoption of adaptation technologies at the farm or household levels. Being aware of economic losses due to weather risks, policymakers are concerned with finding solutions to support vulnerable households in case of poor harvests (Budhathoki et al., 2019; Dale et al., 2019). Indeed, within the context of developing countries, pro-poor growth policies require risk mitigation and adaptation tools that can help farmers offset the negative effects of climate change and enhance productivity. In that sense, the uptake of an insurance product can play an important role in risk pooling and enhance climate change resilience (Broberg, 2019; Budhathoki et al., 2019; Glauber, 2004; Nordlander et al., 2019).

Traditional agricultural insurance programmes such as hedging plus weather index-based insurance (WII), are existing market instruments used in addressing the effects of climate change on farm household production (Fuchs & Wolff, 2011; McIntosh et al., 2013; Turvey et al., 2006). Traditional agricultural insurance programmes have often failed in developing countries due to moral hazard and adverse selection issues (Du et al., 2014; Glauber, 2004; Miranda & Glauber, 1997; Smith & Goodwin, 1996). Indeed, a farmer might have a poor harvest because of lack of incentives to an optimal use of input knowing that s/he will be paid for such an outcome. This behaviour cannot be controlled by insurance companies. An alternative is to use WII as a market instrument for sharing climatic risks (Clarke, 2016; Hill et al., 2019). WII is a common approach used to respond to crop yield variability induced by rainfall deficiencies (Clarke, 2016; Du et al., 2014; Fuchs & Wolff, 2011; Hill et al., 2019; Shirsath et al., 2019). In fact, among the coping instruments, WII is seen as one of the most efficient that could be used in climate risk management in developing countries (Chantarat et al., 2007; Horton & Keith, 2019; Miranda, 1991; Richards et al., 2004; Shirsath et al., 2019).

In the case of adverse weather events, WII contracts could help cover some losses based on the realization of a weather index, rather than actual production losses which can pose valuation problems. In general, five reasons are given to explain preferences for WII: (i) It is transparent and easily verifiable to policyholders; (ii) its calculation is not vulnerable to manipulation; (iii) its probability distribution can be accurately estimated; (iv) it can be measured inexpensively and in a timely manner, and (v) the realization of the index is highly correlated to household income and consumption risk (Barnett & Mahul, 2007; Chambers, 2007; Duncan & Myers, 2000; Giné et al., 2008; Mahul, 2001). A WII could also enable farmers to make more productive investments while boosting technology adoption (Carter et al., 2016; Jensen et al., 2017).

Weather index-based insurance continues to attract farmers in managing agricultural production risks. For instance, the Ministry of Agriculture of India (2012) reported that, between 2010 and 2011, the rainfall insurance business had attracted 27.7 million farmers with over 38 million hectares of crop areas insured. Over 6 million farmers recovered from crop losses due to adverse weather events. In France, 2 billion Euros were paid to 55,000 farmers as insurance payment for damages caused by drought and frost, while payments reached an average of 149.75 million Euros in Italy each year from 2003 to 2006 (Enjolras et al., 2012). In Africa, some countries such as Kenya, Tanzania, Rwanda and Ethiopia offer WII products to the number of farmers. For instance, about 200,000 poor smallholder farmers were enrolled in the WII market between 2009 and 2013 in Kenya, Tanzania and Rwanda, with US$12.3 million of payments received (Greatrex et al., 2015). The use of WII has increased farmers' understanding and appreciation of insurance policy structures and helped in reducing considerable losses in adverse rainfall years (Glauber, 2004; Miranda & Glauber, 1997; Sarris, 2013; Tesfaye et al., 2019; Ward et al., 2014). Despite the advantages that WII products offer in protecting farmers against natural hazards and adverse weather events, neither public nor private insurance companies currently exist in many developing countries, including Togo, to support farmers in cases of occurrence of these events. So far, opportunities exist to increase agricultural production, but policy makers lack local empirical evidence to provide local solutions to agricultural development.

