Research Article

Farmers' Attitudes Towards Climate Risks and Effects of Farmers' Risk Aversion Behavior on Inputs Use in Northern Togo

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Abstract | This paper analyzes farmers' attitudes towards climatic risks and assesses farmers' risk aversion behavior on inputs use focusing on fertilizer, drought tolerant seeds (DTS) and labor allocation. Multi-stage sampling technique was used to collect data from 704 farm households in three regions (Central, Kara and Savannah) in subsistence agriculture in Northern Togo. Tobit and linear regression models were used to analyze the effect of farmers' risk aversion on fertilizer and DTS uses, and labour allocation, respectively. The results indicate that on average 86.22% of farmers have risk aversion behaviors. Widening the land devoted to maize cultivation would increase farmers' risk aversion while increasing the land devoted to sorghum, tuber and cotton crops would reduce it. Being risk averse leads farmers to reduce the fertilizer and DTS use and allocate more labor in non-farm activities. The more the distance to the nearest input market is, the less the fertilizer is used. However, increasing the amount of agricultural credit would increase fertilizer and DTS use. The study concludes that any implementation of new policies to address climatic risks and food insecurity in the study areas should take into account farm households' attitudes towards risks. Farmers are encouraged for regular visit to extension services whlie policymakers should give special attention to factors such as credit facilities and market access through development of transportation infrastructure in order to reduce farmers' risk aversion in the study areas.

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Introduction

Farming is a business for rural farm households. This business is at risk because of the uncertain nature of the climate. The climate change and variability may affect seriously farm level income, leading to falling sometimes below the threshold of survival (Mirza, 2003; Kahan, 2008; Parry et al., 2004). This will affect farm household livelihood resulting in a change of farmers' behavior in resource allocation decision, which would vary from a farmer to another given their socioeconomic characteristics (Mendola, 2007; Shahabuddin et al., 1986). Various empirical and theoretical studies have been undertaken to understand farm households' attitudes in a risky environment (Feola and Binder, 2010; Mendola, 2007; Antle, 1987; Roy, 1952).

Production and consumption theories and risk aversion theory are often highlighted in the literature describing peasant household behavior (Mendola, 2007; Taylor and Adelman, 2003; Antle, 1987). The safety-first model takes into account the problem of extreme poverty, food insecurity (Haim and

Moshe, 2009; Mendola, 2007). These characteristics combined with frequent effects of natural hazard might lead to change of peasant household behavior about technology adoption (Tambo and Abdoulaye, 2013; Koundouri et al., 2006; Sekar and Ramasamy, 2001). The safety-first decision making model which is often applicable in public welfare arrangement, public resource allocation, investment, funds management in financial markets and project management, seeks to minimize the probability that farm household income falls below a certain level. This theory could better suit for risky and subsistent rain-fed agriculture under the climate change (Qasim, 2012; Arnade and Cooper, 2012; Haim and Moshe, 2009).

In rural areas, where most people rely on rain-fed agriculture and are vulnerable to weather conditions, farm households often protect themselves against climate uncertainties and build their livelihood resilience. Indeed, risk management involves cost and subsistence farm households with poor assets may adopt self-protection to meet their subsistence needs and deal with starvation, in case of a bad harvest (Qasim, 2012; Mendola, 2007; Sekar and Ramasamy, 2001). The socioeconomic characteristics of the household under climate change phenomenon could affect his decision about adoption of new technologies (Tambo and Abdoulaye, 2012; Koundouri et al., 2006). It is important to indicate that farm household has an income goal to achieve and that income goal is also seen as a disaster level, since temperature and precipitation could be determinants (Wossen et al., 2017; Fisher et al., 2015; Abdoulaye and Sanders, 2006; Sekar and Ramasamy, 2001).

In the specific case of Togo, temperature has increased on average 1.1°C each year since 1960 at the rate of 0.24°C per decade, while precipitation has decreased at the rate of 2.4% per decade affecting food crops production (Ali, 2018; Tchinguilou et al., 2012). It is clear that, these changes in climatic conditions would affect farmers' decisions regarding resource allocation (Ali, 2019; Blank et al., 2005; Sekar and Ramassissy, 2001). It becomes difficult to deal with climate change faced by farm households, given the characteristics of their asset (Shahaduddin et al., 1986). As a result, they may adjust their decision that could affect farming operation, such as adjustment of crop portfolio and inputs use as well. According to Kahan (2008), whatever the sort of risk farmer faces in agriculture, he will always think about what to plant, the appropriate time to plant, on which kind of land he will plant, how and how much to plant, what seed to use and at which rate, the amount of fertilizer to be applied, when fertilizer should be applied, and how to allocate the available resources. The outcome cannot be predicted, given the time lags between inputs use decision and harvesting periods. Adopting new technologies to minimize the potential effects of climate change is highly encouraged, but still questionable in the case of developing countries like Togo. The risk aversion behavior could affect farmers' decision about the adoption and use of the available technology to deal with climate risks.

