



Socio-demographic determinants of farmers' beliefs about climate change cause in the Sudanian zone of Benin

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Abstract: Understanding farmers' beliefs on climate change is crucial as it drives the adaptation strategies that they might adopt. This paper investigates farmers' beliefs on climate change in the Sudan Savannah Zone of Benin, a region heavily reliant on rain-fed agriculture. The multinomial logit model is applied to cross-sectional data collected through a survey of 60 randomly selected farm households. The findings suggested that 33.33%, 31.67%, 21.67%, and 13.33% of the farm households believe that climate change is due to human activities, to natural changes in the environment, gods anger, and to both human activities and natural changes in the environment, respectively. Moreover, the estimation results of the determinants of climate change cause indicate that the gender of the household head, the ethnic group, and household size influence significantly climate change beliefs. Based on the findings, information on the fact that climate change is not only due to natural changes in the environment, but is also due to anthropogenic greenhouse gases should be provided to farmers. This paper contributes to the literature by analyzing what farmers believe as causes of climate change which is beyond climate change perception. Moreover, the variable ethnic group and household size are found for the first time to our knowledge to determine climate change beliefs.

Keywords: Agriculture, Global warming, multinomial logit, gods anger.

Déterminants socio-démographiques des croyances des agriculteurs sur la cause du changement climatique dans la zone soudanaise du Bénin

Résumé : Comprendre les croyances des agriculteurs sur le changement climatique est crucial car cela détermine les stratégies d'adaptation qu'ils pourraient adopter. Cet article évalue les croyances des agriculteurs sur le changement climatique dans la zone de savane soudanaise du Bénin, une région fortement tributaire de l'agriculture pluviale. Le modèle logit multinomial est appliqué à des données transversales recueillies au moyen d'une enquête auprès de 60 ménages agricoles sélectionnés au hasard. Les résultats suggèrent que 33,33 %, 31,67 %, 21,67 % et 13,33 % des ménages agricoles pensaient que le changement climatique est dû aux activités humaines, aux changements naturels de l'environnement, à la colère des dieux et aux activités combinées des humains et aux changements naturels de l'environnement, respectivement. De plus, les résultats de l'estimation des déterminants du changement climatique indiquent que le sexe du chef de ménage, l'ethnicité et la taille du ménage influencent de manière significative les croyances en matière de changement climatique. Sur la base des résultats, des informations sur le fait que le changement climatique n'est pas seulement dû aux changements naturels de l'environnement mais sont principalement dus aux gaz à effet de serre anthropiques peuvent être fournies aux agriculteurs. Cet

article contribue à la littérature en analysant les croyances des agriculteurs sur les causes du changement climatique qui va au-delà de la perception. De plus, les variables ethnicité et taille du ménage sont trouvées pour la première fois à notre connaissance comme déterminants des croyances en matière des causes du changement climatique.

Mots clés : Agriculture, réchauffement climatique, logit multinomial, colère des dieux.

1. Introduction

Climate change constitutes one of the major threats to economic activities across the world (Pörtner et al., 2022). Empirical evidence confirms that climate change affects agriculture in non-industrialized countries due to its rain-fed nature and it will still be affecting this sector if relevant adaptation measures are not taken (Lokonon et al., 2015; Di Falco & Veronesi, 2013, 2014; Di Falco et al., 2011). The agricultural sector is the mainstay of the economy of non-industrialized countries. For instance, in Benin, the agricultural sector, characterized by the predominance of smallholder farm households, is the source of employment for about 70% of the active population, contributes 33% of the gross domestic product (GDP) and about 75% of export revenues (MAEP, 2017).

As climate change casts a shadow over the future of agriculture, the impacts of climate change in Benin are diverse (Adjacou, et al. 2022). The IPCC projects a decline in agricultural yields in West Africa, which could be between 5 and 20% in Benin (Pörtner *et al.*, 2022). The most predominant impact indicator declared by the populations in North is food insecurity (22%), which is the consequence of the disruption of sowing dates (16%) and the drop in yield (15%). Poverty (14%) is seen as exacerbating and persistent over the years (Vodounou & Onibon Doubogan, 2016; Sodjinou & Hounkponou, 2019). Another study also shows a decline in the availability of fish resources, fishing success and water level in North Benin (Nago *et al.*, 2019). Based on the Ricardian analysis developed by Mendelsohn *et al.* (1993), another study shows that the impact of climate change on agriculture in Benin is likely to be negative in the long term (Agossou, 2012). The details from this paper regarding the horizon 2100 provide that the impact of climate change on the agricultural value added per hectare is estimated at -\$365.53 or -21.87% compared to its 2008 value. Consequently, the whole economy will be affected by climate change. It is therefore urgent to put in place adequate policies and strategies that can facilitate adaptation to climate change. It should be noted that some areas in Benin and crops may benefit from climate change. The economic impacts of climate change on agriculture have shown that maize and yam production will increase by 2050 (Satoguina, 2016).