The objective of this paper is to estimate the willingness to pay for WII in a semi-subsistence farming setting using data from northern Togo. Specifically, the study seeks to: (i) assess farmers' perception of WII policy interventions, (ii) evaluate the effect of attribute-based insurance contracts on farmers' preference for a potential WII market, and (iii) estimate the average amount that farmers would be willing to pay for a potential WII as a market option for sharing climatic risks. In other words, this paper seeks to contribute to understanding of how insurance could be used as a climate change adaptation strategy in semi-subsistence farming systems where farmers are not necessarily producing only for the market, but also for subsistence. Risk management in agriculture itself could also open up opportunities for governments and financial institutions to finance agriculture in developing countries where farming activities lack funding for expansion. This paper sets itself apart from previous works by focusing on cereals such as maize and sorghum, which are well-known staple crops produced in the West African sub-region for subsistence.

The remainder of the paper is organized as follows: Section 2 outlines the methodological approaches employed for the study. The results are presented and discussed in Section 3. Section 4 concludes and suggests possible policy recommendations inferred from the results of the study.

2. Methodological approach

This section presents the study area, data collection procedure and the empirical model used.

2.1. Area of study and data collection procedure

Agricultural production in Togo contributes to about 40% of the gross domestic product (GDP), represents 20% of total exports, and employs about 70% of the total work force with less than 2% of cultivated lands under irrigation (AfDB et al., 2016). Food crops production is the main activity of the most vulnerable households and cereal production contributes to about 68.5% of agricultural GDP (FAO, 2015). Changing trends in the climate are expected to impact on food crop production, in addition to farmer behaviour in technology adoption (Ali, 2019; Asfaw et al., 2016). The temperature has increased on average about 1.1°C since 1960, while precipitation has decreased on average about 2.3 mm per month leading to shorter rainy seasons, which start around 30 days later than usual (Tchinguilou et al., 2012). Maize, sorghum and rice are the main food crops produced in the study area and they represent about 30%, 85% and 69%, respectively, of the national production from 1972 to 2014 (Ali, 2018).

A multistage sampling technique was used to collect cross-sectional data from 704 agricultural households. At the first stage, three regions in northern Togo – Central, Kara and Savannah were selected on the basis of their rainfall characteristics (Figure 1).

These regions are characterized by three agro-ecological zones (Figure 1) and have one wet season and one dry season each year compared to two wet seasons and two dry seasons in the southern regions of Togo. The second step was the random selection of three districts in each region (Figure 1). The third stage was the random selection of five villages in each district, and then a fourth stage where farm households were selected randomly in each district. Using the list of farm households provided by the villages' administrators, the surveyed farm households were randomly selected. Face-to-face interviews were conducted using a structured questionnaire, which was twice pre-tested. Detailed information was collected on: the agricultural households' socioeconomic characteristics; farmers' perceptions of climate change and its effects on different crops; preferences on drought insurance, flood and high-temperature insurances. Data were also collected on the perceptions of WII; willingness to pay for it, and preferences on hypothetical insurance attributes, such as loans; access to drought-tolerant seeds (DTS); and the use of climate information in decision making.

Literature was helpful in the choice of the attributes used to design the WII contracts (Ali & Awade, 2019; Bhattacharya & Osgood, 2014; Giné et al., 2008; Hamukwala et al., 2018; Hill et al., 2013; Hill et al., 2019). Four attributes were considered (Table 1).

It has been shown in the literature that WII uptake in developing countries often fails to sustain, with demand tending to drop after a heavily subsidized pilot stage; the explanation often given for this is that WII is mostly offered as a standalone product (Bogale, 2015; Giné & Yang, 2009; Sibiko et al., 2018; Tadesse et al., 2015). Consequently, DTS, loans and weather information – often identified as key elements in climatic risk management – were taken into account in the design of insurance packages in this study.