In the absence of formal insurance product that can help farmers smooth the potential effects of climate change, understanding how the degrees of risk of farmers affect their decisions about input uses, can be helpful in the formulation of sustainable agricultural policies. There is a need to understand farmers' attitudes towards climatic risks which could be integrated in the design of agricultural risk management plans. However, to the best of our knowledge, a little has been done to better understand how Togolese farmers behave towards climatic risks at the household level and how this behavior is affecting their decision on the use of fertilizer and drought tolerant seeds (DTS) technologies and labor allocation as well. This research attempts to fulfill this knowledge gap. This study analyses farmers' risk aversion behavior on technology adoption in Northern Togo. Specifically, it aims to measure the degree of farmers' risk aversion. It also analyzes the determinants of risk aversion behavior and examines the effects of risk aversion behavior on decisions about fertilizer and DTS technology adoption and labor allocation. The remainder of the paper is organized as follows: Section 2 presents the materials and methods while results and discussion are presented in section 3. Section 4 concludes the study with policy implications.

Materials and Methods

Areas of study and data sources

The study was carried out in the Northern regions of Togo characterized by three agro-ecological zones (Figure 1) and mono-modal rainfall pattern.

The growing season starts from April to October every year and dry season stretches from November to March. Maize, sorghum, rice, soya beans and beans are the most food crops that are cultivated in these regions. Over the period of 1972 to 2014, average maize, sorghum and rice production was about 30%, 85% and 69% of national production, respectively in these regions.

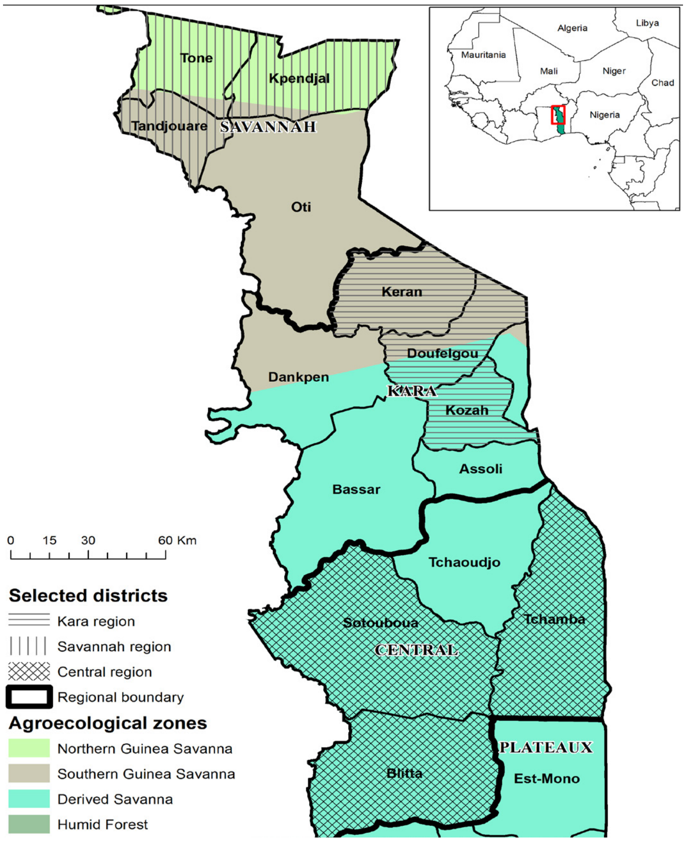

Figure 1: *The agro-ecological zones and study areas;* **Source:** *Author, using World Clim-Global Climate data.*

Multi-stage sampling technique was used to collect data from 704 farm households. Based on rainfall characteristics, Central, Kara and Savannah regions were selected at the first stage. The next step was the selection of three districts in each region based on the intensity of cereal production (i.e. maize, sorghum and rice) thanks to the guidance of the Togolese Institute of Agronomic Research (ITRA). The last stage was the random selection of the households using random number table and the households lists provided by the chief of each village. A structured questionnaire addressed to each household head was used.

Analytical approach of decision making under uncertainty: Roy's principle of safety-first

Three approaches of safety-first model are often discussed in the literature: Roy's approach (Blank et al., 2005; Roy, 1952), Telser's approach (Hatch et al., 1989; Telser, 1955-1956) and Kataoka's approach (Moscardi and de Janvry, 1977; Kataoka, 1963). These approaches differ from one another by the objective functions or constraints faced by the decision maker (Chiu and Li, 2009). Let assume that the farm household production function is stochastic since there is a time lag between the inputs use decision period and harvesting period. To deal with starvation in high climatic risks conditions , the vulnerable household might reallocate the available resources in such a way to keep its minimum consumption needs. Assuming that the farm household's production sets satisfy all properties required by the neoclassical production function (non-emptiness, closeness, free disposal) and if the independence assumption between the random components of output of each crop and its price hold, it is possible to derive the farm household expected income (M_y) and the total variance of net income (σ_y^2).