Therefore, it is urgent to undertake actions for climate change adaptation.

The consideration of adaptation measures in the agricultural sector, to mitigate climate change impacts and/or to seize the opportunities, depends on the perception of climate change and the beliefs regarding climate change (Lokonon & Mbaye, 2018; Wheeler et al., 2013; Deressa *et al.*, 2011; Maddison, 2007).

Climate change perception is a complex process that encompasses a range of psychological constructs such as knowledge, beliefs, attitudes and concerns about if and how the climate is changing (Whitmars & Capstick, 2018). The evolution of risk perception studies has been research on environmental beliefs, attitudes, and values. Although the literature on public opinion often uses the terms “values,” “beliefs,” “attitudes,” and even “paradigms” somewhat interchangeably, we use the term “climate change beliefs” to refer to non-issue-specific cognitive orientations. A reasonable assumption characterizing this research tradition is that environmental cognitions are the bedrock of support for environmentally friendly or hostile behaviors and are the basis of environmental risk perceptions (Dunlap & Scarce, 1991). From this perspective, risk perceptions are an integral by-product of environmental beliefs and not independent causes of behavior. Perception is an important link between beliefs and adaptation (Jooste *et al.*, 2018).

Understanding climate policy risk responses and other social, economic and policy perspectives is a vital component of understanding climate change beliefs, risks and behaviors (Haden et al., 2012). Azadi (2019) found a complex relationship between overall climate change belief, risk perception, psychological distance, trust and risk salience, and farmers' adaptation behaviors. So, it is of paramount importance for policymakers to understand the beliefs of farmers on climate change in order to design policies towards boosting agricultural production and dealing with food insecurity. Heath *et al.* (2006) investigated three beliefs concerned with global climate change: the likelihood that it exists, whether it has human or natural causes, and whether its consequences are negative or positive. In the case of this paper, we assess the beliefs on climate change as the cause of climate change according to the beliefs of farmers.

Currently, most of the literature is relative to climate change perception. Few papers which deal with the

beliefs on climate change lack the determinants of these beliefs (Chisale *et al.*, 2022; Lee *et al.* 2015; Debela *et al.* 2015; Saleh Safi, *et al.* 2012 & McCright, 2010). So, this paper includes what farmers believe as causes of climate change which is beyond climate change perception as well as their determinants. Actually, the nature of measures to be taken to mitigate the adverse effects of climate change on farming activities depends on what farmers think as causes of changes in climate (Arbuckle *et al.*, 2013; Wheeler *et al.*, 2013; Haden *et al.*, 2012). In fact, farmers may think that climate change is due to the fact that they have offended God and/or gods so that he (they) is (are) angry. Only a few studies to our knowledge have considered farmer's beliefs. Mena-pace *et al.* (2015) analysed farmers' short- and long-run perceptions of agricultural risks related to climate change. They identified climate change beliefs as a critical factor explaining the short- versus long-run difference in risk perceptions: those who believe in climate change project larger future crop losses. Arbuckle *et al.* (2013) analysed, among others, farmers' beliefs about climate change and attitudes toward adaptation and mitigation. In reality, adaptation strategies could be linked to farmers' beliefs because for example, if farmers believe that climate change is a phenomenon due to God or gods anger, they will decide just to pray or to offer sacrifices to gods, to ask them to let rainfall coming back (Yegbemey, *et al.* 2020). As for Wheeler *et al.* (2013), they explored the influences associated with farm adjustment strategies, and particularly the role that climate beliefs play. Wheeler *et al.* (2013) found that the relationship between climate change belief and adopting various adaptive strategies appears to be often endogenous, especially for accommodating strategies. The presence of believers in the cultural and spiritual causes of climate change in a particular area presents a challenge to mobilize them toward implementation of climate intervention measures (Chisale *et al.*, 2022). McCright (2010) found that a greater percentage of women (64%) than men believe that global warming is primarily caused by human activities. Moreover, older people tended to believe that the causes of global climate change are natural (Heath *et al.* 2006). So, the determinants of farmers' beliefs on the causes of climate change are gender and age. One can see that in the literature it is difficult to find out more determinants of farmers' beliefs on the causes of climate change. This study is an attempt to fill in this gap by checking if the variables determining the perceptions of farmers on the causes of climate change are the same in the case of the beliefs.