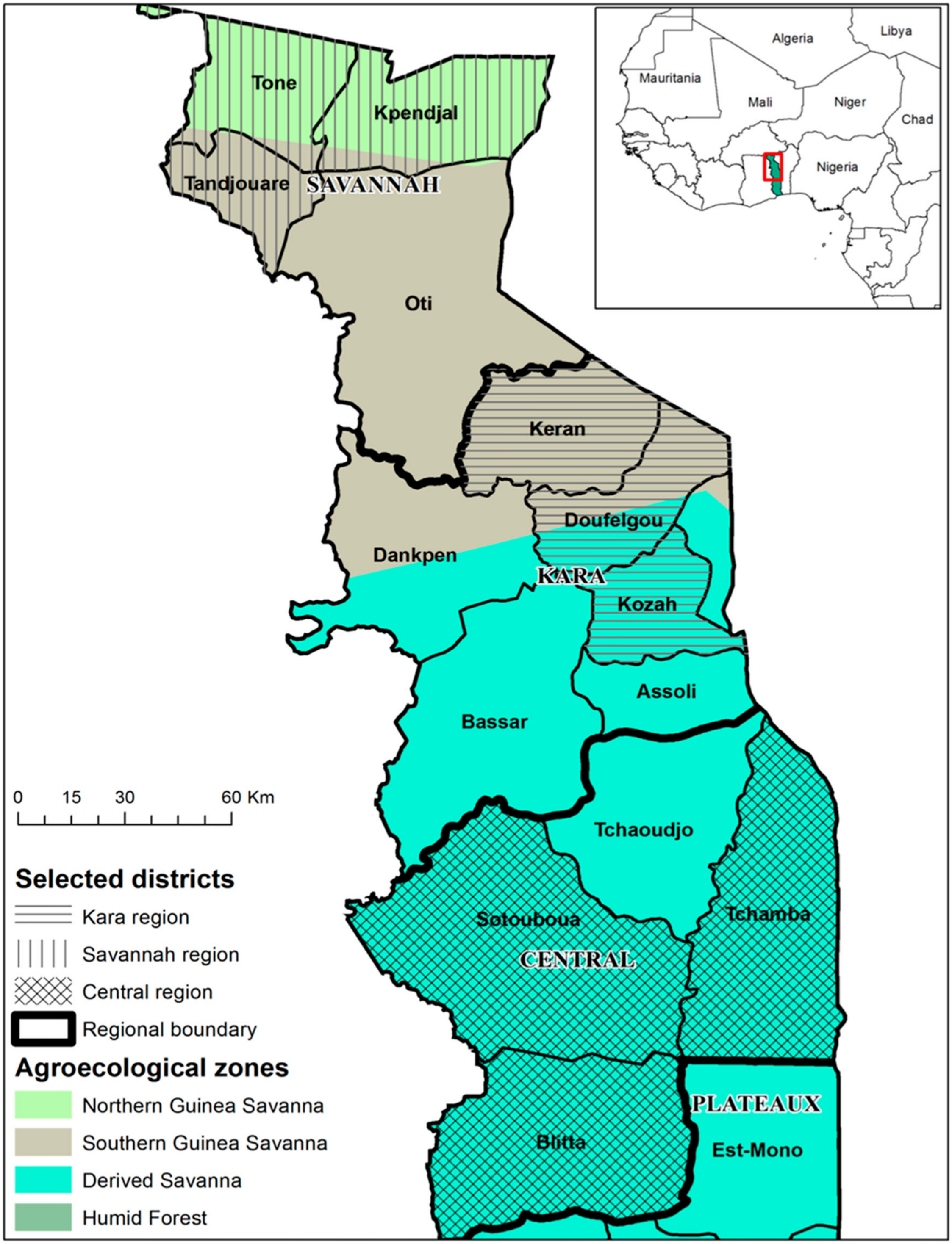

Figure 1 Study areas.

Table 1. Selected attributes and their possible levels.

Attributes	Possible levels		
Premium (with maximum payout of $140.00 per hectare)	$17.50	$14.00	$7.00
The insured will get drought tolerant seeds (DTS) when signing the contract	Yes	No	
Get loan ($60.00) and payment plus fixed interest of $6.00 is made after the harvest, but the insured farmers must be organized by group or cooperative	Yes	No	
The insurer guarantees the provision of weather information through mobile phones in insured local language	Yes	No	

The first attribute of the WII package is the insurance premium. The results from the pilot study showed that the minimum revenue per hectare, that a farmer can receive from growing maize, sorghum or rice, if the rainy season is good was on average about $140.00. This amount was considered as a maximum payout that an insured farmer can get if crops fail due to drought. Three different premium levels were then offered based on the maximum payout per hectare: $17.5 (12.5% of the maximum payout); $14 (10%) and $7 (5%).