In the framework of risk avoidance behavior, the distribution of net income is unknown; hence Roy has used *Biname-Tchebycheff inequality* and sets the safety-first principle that investors in a risky environment, maximize the ratio of the excess of expected portfolio return (M_Y) to the disaster income level (d) over the standard deviation of the return on the portfolio (σ_y). Assuming that the distribution function of the net income (Y) is monotonic, it can be transformed into standardized variable (Z) as:

$$Z = \frac{(Y - M_y}{\sigma_y} \text{ Such that } Prob\,(Y < d) = F\left[\left[\frac{(d - M_y}{\sigma_y}\right]\right] \quad ....(1)$$

The distribution function of the net income (Y) is a function of its mean (M_y) and its variance (σ_y^2). The disaster income (d) can be measured by the farm household's standard of living, or by its minimum consumption needs. It can also be calculated using the information collected at the household level. According to Shahabuddin et al. (1986), the disaster income can be calculated as the sum of household consumption needs and urgent debts by reducing the value of minimum resale of liquid asset and the off-farm income of that household. The method of calculation of disaster income used by Shahabuddin et al. (1986) is similar to the approach used by Sekar and Ramasamy (2001). The minimum consumption need of the household can be estimated using information on consumption expenditures incurred by farm households during the year preceding the survey. It comprises the expenditures on grains foods, clothing, medicine, education, social ceremonies, kerosene, salt, sugar, gifts ligation, communication cost. The liquid asset could be calculated as the sum of cash, value of checks and savings, revenue from rented properties, mutual funds, and the value of agricultural stocks including livestock.

Mostly, in peasant agriculture, farmers undertake their activities only on their limited land. Sometimes, only two or three hectares of land are available for the farmer. In resource allocation for crop production under climate change, the farm household would be constrained by the availability of land. For those reasons, the land is introduced in the model as a constraint in resource allocation for crop cultivation. The Roy principle of safety-first of the typical farm household can be written as follows:

$$\begin{cases} Maximization\ of\ Prob\ (y < d) = F\left[\left[\frac{(d - M_y}{\sigma_y}\right]\right] \\ Subject\ to:\ \sum_{i=1}^{n} L_i = Ƚ \end{cases} \quad ....(2)$$

L_i is the land devoted to the cultivation of crop i and Ƚ is the total farm household's cultivated land. Using Lagrangian, the optimal conditions are derived. The profit maximization or cost minimization behavior leads to the optimal conditions that the value of marginal product of inputs should be equal to their own prices (Mas-Colell and Green, 1995). It means that at the equilibrium, farm household tries to allocate the available resources, so that the expected value of marginal productivity of each crop should be equal to its perceived inputs costs associated with the production of that crop. Farm household operates efficiently in that case (rational expectation). Missing this condition puts the household in starvation according to the neoclassical conclusion on efficient conditions. No more or no less variable inputs are used in the production process at the optimum.

However, the rational expectation does not take into account weather conditions and its derivative risks and perceived risks are therefore assumed neutral. The risk neutrality assumption may fail in rain-fed agriculture with no irrigation practices, as well as the absence of formal agricultural insurance. The output and price risk factors may be reflected in the perceived cost of the use of inputs in the production of that specific crop (Shahabuddin et al., 1986). Assuming that the farm household cannot be rational due to climate change, testing the efficiency of resource allocation becomes a problem of testing whether farm households are risk averse, risk lovers or risk neutral. Farmers' perceived risk is dependent on risk aversion coefficients drawn from the solution of the maximization problem of the Equation (2). From the optimal conditions, risk factor is equivalent to the objective function stated by Roy (Blank et al., 2005; Bigman, 1996). This risk coefficient function of farm household *i*, is estimated as follows:

$$Risk\_COEF_i = \frac{d - M_y}{\sigma_y} \quad ...(3)$$

Following Sekar and Ramasamy (2001), the disaster income level (*d*) is estimated as:

Disater income level = Minimum consumption needs + Credit outstanding (Institutional and non institutional credit) – Liquid asset (from business and livestock) – Non agriculture income (from trade and industry).

If $Risk\_COEF_i < 0$, Then, the farm household is a risk averse; $Risk\_COEF_i < 0$, Then, the farm household is a risk neutral and $Risk\_COEF_i < 0$, Then, the farm household is a risk lover.