In the light of the literature on the determinants of farmers' perception on the causes of climate change, the independent variables included in the estimations (e.g., Chisale *et al.*, 2022; Lokonon & Mbaye, 2018; Debela *et al.*, 2015; Fosu-Mensah *et al.*, 2012; Silvestri *et al.*, 2012; Deressa *et al.*, 2011; Maddison, 2007) are:

the gender of the household head, the age of the household head, the ethnic group of the household head, the size of the household, the experience of the household head in agriculture, farm size, and having agriculture as the sole source of revenue or not. Experience in agricultural activities is positively associated to climate change perception (Chisale *et al.*, 2022; Lokonon & Mbaye, 2018). Lokonon & Mbaye (2018) found that climate change perception is negatively related to household size. As for the formal education level, it is found playing a paramount importance in climate change perception (Chisale *et al.*, 2022; Fosu-Mensah *et al.*, 2012; Silvestri *et al.*, 2012). The gender of the household head can influence the likelihood of perceiving climate change (Chisale *et al.*, 2022; Fosu-Mensah *et al.*, 2012; Maddison, 2007). Farm size is also hypothesized to affect climate change beliefs. Indeed, assets and wealth may influence climate change perception (Silvestri *et al.*, 2012; Fosu-Mensah *et al.*, 2012; Deressa *et al.*, 2011).

This study aims to investigate farmers' beliefs on the causes of climate change. Specifically, this paper analyses (i) farmers' beliefs on the causes of climate change and (ii) the determinants of these beliefs in the context of the Sudan Savannah Zone of Benin.

2. Material and methods

2.1. Study area

This study focuses on the Sudan Savannah Zone of Benin located in the Northern part of the country. The primary data used in this paper were collected in three communes (Boukoumbe, Ouake and Banikoara). The area is characterised by a rainy season and dry season. Generally, the rainy season is from May to November in the study area. The annual rainfall in the study area is about 780 mm and the number of annual rainy days is about 45 days. The three communes received seven months of rainfall with a peak period in June. The temperature is generally warm in these communes ranging between 28° C and 34° C with a relative humidity between 65% and 94%.

The survey covers six communities within the communes, namely Dikouteni, Koumagou, Gomparou Peulh, Sampeto, Kakpala and Kawado (Figure 1). The selection of the communes was based on the following criteria: (i) level of vulnerability to climate change, (ii) perceived levels of demonstration/application/use of indigenous knowledge, and this is due to farming methods and farming systems practiced (mechanization and irrigation are not available), (iii) accessibility for the survey. According to MCVDD (2014), West Atacora Zone (Boukoumbé) and North Donga (Ouaké) are vulnerable to climate change. Alibori (Banikoara) is less vulnerable to climate change.