The second attribute means that an insured farmer will receive DTS when signing the WII contract. The literature suggests that incorporating other risk management tools such as improved DTS plus weather information in the WII policy could increase adoption of these technologies (Ward et al., 2020), and thereby be more effective in mitigating drought risks than WII alone (Budhathoki et al., 2019; Ricome et al., 2017; Ward et al., 2020). The government can assist insurance providers by subsidizing the additional cost of providing improved seeds and weather information.

The third attribute concerns loans. The problem of access to loans in agricultural sector has been a common and critical issue in low-income countries, even though making loans available could improve agricultural production. To this end, insured farmers will get a loan of $60.00 where repayment plus a fixed interest (10% of the loan amount) is made after the harvest (attribute 3). In order to minimize the risk of non-payment, insured farmers are required to be organized into groups ranging from 5 to 10 farmers. This strategy is often applied by micro-finance institutions as an alternative to collateral in rural areas (Armendariz & Morduch, 2007 Besley & Coate, 1995; Kodongo & Kendi, 2013). Also, according to Armendariz and Morduch (2000) taking a loan through an organized group can facilitate climate risk management through education, training for efficient use of credit and greater speed of technology adoption. Attribute 4 offers weather-related information that could be given to the insured farmers through mobile phones in the local language.

The attributes described could be used in different combinations to design a variety of insurance contracts. Expecting each respondent to choose between the full ranges of 24 different insurance contracts could lead to confusion in the choice among attributes and give inconsistent answers. To make it easier and minimize such bias, an orthogonal design technique was used. The number of possible insurance packages was reduced to 8 instead of 24 through random selection using SPSS software. The selected insurance packages were displayed on 4 cards, each showing 2 insurance packages. An example of a card is given in Table 2.

Assuming that the individual is rational in his/her choice and after explaining what WII is and how it functions, those who were interested were asked to specify their preferred insurance package. The status quo option: '*I am not interested in such packages*' was added on all cards. In the specific example of Table 2, the respondent is expected to make a trade-off between DTS and weather information. If the respondent chooses the status quo option, it implies that his/her utility from participating in the new WII programme is less than his/her utility level from not participating in the insurance programme and vice versa.

Table 2. Example of a card given to respondents.

Weather index-based attributes	Package 1	Package 2	I am not interested in such packages
Premium (with maximum payout of $140.00 per hectare)	$17.50	$14.00	
The insured will get DTS when signing the contract	No	Yes	
The insurer guarantees the provision of weather information through mobile phones in insured local language	Yes	No	
Choose the preferred insurance package	☐	☐	☐

2.2. Empirical model: choice Modelling approach

Demand for WII depends on the farmers' expected utility. Thus, WII demand analysis relies on welfare measurement theory or expected utility theory (Lancaster, 1966). Several approaches can be used to measure social welfare, with most of them based on environmental economics literature related to the valuation of non-market commodities (Boyle & Bishop, 1988; Kwak et al., 2016; Lloyd-Smith, 2018; Ward et al., 2014). There are two approaches to the valuation of non-market commodities: revealed preference and stated preference (conjoint analysis, contingent valuation method and choice modeling). Because of their flexibility, the contingent valuation method (CVM) and choice modeling approach (CMA) are most widely used (Blamey et al., 1999; Hamukwala et al., 2018; Hanemann, 1984; Hanley et al., 2001; Tesfaye et al., 2019). CVM is used to assess market demand or motivation to accept a proposed programme, product or service. Although CVM is appreciated by researchers, its use in environmental policy appraisal is limited for several reasons. According to Hanemann (1994) and Arrow et al. (1993), CVM survey accuracy can be undermined by poor research design and may involve strategic bias during the bid vehicle step, especially when the respondent deliberately influence the outcome (Rolfe, 1999). Following Hanley et al. (2001), CMA was used for this study to assess farmers' willingness to pay for a hypothetical WII, because it offers more than two alternative bids to respondents and its survey techniques help to avoid 'yes' response and therefore minimize response bias.