Risk aversion behavior and technology use decision

Drawing attention on factors that influence farmers' attitudes towards agricultural risks would be helpful in climate risks managements. Unlike Shahabuddin et al. (1986) and Sekar and Ramasamy (2001), Probit model was used to better understand the determinants of farm households' risk aversion behavior. The surveyed farm households were divided into two groups since there were no risk neutral farmers in the data: farm households that are risk averse behavior are scored 1 and those who are risk lovers are scored 0. Risk aversion measured as a binary dependent variable is a function of climatic risks and farm household's socioeconomic characteristics. Risk aversion is labeled as a latent variable. If Y^* denotes the latent variable of the decision to adopt risk aversion behavior, then its relationship with the potential explanatory variables would be written as:

$$Y_i^* = X'\beta + \mu_i \quad .....(4)$$

Where;

X is a vector of explanatory variables, β is a column vector of predictor coefficients and μ_i is an error term assumed to be normally distributed. The parameters are estimated using maximum likelihood. The decision to adopt risk avoidance behavior is expressed in Equation (5):

$$Y = \begin{cases} 1 & if \quad Y^* < 0 \\ 0 & otherwise \end{cases} \quad .....(5)$$

Thus, the model takes the form:

$$P_r(Y = 1|X) = \Phi(X'\beta) \quad ....(6)$$

ϕ, is the cumulative distribution function and the maximum likelihood estimation is given by:

$$Log\ L(\beta) = \sum_{i=1}^{n} (y_i Log\Phi(X_i'\beta) + (1 - y_i)Log(1 - \Phi(X_i'\beta)) \quad ....(7)$$

In order to analyze the effects of risk aversion behavior on labor allocation decision, the linear regression technique was used (Equation 8).

$$LAB = \sum_{i=1}^{N} \beta_i X_i + \varepsilon_i \quad .....(8)$$

The dependent variable is the labor used (*LAB*) and measured as the total number of man-days. X_i is a vector of exogeneous variables, ε_i, is an error term assumed to be normally distributed.

In the sample, on average 7.53% and 30% of respondents do not use fertilizer and drought tolerant seeds (DTS), respectively. In that case, the coefficients obtained from the ordinary least square estimation are biased and inconsistent because some of the values of dependent variables are zero. For these reasons, Tobit model was used to assess the effects of farm households' risk aversion behavior on the decision about the use of fertilizer and DTS. The observations of the dependent variable that take the value "zero" can be censored under Tobit model and the same properties under OLS are valid. According to Wooldridge (2014), the response variable is not directly observable and therefore can be expressed as a latent variable in Tobit model.

$$Y = Max\ (0, Y^*) \quad .....(9)$$

Equation (10) implies that:

$$\begin{cases} Y = 0 & if \quad \beta_0 + X\beta + \mu \leq 0 \\ Y = Y^* & if \quad \beta_0 + X\beta + \mu > 0 \end{cases} \quad .....(10)$$

The amounts of fertilizer and DTS are measured as the quantity of kilograms used.

Results and Discussion

Descriptive statistics of surveyed farm households

The data showed that surveyed population is relatively young (44 years). The distribution of age of the respondents ranged between 20 and 90 years with (Table 1).

The larger the farm household is, the more the probability of adoption of risk avoidance behavior would increase (average household size was 8 members). On average, 15.48% of farmers do not have any formal education, while 46.87% have attended at least a primary school and 33.22% a secondary school. Education promotion seems to be very important since it can help farmers in adopting the best agricultural practices to increase productivity.

Data show some disparities between cultivated land among regions and crops (Table 1). The small-scale farmers are dominant, operating on very limited farmland (average 2.75ha). The average land devoted to the maize cultivation was relatively small (1.05ha). However, the difference between the average land devoted to cultivation of maize in Central and Kara region is positive and statistically significant at 1% level. It implies that, farmers in the Central region devote more land to maize cultivation compared to those in Kara region. For sorghum, farmers in Kara region have higher average cultivated land (0.82ha) than Central (0.62ha) and Savannah (0.57ha). Grain legumes (soya beans, beans), and tuber crops are mostly cultivated in Central region. However, cotton is more cultivated in Savannah region compared to Central and Kara regions. Perhaps, the climatic conditions in Savannah region are more favorable to the cultivation of cotton compared to the other regions. Fertilizer application is relatively low. The average fertilizer application rate in Northern Togo was only 92.23 kg. ha^{-1}. This might be due to farmers' low level of purchasing power and the market accessibility. The distance from the nearest inputs market is relatively long (9Km on average, Table 1). This might lead to the loss of man-days.

Risk aversion among farm households in the Northern regions of Togo

The risk behavior among farm households in Northern Togo is presented in Table 2.