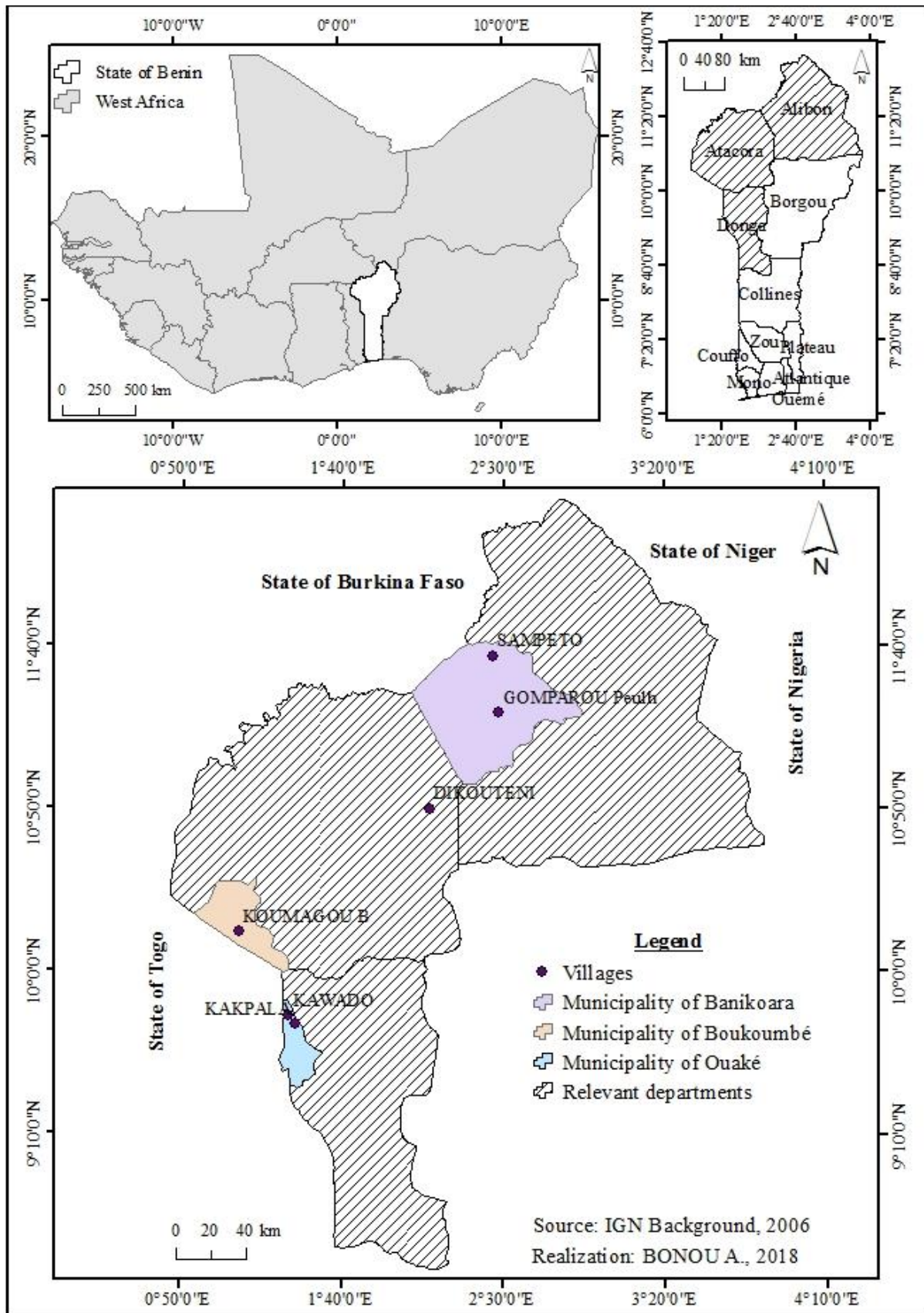


Figure 1. Map of the study area illustrating the surveyed communities / Carte de la zone d'étude montrant les localités enquêtées

2.2. Research units and sampling

The sample consisted of 60 smallholder farmers selected randomly in six villages (10 smallholder farmers each). This helped also to record the entire interview and take pictures.

2.3. Data and variables

Data was collected from 28th August to 4th September 2017. It was a digital survey conducted with KoboCollect. For the administration of semi-structured questionnaires, we used two enumerators who are agricultural economists. Sixty semi-structured questionnaires were administered to smallholder farmers. The collected data included socioeconomic characteristics such as age, gender, household size and questions on climate change beliefs: What do you think about climate change in regard to natural changes, human activities and the anger of God or gods? The response of the farmer is among the list: climate change is occurring, and is caused mostly by human activities; climate change is occurring, and is caused equally by natural changes in the environment and human activities; climate change is occurring, and it is caused mostly by natural changes in the environment; there is not sufficient evidence to know with certainty whether climate change is occurring or not; climate change is occurring and is due to God or gods anger and; climate change is not occurring; others (specify).

The dependent variable contains four categories characterising farmers' beliefs on climate change (Figure 2). These are Gods anger, Natural changes in the environment, Human activities and Natural changes in the environment as well as to human activities. This paper captures assets and wealth through farm size and having agriculture as the sole source of revenue or not. The age and the ethnic group of the household head are included in the set of explanatory variables as they have the potential to influence beliefs on climate change. For instance, experience in life (captured by age) may shape farmers' beliefs on climate change and the customs related to land tenure vary across ethnic groups and therefore, ethnic group can influence the formation of beliefs on climate change.

2.4. Model

In this paper we are interested in estimating the likelihood that a farm household will belong to a certain category of beliefs on climate change. Climate change beliefs were measured through a four-category question that measures belief about the causes of climate change.

Being a female leads one to believe that global warming is primarily caused by human activities as opposed to men (McCright, 2010). Moreover, older people tended to believe that the causes of global climate change are natural (Heath *et al.* 2006). So, the determinants of farmers' beliefs on the causes of climate

change are gender and age. One can see that in the literature it is difficult to find out more determinants of farmers' beliefs on the causes of climate change. This study is an attempt to fill in this gap by checking if the variables determining the perceptions of farmers on the causes of climate change are the same in the case of the beliefs.

In the light of the literature on the determinants of farmers' perception on the causes of climate change, the independent variables included in the estimations (e.g., Chisale *et al.*, 2022; Lokonon & Mbaye, 2018; Debela *et al.*, 2015; Fosu-Mensah *et al.*, 2012; Silvestri *et al.*, 2012; Deressa *et al.*, 2011; Maddison, 2007) are: the gender of the household head, the age of the household head, the ethnic group of the household head, the size of the household, the experience of the household head in agriculture, farm size, and source of revenue.