$$U_{ij} = V_{ij}(X_{ij}) + \epsilon_{ij} \quad (1)$$

U_{ij} is the utility function of individual i when choosing alternative j within a finite choice set $\mathcal{S}$. This utility function can be decomposed into two components: the deterministic component (V_{ij}) which captures the observable characteristics like the socioeconomic characteristics of respondents and the stochastic component (ϵ_{ij}) which is the individual's unobservable characteristics that might influence his/her choice. X_{ij} is a vector of observable characteristics that could influence the utility function of the individual i when choosing the alternative j. If V_{ij} is linear in its parameters, the utility function of individual observable characteristics for choosing the j^{th} alternative could be written as:

$$U_{ij} = aX_{ij} + \epsilon_{ij} \quad (2)$$

Between two alternative options j and t within the choice set (j and t are elements of $\mathcal{S}$ and $j \neq t$), the respondent i will choose the option t rather than any other alternative j**,** if and only if the expected utility from choosing the option t is greater than choosing the option j. The decision of the respondents is stochastic because of the unobserved components associated with choices being made. The choice of an alternative t implies that:

$$\text{Prob}(U_{it} > U_{ij}) = \text{Prob}[(V_{it} - V_{ij}) > (\epsilon_{ij} - \epsilon_{it}), \quad \text{For all} \quad t \neq j] \quad (3)$$

It is important to remember that the econometric objective of this exercise is to estimate the effect of individual observable characteristics and attribute of each option on the probability that option t will be the most preferred one. Then, given the independence assumption between alternative choices, the probability of choosing an alternative t over the alternative j is given by:

$$\text{Prob}\{t/\mathcal{S}\} = \text{Prob}[(V_{it} > V_{ij}), \quad \forall\, t \neq j] = \frac{\exp(\omega V_{it})}{\sum_j \exp(\omega V_{ij})} \quad (4)$$

Equation (4) is called the conditional Logit model in which ω is a scale parameter which is inversely proportional to the standard deviation of the error distribution and is assumed to be one. The model is then estimated using maximum likelihood procedures. The log-likelihood function can be stated as follows:

$$\log L = \sum_{i}^{N} \sum_{j=1}^{J} Y_{ij} \log\left[\frac{\exp(V_{it})}{\sum_{j=1}^{J} \exp(V_{ij})}\right] \quad (5)$$

Y_{ij} is an indicator variable, which is coded by 1**,** if the respondent chooses option (t) and 0 otherwise. The estimation of the market share ($MS(t)$) of choosing alternative t is also possible, knowing individual differences in the utility function (Equation 6).

$$MS(t) = \sum_{i=1,N}\left[\frac{\exp(\omega V_{it})}{\sum_j \exp(\omega V_{ij})}\right] / \sum_{j\in S}\left[\sum_{i=1,N}\frac{\exp(\omega V_{ij})}{\sum_j \exp(\omega V_{ij})}\right]*100 \qquad (6)$$

N is the total number of respondents. After estimation of the market share of various insurance contracts, it becomes easier to compute farmers' willingness to pay for compensating variation in welfare (*WTPCVW*) for each attribute using the 'status quo option' as the baseline option of welfare measurement (Equation 7).

$$WTPCVW = b_y^{-1}\left[\ln\sum_i \exp(V_i^1) - \ln\sum_i \exp(V_i^0)\right] \qquad (7)$$

V_i^0 is the utility from the baseline option and V_i^1 is the utility from the alternative state. b_y is the coefficient of the attribute's cost. It represents also the value of marginal utility of income. Assuming that before and after policy option, the choice set includes a single solution, the welfare measured by (7) will be reduced to Equation (8).

$$WTPCVW = \frac{1}{b_y}[V_i^1 - V_i^0] \qquad (8)$$

From (7) the implicit prices could be derived, since the deterministic part of the individual utility function can be expressed as a linear function of all the observed characteristics.

2.3. Descriptive statistics

The summary statistics of the data used in this study (Table 3) show that the average age of the surveyed population is about 43 years and they work on farms of limited size (on average about 2.75 hectares).

A negative relationship between age and farmers' enrollment in WII if the premium level increases is assumed. However, we assume that the more the farm size increases, the more the farmer would be willing to enroll in WII. The liquid assets of a farm are measured as the sum of the cash, checks and savings (from banks, microfinances, and mutual funds), value from agricultural stocks and assets (eg: livestock) that could be easily sold to deal with any emergency at the household level. The data show that the farm households in the study areas have very low assets ranging from \$1 to \$512 with an average of about \$33.93. Liquid assets, capturing household wealth, are expected to positively or negatively affect the farm household decision about the enrolment in WII programme (Clarke, 2016; Giné et al., 2008).