The mean risk coefficients in all regions are negative, relatively high and statistically different from zero,

Table 1: *Farm households' socioeconomic characteristics.*

Variables	Mean				t test		
	Whole Sample	Central Region (1)	Kara Region (2)	Savannah Region (3)	(1)-(2)	(1)-(3)	(2)-(3)
Age (Number of years)	43.81	41.53	42.55	46.99	-1.01	-5.45***	-4.44***
Household size	7.5	6.57	7.11	8.72	-0.54	-2.14***	-1.60***
Active HHM	4.85	3.64	4.36	5.41	-0.71***	-1.75***	-1.043***
No formal education (%)	15.48	2.41	2.69	10.36	0.65	-0.079	-0.076
Primary (%)	46.87	19.88	11.93	15.05	0.07	0.04	-0.031
Secondary I (%)	33.24	13.07	9.94	10.22	0.031	0.028	-0.002
Secondary II (%)	3.55	1.14	1.70	0.71	-0.005	0.004	0.009
University (%)	0.85	0	0.42	0.43	.	.	.
Cultivated Land (ha)	2.75	3.13	2.41	2.63	0.70***	0.50***	-0.20
Land for maize (ha)	1.05	1.11	0.86	1.13	0.24***	-0.02	-0.26***
Land for sorghum (ha)	0.65	0.62	0.82	0.57	-0.20***	0.04	0.24***
Land for rice (ha)	0.17	0.15	0.16	0.19	-0.02	-0.041	-0.02
Land for grain legume (ha)	0.63	1.08	0.45	0.34	0.62***	0.74***	0.11**
Land for tuber crop (ha)	0.08	0.17	0.05	0.01	0.11***	0.15***	0.03***
Land for cotton (ha)	0.21	0.05	0.14	0.42	-0.09***	-0.37***	-0.27
Experience (Number of years)	21.10	15.59	19.69	27.61	-4.04***	-12.02***	-7.97***
Fertilizer amount (Kg)	253.64	232.58	233.85	288.91	-1.26	-56.32***	-55.06**
Distance to the Market	9.29	11.84	8.22	7.52	3.61***	4.31***	0.70

**** p<0.01; ** p<0.05; * P<0.1; HHM: Household members.*

indicating the large proportion of farmers having risk aversion behavior (Table 2). The proportion of farmers that have risk aversion behavior represents 82.10% and 86.10% for Central and Savannah regions, respectively and 92.02% in Kara region. Putting all regions together, the results show that on average 86.22% of households in Northern Togo are risk averse.

Table 2: *Risk attitudes among farm households in the Northern regions of Togo.*

Range of Risk Attitudes	Central (%)	Kara (%)	Savannah (%)	Total (%)
Below -10	11.67	14.36	6.56	10.51
-10 to -5	10.51	14.90	13.52	12.79
-5 to 0	59.92	62.76	66.02	62.92
0 to 5	17.51	6.02	13.90	13.35
5 to 10	0.39	1.06	0.00	0.43
Above 10	0.00	0.00	0.00	0.00
Mean risk coefficients	-7.98***	-8.46***	-9.73**	-8.75***
Standard error	1.93	1.73	5.49	2.18
Standard deviation	30.98	23.81	88.43	58.06
Number of Households	257	188	259	704

**** p<0.01; ** p<0.05; * P<0.1*

Eventually, farmers have harvest income target that would secure their family subsistence and therefore, behave such a way that goals be achieved given the climatic and other type of risks they face (Ali, 2019; Abdoulaye and Sanders, 2006). Also, the farm household socioeconomic characteristics and rainfall characteristics which influence food security status in these regions would probably lead to the adjustment of labor allocation and fertilizer and DTS technology use.

Determinants of risk aversion behavior among farm households in Northern Togo

The analysis focused on farm households that have risk aversion behavior. Before analyzing the factors that would probably affect farm household behavior, it is important to check whether there was a significant difference in socioeconomic characteristics between risk averse and risk takers (Table 3).

There is a significant difference between farm households that are risk averse and those who have gambling behavior (Table 3). For instance, the difference in age between these two groups is negative and statistically significant at 5% level. This indicates that farmers with risk aversion behavior are older than risk lovers. Moreover, the results show that there is no

Table 3: *Socioeconomic characteristics and farmers' risk aversion behavior in Northern Togo.*

Variables	Risk aversion		Risk Lovers		Difference (2)-(1)
	Mean (1)	Standard Deviation	Mean (2)	Standard Deviation	
Age (Number of years)	44.17	12.03	41.56	9.79	-2.60**
Education (1=Formal, 0 =No formal)	0.84	0.35	0.82	0.38	-0.02
Family size (Household members)	7.58	3.72	7.03	3.88	-0.55
Experience (Number of Years)	21.35	1.75	19.48	11.36	-1.86
Labour (Man-days)	125.75	82.85	168.85	72.91	43.09***
Fertilizer (Kilograms)	241.96	224.92	304.83	201.14	62.86***
Cultivated Land (Hectare)	2.63	1.44	3.47	1.25	0.84***
Land devoted for Maize, Sorghum and Rice (Hectare)	1.82	0.99	2.10	1.02	0.28**
Land devoted for grain legume, tuber crops and cotton	0.84	0.83	1.47	0.78	0.63***
Amount of loan taken (FCFA)	23051.9	58699.9	36917.5	63174.9	13865.63**
Total observation	607		97		

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

difference between risk takers and risk aversion farmers in terms of education, farming experience and family size. The fertilizer application and allocated labor are determinants in achieving farm households' goals. The farm households that have gambling behavior tend to use more labor and fertilizer compared to those who have risk-avoidance behavior. The average fertilizer applied was about 242Kg and 305Kg, for risk averse and risk takers' farm households, respectively. The difference in total cultivated land among these two groups of farmers is also positive and significant at 1% indicating that risk aversion farmers are more land constrained than the risk lovers. The amount of loam has played an important role among households. The average amount of credit that farm households with risk aversion behavior had taken was 23052 FCFA, while it was about 36918 FCFA for risk takers. The difference in the amount of credit taken between these two groups was positive and statistically significant at 5% level. Having the higher amount of credit leads farmers to take more risk. The marginal effects from Probit model, analyzing the determinants of farmers' risk aversion behavior are indicated in Table 4.

The results show that, being in the Kara region increases the probability of farmers adopting risk avoidance behavior compared to those in Central region. The oldest, is the head of household; the more the likelihood that household adopt risk aversion behavior. The coefficient of family size is positive and significant at 1%, indicating that, the farm households with larger family size tend to adopt risk avoidance behavior. Also, a head of household being more experienced in farming will reduce the probability of farm household to adopt risk aversion behavior.

The land and labor allocation have played an important role in determining household behavior. Labor may not be available at the peak time of the farming leading to the crop failure (Kahan, 2008). Indeed, the results indicate that increasing labor in terms of man-days could reduce the probability of farm household to be risk-averse (Table 4). Availability of labor would help the farmers to take care of their farms at the peak periods. The farm households' perceptions of crops' exposure to climatic risks led farmers to behave accordingly. For example, expanding the area under maize cultivation led farmers to be more risk averse. Perhaps maize is more exposed to climate risks compared to other crops in the study areas as found by Ali (2018). For instance, expanding the area under cultivation of sorghum, grain legume and cotton tend to decrease the probability of farm households to adopt risk aversion behavior. Probably, grain legume (soya beans, beans), sorghum and cotton are more resistant to drought; hence the preference of farmers with risk aversion behavior. The income goal is achieved by selling all or part of sorghum, grain legume, and cotton. This income is used for household needs such as social ceremonies, buying medicine for household care, paying school fees for children, wedding and cloths during the festivities. This is seen as the rewards of the family members from their farm activities (Abdoulaye and Sanders, 2006).

Table 4: *Determinants of risk aversion behavior of farm households in Northern Togo.*

Variables	Probit results		Marginal Effects	
	Coef	Std Error	Coef	Std Error
Kara Region (Dummy)	0.419**	0.207	0.071**	0.035
Savannah region (Dummy)	-0.521**	0.225	-0.089**	0.038
Gender (1=Male, 0=Female)	-0.283	0.253	-0.048	0.043
Age	0.016*	0.008	0.002*	0.001
Log Family size	0.705***	0.175	0.120***	0.029
Log Experience	-0.275*	0.152	-0.047*	0.026
Education (1=Formal, 0=Non formal)	0.285	0.198	0.039	0.034
Log labour (man-days)	-0.572***	0.151	-0.098***	0.025
Land devoted for Maize (hectare)	0.182*	0.110	0.031*	0.018
Land devoted for Sorghum (hectare)	-0.218*	0.120	-0.037*	0.020
Land devoted for Rice (hectare)	-0.041	0.209	-0.007	0.035
Land devoted for Grain legume (hectare)	-0.280**	0.114	-0.048**	0.019
Land devoted for Tuber Crop (hectare)	0.108	0.258	0.018	0.044
Land devoted for Cotton(hectare)	-0.549***	0.148	-0.094***	0.024
Floods events (1=Yes; 0=No)	0.351**	0.176	0.060**	0.030
Food shortage (1=Yes, 0=No)	0.300*	0.158	0.051*	0.026
Death of livestock due to shortage of fodder and water (1=Yes, 0=No)	0.483***	0.169	0.082***	0.028
Decrease of rainfall (1=Yes; 0=No)	1.546***	0.607	0.265***	0.103
Access to extension Services (1=Yes; 0=No)	-0.325**	0.152	-0.055**	0.025
Use of fertilizer (1=Yes, 0=No)	-0.065	0.316	-0.011	0.054
Access to Electricity(1=Yes, 0=No)	-0.193	0.156	-0.033	0.026
Intercept	1.081	0.921		
Log pseudolikelihood=-220.91; Wald chi2(21)=104.28***; Pseudo R2=0.2173				

**** p<0.01; ** p<0.05; * P<0.1*

The induced effects of climate change have significantly influenced farm households' risk aversion behavior in Togo. For instance, food shortages, flood events, the death of livestock due to shortage of water and fodder have increased the probability of farm households to adopt risk avoidance behavior. Access to extension services has reduced the probability of farm households to adopt risk aversion behavior. Policies toward climatic risk management, and supply and adoption of new technology would enhance productivity and reduce vulnerabilities to climate change. Understanding the effect of adoption of risk avoidance attitudes on farm households' decisions about inputs use under climate change would be important.