In order to help vulnerable households start small businesses, the Togolese government initiated a programme called the National Fund for Inclusive Finance (FNFI credit) which aims at allocating small amounts of credits. Access to this fund might be expected to positively affect farmers' willingness to enroll in the WII programme. On average, about 33% of farmers in the sample have access to this type of credit (Table 3). While

Table 3. Summary statistics.

Variables	Unit	Mean	Standard Deviation
Premium (per hectare)	US dollars	12.44	5.97
Access to DTS	Dummy	0.33	0.47
Access to loans	Dummy	0.55	0.49
supply weather information	Dummy	0.44	0.50
Age	Number of years	43.81	11.77
Farm size	Hectares	2.75	1.44
Liquid asset of the household	US dollars	33.93	40.15
Access to FNFI credit	Dummy	0.32	0.43
Have access to climate information	Dummy	0.25	0.43
No formal education	Dummy	0.15	0.36
Primary education	Dummy	0.47	0.49
Number of respondents	704		

education is seen as a key element in technology adoption, 15% of farmers do not have any formal education and only about 47% had basic formal primary level education.

3. Results and discussion

3.1. Farm households' perception of WII

The study has found that virtually no farmers (97%) have ever heard about WII. The WII product therefore needs to be carefully explained to respondents. Almost all the respondents (over 99%) positively assessed the WII policy intervention and were willing to participate in this programme. Separating drought, flood, and high-temperature insurances as different insurance products, the results show a disparity within farmers' responses to the products (Table 4).

About 99% of respondents are likely to participate in the proposed drought insurance programme, 47% in the flood insurance programme and, 5% in high-temperature insurance. Based on farmers' experience about the impact of climate change on farming activities, drought is perceived to be the most problematic weather risk and maize is the most affected food crop (Table 4). For example, over 97% of farmers are willing to insure maize against drought, but only 24% and 20% of farmers, respectively, would accept to insure sorghum and rice. None of the respondents revealed preferences to insure maize, sorghum or rice against flood and high temperature. This result confirms those found by Parkes et al. (2018) and Ali (2018) that maize is the food crop in Togo most affected by climate change and the most consumed cereal in the country. Apart from the selected crops (maize, sorghum and rice), some farm households are ready to insure cotton, soybeans and beans (Table 5).

For instance, about 25% of farmers expressed their desire to insure cotton, while 10%, would insure their soybeans. Only 5% of respondents are willing to protect beans.

3.2. Econometric results of attribute based WII demand

Two different model specifications were analysed using conditional logit (Table 6). The first model (model 1) is the attribute-based specification, while the second model (model 2) considers different attributes with farm household socioeconomic characteristics (Table 6). To control the over-fitting of the model and make sure that the utility function approximation was consistent, we applied the robust estimation option (Shi & Yin, 2018). The attribute-based specification parameters are significantly different from zero at 1% level. These parameters also have the expected signs.

The study shows that the level of the insurance premium, seen as the price to pay to get enrolled in the insurance programme, negatively influences the demand for insurance, a result that is also found in the literature (Goodwin, 1993; Hill & Robles, 2011; Sherrick et al., 2003). Therefore, offering insurance as a standalone product seems not to be attractive.

The study results show that offering DTS and loans for agricultural activities is likely to significantly motivate farmers to pay for WII, as also confirmed in the literature (Giné et al., 2008; Cherrick et al., 2004). Providing weather information to the insured farmer through a mobile phone in the local language also increases farmers' utility from participating in the hypothetical WII market. The odds ratio of this attribute is high, suggesting that farmers would adopt WII if insurance providers could take the provision of such weather-related information into account in the proposed WII packages. This will encourage farmers to produce not only for subsistence, but toward commercialization (semi-subsistence farming). The results of the attribute-

Table 4. Type of insurance programme and farm households' preferences.