Farmers' risk aversion behavior and input use in Northern Togo

The effects of farmers' risk aversion behavior on inputs use in the study areas is presented in Table 5. Model 1 and 2, are Tobit model, while model 3 is a linear regression model. The results indicate that, farmers in Kara region use less drought tolerant seeds (DTS) compared to those in Central region. The family size and age of the head of the household are positive and statistically significant in Model 3. It implies that, the older household head and larger family size, the more the labor is needed. The results show also that, the farmers with no formal education tend to reduce the fertilizer use. Adult education and extension services are needed to disseminate knowledge in fertilizer application. The coefficient of risk is positive and significant in models 1 and 2. Increasing the risk coefficient imply the shift of risk aversion behavior towards risk lovers. The positive and significant risk coefficient in model 1 and 2 indicating the shifting from risk aversion to risk lovers behavior. However, risk aversion farmers tend to use less DTS and allocate less labor in farming activities (model 2 and 3 in Table 5). Using DTS involves costs and may

Table 5: *Farmers' risk aversion behavior and inputs use in Northern Togo.*

Variables	Amount of Fertilizer used (Model 1)		Quantity of DTS used (Model 2)		Labor used in Man days (Model 3)	
	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
Kara Region: (Dummy)	27.85	18.07	-48.11***	6.97	12.80*	7.45
Savannah Region (Dummy)	1.67	21.99	6.58	6.93	-13.59*	7.33
Sex (1=Male, 0=Female)	-1.13	20.09	-5.61	7.74	-3.73	6.45
Age (Number of Years)	-0.76	0.62	0.11	0.21	0.49*	0.25
Log Family Size	31.73*	17.54	-1.50	5.91	17.26**	6.80
No Formal Education (Dummy)	-33.92*	19.95	-0.12	6.79	-8.22	7.06
Log Labor (Man-days)	46.07***	11.95				
Risk coefficient	0.14***	0.03	0.16	0.12	-0.01	0.02
Risk averse (1=Risk averse, 0=Risk lover)	-5.12	19.86	-21.53***	6.83	-13.77*	7.51
Land devoted for Maize (hectare)	147.86***	18.02	22.43***	4.43	15.24***	5.54
Land devoted for Sorghum(hectare)	-13.26	11.92	-6.62	4.11	22.64***	5.39
Land devoted for Rice (hectare)	20.88	30.48	23.17***	7.77	38.58***	9.40
Land devoted for grain Legume (ha)	-16.16	11.43	10.84***	3.93	27.04***	4.54
Land devoted for Tuber Crop (hectare)	-55.53**	22.69	-25.23**	10.30	27.33**	11.85
Land devoted for Cotton (hectare)	89.37***	18.03	4.22	4.86	31.89***	6.97
Land Rented (1=Yes, 0=No)	-23.07	17.45			20.48***	6.78
Quantity of Fertilizer (Kilograms)			0.02	0.01	0.08***	0.02
Quantity of Manure (Kilograms)	0.04***	0.01			0.01	0.004
Quantity of Pesticide (Litre)	0.12***	0.01	-0.2.3x10^{-3}		0.01**	0.004
Log Distance to the market (Km)	-11.10*	6.70	-2.27	2.49	10.86***	2.89
Loan Amount (FCFA)	6.49x10^{-4}***	1.17x10^{-4}	1.3x10^{-5}	1.3x10^{-2}	3.71x10^{-5}	5.41x10^{-5}
Extensions services (1=Yes; 0=No)	42.64***	15.43	28.87***	5.45		
Access to Electricity (1=Yes; 0=No)	26.37	16.86	9.34*	5.58		
Raining season comes later than usual (1=Yes, 0=No)	52.88**	26.76	-6.71	19.27	-10.26	14.13
Raining season gone earlier than usual (1=Yes; 0=No)	30.58*	18.50	18.26**	7.72	-8.23	8.42
High risk of crop Damage due to drought (1=Yes, 0=No)	43.45**	20.64	-13.32	9.03	-13.54	8.64
Intercepts	-285.54***	71.10	23.90	26.18	16.21	23.24
	N=704; Pseudo; R2=0.0549; Log likelihood=-4286.7264		N=704; Pseudo; 2=0.0528; Log likelihood=-815.6951		N=704; F=76.44***; R^2=0.4755	

**** p<0.01; ** p<0.05; * P<0.1*

become risky if some norms are not respected. Under climate change with less access to extension services, a farmer may prefer to minimize the probability that their crops fail and therefore, use the traditional seeds that would be costless.