Insurance programme	% of Respondents	Willing to insure maize (%)	Willing to insure sorghum (%)	Willing to insure rice (%)
Drought insurance	98.44	97.30	24.43	20.45
Flood insurance	48.86	0	0	0
High temperature insurance	5.26	0	0	0
Total of respondents	704	704	704	704

Table 5. Other suggested crops that could be insured.

Other crop that could be insured	Proportion of respondents (%)
Cotton	25.01
Soybeans	9.54
Beans	5.25
Total of respondents	704

based specification are also similar to those taking into account the interaction of agricultural households' socio-economic characteristics with other variables (Kwak et al., 2016) in model 2. Apart from attributes that are used to design the WII contract, other factors affect farmers' decision to enroll in the WII programme. For instance, households who have access to FNFI credit value DTS more highly, and are therefore more likely to enroll in the WII programme.

Farm size could also explain insurance demand (Sherrick et al., 2004; Xu et al., 2008). The results show that farmers with larger farms are less sensitive to increase in the premium level, and are therefore more likely to enroll in the WII market. The results also show that increasing cultivated lands could lead to an increase in demand for WII. These results are similar to those of Enjolras et al. (2012) and Xu et al. (2008). However, the oldest household heads are more concerned about insurance premiums compared to the youngest household heads, and therefore attach less importance to enrolling in WII. The results also suggest that farmers who have access to weather-related information place more value on the WII policy intervention and therefore increasing the premium level does not affect their decision.

Farmers who have attained only primary school education level were found to be less willing to enroll in WII, when the premium level increases. Sometimes, buyers' beliefs about insurance product providers influence their buying decision, especially if it is the first time those buyers interact with formal financial institutions (Gaurav et al., 2011). Farmers may think that the insurers are better informed about their products, so that they have a greater advantage over them (asymmetry of information). Farmers may also think that the expected premium to be paid is a 'waste of money' if the rainfall is good, thus limiting demand for WII. For these reasons, any study dealing with insurance policy intervention in rural areas, where only few farmers have had a formal education, should clearly describe the product and increase farmers' understanding. Hill et al. (2013), studying the adoption of a WII in rural Ethiopia, find similar results which confirm that not only wealthier individuals, but also educated people, are more likely to purchase insurance products.

Promoting education for farmers may increase their understanding regarding the WII programme. There is a need to help farmers understand that, the premium is not a 'waste of money' since agricultural risks are highly correlated with weather conditions. The results indicate also that the probability of WII enrolment decreases

Table 6. Econometric results from conditional logit.

Choice of alternatives	Model 1			Model 2		
	Odds Ratio	*Coef*	*Z*	Odds Ratio	Coef	*Z*
Premium	0.9997***	−0.0002***	−8.40	0.9997***	−0.0003***	−3.40
Access to DTS	13.0126***	2.5659***	14.82	11.6951***	2.4592***	14.06
Access to loan	3.6676***	1.2995***	5.89	3.8187***	1.3399***	5.27
Weather information supply	17.2579***	2.8482***	16.92	17.1141***	2.8399***	14.37
Access to DTS*FNFI credit				1.6859***	0.5223***	2.65
Premium*Farm size				1.0001***	0.0001***	3.43
Premium*Access to climate Information				1.0001***	0.0001***	2.61
Premium*Household asset				1.0000	2.38e-09	1.53
Access to DTS*No formal education				0.4941***	−0.7049***	−2.76
Premium*Primary				0.9998***	−0.0001***	−3.08
Premium*Age				0.9999**	−3.05e-06**	−2.06
Pseudo R^2			0.46			0.48
Number of households	704					
Choice sets per household	9					
Number of observation	6336					
Wald-Statistics			831			826

***$p < 0.01$; **$p < 0.05$.

Table 7. Market shares and willingness to pay for WII packages.

Packages	P1	P2	P3	P4	P5	P6	P7	P8	Status quo
Premium ($)	17.50	14.00	17.50	14.00	17.50	7.00	17.50	7.00	
DTS	No	Yes	No	No	Yes	No	Yes	No	
Loan	No	No	Yes	Yes	Yes	Yes	Yes	Yes	
Weather information	Yes	No	No	Yes	Yes	No	No	Yes	
Market share	3.41%	0%	0%	3.55%	61.22%	2.13%	4.83%	24.29%	0.57%
WTP ($)	0.59	0	0	0.49	10.71	0.15	0.85	1.17	0

when farmers do not have any formal education, even when there is the added motivation of offering DTS. This would suggest that, the more the farmer is educated, the better s/he understands that DTS is a useful adaptation measure to climate change. Therefore, promising DTS as part of the WII contract could increase farmers' expected utility in participating in the WII policy intervention.