Risk aversion farmers might allocate more labor in off-farm and non-farm activities that are less risky to climate conditions. Indeed, at the end of the crop season, the young men and women in Northern Togo, often migrate mostly in the southern regions and neighboring countries, where they undertake off-farm activities. They often come back at the beginning of the new seasons with some remittance that serve them to feed their family before the harvest of the following season. Given the frequencies of climate change effects, the young men and women, which are the main source of labor in farming activities, prefer to migrate to the cities where they undertake small business, such as trade and taxi-moto. This can also explain; the less use of labor by risk aversion farmers. Inputs use has a link with land allocation for different crops in the study areas. For instance, expanding the area under cultivation of maize and cotton will increase the use of fertilizer, while farmers tend to decrease the fertilizer use when growing tuber crops.

Tuber crop was negative and statistically significant at 5% level (model 2; Table 5). It implies that increasing the area under cultivation of tuber crops would lead farmers to reduce the use of DTS. Also, increasing the quantity of pesticides/herbicides used does not reduce the quantity of fertilizer applied by farmers.

The institutional factors such as the amount of credit; access to extension services and electricity and the accessibility to the nearest input market are determinants of inputs use in the study areas. Indeed, the results indicate that increasing the amount of credits received by \$2.00 would increase the fertilizer application rate by 1kg. However, the coefficient of distance to the nearest input market is negative and statistically significant at 10% level (Model 1). This implies that the access to market is determinant of fertilizer use. The farther away the farm household is from the nearest inputs market, the higher the transportation cost is; leading to the loss of man-days and that might push farmers to use less fertilizer. Access to market and the nature of infrastructure in rural showed its importance in agriculture development (Dillon and Barrett, 2017; Kamara, 2004). Access to extension services is positive and statistically significant in fertilizer and DTS models (Models 1 and 2, Table 5). The more a farmer has access to extension services, the more he learns how to use DTS and apply the appropriate rate of fertilizer as well as increasing understanding about the advantages and disadvantages of using these technologies. In addition, increasing access to electricity could probably increase the use of DTS (model 2, Table 5). The study showed that the perception of high risk of crop damage due to drought leads farmers to use more fertilizer to increase productivity. There is a need for policy intervention regardless of farm household behavior against climatic risks and other institutional factors in order to enhance farmers' productivity and increase well-being.

Conclusions and Recommendations

This paper has analyzed farmers' attitudes toward climate risks in Northern Togo using Roy criteria of safety-first. It has equally assessed the determinants farmers' risk aversion in the study areas using probit model and assessed the effects of risk aversion behavior on inputs use such as the fertilizer, drought tolerant seeds (DTS) and labor allocation using Tobit and the linear regression methods. Cross sectional data collected from 704 households were used. On average 86.22% of farmers have risk aversion behaviors in farming business. Farm households' socioeconomic characteristics were determinant in adoption of risk aversion behavior. The results from the Probit model have shown that increasing the land under maize cultivation and experiences in climate change effects have increase the probability of adopting the risk aversion behavior. However, access to extension services and increase of land devoted to the cultivation of sorghum, grain legume, tuber crops and cotton will reduce farmers' risk aversion in the study areas.

The risk aversion behavior of farm households has significantly affected the inputs use, such as fertilizer, drought tolerant seeds and allocated labor. The results show that the farm households with risk avoidance behavior tend to use less fertilizer and DTS and use less labor in farming activities compared to farm households with gambling behavior. Also, the non-access to the market and farmers with no formal education tend to use less fertilizer. Similarly, growing tuber crops, beans and soya beans lead farmers to use less fertilizer. However, the increase of the amount of credit received would enhance the farmers' purchasing power and use more fertilizer and access to extension services would boost productivity and reduce farm households' vulnerability to food insecurity. The implementation of new policies to deal with climatic risks in the study areas should take into account farmers' attitudes towards climatic risks. Climate risks management and development of risk preparedness plans are therefore encouraged in order to reduce farmers' risk aversion. Reducing farmers' risk aversion may need to focus on education and extension services would be helpful drought tolerant seeds (DTS) and fertilizer technologies adoption and enhance farmers' adaptive capacity to climate change. Also, the quality of transport infrastructure that is determinant of access to market and value chain for agricultural development would create win-win situation for all the agricultural value chain actors. Moreover, the flexible financial policy toward agricultural activities could enhance farmers' inputs purchase power and increase fertilizer and DTS technology adoption.

Novelty Statement

The paper highlights the importance of farm households' risk aversion behavior on technologies use and contribute in strengthening the implementation of policies that seek to address food insecurity in climatic change context.

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