3.3. Ranking WII packages and farmers' willingness to pay

The market share of the proposed WII packages and average willingness to pay for each are shown in Table 7. A rational farmer will choose the package that provides the highest expected utility. Package 5 is by far the most preferred insurance contract. It provides DTS to farmers when signing the contract, as well as a loan of $60 (requiring repayment after harvest with a fixed interest rate of 10%, and under the condition that the insured are organized in a group of 5–10 people).

The insurer also undertakes to provide weather information through TV, radio and mobile phones in the insured local language. About 61% of farmers prefer package 5. The average insurance premium to be paid for that option is about $11 (Table 7). This result shows that combining WII with other risk management tools would enhance the insurance take-up in developing countries characterized by low adaptive capacities, as also reflected in the literature (Budhathoki et al., 2019; Carter et al., 2016; Tadesse et al., 2015). For example, Tadesse et al. (2015) reported that interlinking WII with credit or safety nets would increase the insurance take-up in agriculture in Sub-Saharan Africa. According to Sibiko et al. (2018), supplying insurance products through a group network would increase the probability of enrolment in a WII market. Individuals with a low level of education could be motivated to purchase WII if it could be provided through a group network (Giné et al., 2008; Hill et al., 2013). Also, Budhathoki et al. (2019) and Carter et al. (2016) have shown that the low uptake of insurance products is not related to the premium, but to the design of the product itself. The second most preferred option for farmers is the case where the farmer is expected to pay $7 as a premium, with the possibility of a loan and weather information. About 24% of farmers preferred this contract. Other contracts are similar in the opinion of respondents, except packages 2 and 3, for which no respondent was ready to pay. Only a very few respondents, (less than 1%) preferred the status quo option (no interest in the proposed package).

4. Conclusion and policy implications

Agricultural insurance is becoming a necessity as a result of the impact of climate change and climate variability on agriculture. However, moral hazard and adverse selection biases, which often occur in the implementation of traditional climate risk coping strategies, have been experienced in the context of developing countries. Weather index-based insurance (WII) provides an alternative for sharing climatic risks, but has not yet been widely implemented. This study has assessed farmers' willingness to pay for WII as a market option for sharing climatic risks, by applying a choice modeling approach to cross-sectional data collected in a survey of 704 households in northern Togo.

The results indicate that a large proportion of respondents (98%) are willing to insure their crops against drought. The study finds that on average, 97% of respondents would insure the maize against drought compared to sorghum (24%) and rice (20%). These results indicate that drought is the greatest weather risk concern for farmers, and maize is perceived to be the most vulnerable food crop as a result of climate change. Also, over 99% of respondents were willing to enroll in the WII market. The WII policy intervention would be attractive if the insurance contract could jointly take into account the provision of DTS, credit as well as weather information. The market share of such a hypothetical insurance product could reach at least 61%. Also, the education level of farmers is likely to positively influence the adoption of WII and DTS. Meanwhile, the highest premium level tends to decrease farmers' willingness to participate in the WII programme. The study indicates that, as a complement to WII, attention should be given to additional attributes such as providing DTS to farmers, offering loans and ensuring that farmers not only have access to weather information, but more importantly, that such information is also integrated these into their decision making processes through farmer-based organizations. Linking WII to other risk management instruments such as DTS, credit and weather information could be a great step in moving toward a semi-subsistence farming system, where a farmer produces not only for subsistence, but also for market. There is also the need to educate and advertise WII and help farmers better understand the advantages of the WII programme. Having easy access to locally relevant weather forecasts is also important. Therefore, increasing the number of weather stations and the quality of needed instruments is recommended for better implementation of a WII. Future research could analyse the supply side of WII, to determine the equilibrium price of offering such packages. Such research could take into account the potential for existing financial institutions and/or insurance companies, in Togo and in other African countries, to provide WII.

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