Experience in agricultural activities is positively associated to climate change perception (Chisale *et al.*, 2022; Lokonon & Mbaye, 2018). Lokonon & Mbaye (2018) found that climate change perception is negatively related to household size. In contrario, large households may be forced to divert part of the labour force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by large family size (Yirga 2007). Then household size is positively related to the perception of adapting to climate change.

The variable education level of the household is a determinant of climate change perception (Chisale *et al.*, 2022; Fosu-Mensah *et al.*, 2012; Silvestri *et al.*, 2012). The gender of the household head influences the likelihood of perceiving the cause of climate change (McCright, 2010; Fosu-Mensah *et al.*, 2012; Maddison, 2007). Farm size is also hypothesized to affect climate change beliefs (Wheeler *et al.*, 2013). Indeed, assets and wealth may influence climate change perception (Silvestri *et al.*, 2012; Fosu-Mensah *et al.*, 2012; Deressa *et al.*, 2011). These positive and negative associations do not provide conclusive evidence in the context of the determinants of beliefs on climate change causes. They merely highlight the possible association between these variables and beliefs on climate change causes.

Climate change beliefs is of paramount importance in conducting agricultural activities owing to the rain-fed nature of agriculture in Benin, including the Sudan Savannah Zone of Benin. Indeed, farmers will take appropriate adaptation measures with regards to their beliefs on climate change (Arbuckle *et al.*, 2013; Wheeler *et al.*, 2013; Haden *et al.*, 2012). A rational farm household i will conceptualize her/his beliefs on climate change with respect to her/his characteristics, X_i . These characteristics include those that are internal to the household such as the gender, the age, the education level of the household head, the size of the household, farm size, the ethnic group, and source of revenue. In

this paper, four types of beliefs about climate change are considered: (i) climate change is due to natural changes in the environment, (ii) climate change is due to natural changes in the environment as well as to human activities, (iii) climate change is due to God or gods anger, (iv) climate change is due to human activities. Therefore, the dependent variable contains four categories, and there is no natural order between these four categories of beliefs. Thus, it is not possible to rank these four categories of beliefs.

Thus, the empirical model to be estimated is specified as follows:

$$Y_i = X_i' \beta + \mu_i \quad (1)$$

where

$$Y_i = \begin{cases} 1 & \text{if Natural changes in the environment} \\ 2 & \text{if Natural changes in the environment as well as} \\ & \text{to human activities} \\ 3 & \text{if gods anger} \\ 4 & \text{if Human activities} \end{cases} \quad (2)$$

μ_i is the error term which is independently and identically distributed. Because the dependent variable is categorical and there is no natural order between the categories, (1) should be estimated by a multinomial probability model (e.g., multinomial logit and multinomial probit models). The paper opts for a multinomial logit

model which is an alternative to the multinomial probit model. The multinomial logit model relaxes the independence restrictions built into the multinomial probit model (Greene, 2012).

3. Results and discussion

3.1. Farmers' beliefs on climate change

Table 1 presents a detailed description of the independent variables and their descriptive statistics. Figure 2 presents farmers' beliefs on climate change. The results indicate that 33.33% of the farm households believed that climate change is due to human activities. This result confirms the findings that the belief in anthropogenic causes of climate change is a major determinant of risk perception (Lee *et al.* 2015; Saleh Safi, *et al.* 2012; McCright, 2010).

About one-third (31.67%) of farm households also considered climate change as a natural phenomenon. More than one-fifth (21.67%) of them believed that climate change is due to God or gods anger, while the remaining 13.33% attributed climate change to both human activities and to natural changes in the environment.

Table 1. Independent variables and descriptive statistics / Variables indépendantes et statistiques descriptives

Variables	Description	Mean	Std. dev.	Minimum	Maximum
Gender	Dummy variable (1 if Male and 0 if female)	0.95	0.22	0	1
Age	In years	43.82	13.74	20	80
Ethnic group					
Bariba ethnic group	Dummy variable (1 if yes and 0 if no)	0.18	0.39	0	1
Lokpa ethnic group	Dummy variable (1 if yes and 0 if no)	0.32	0.47	0	1
Others ethnic group	Dummy variable (1 if yes and 0 if no)	0.50	0.50	0	1
Household size	In number of persons	11.18	7.29	3	35
Experience	In years	24.82	14.38	0	73
Farm size	In ha	5.63	5.93	0.75	30
Agriculture as the only source of income	Dummy variable (1 if yes and 0 if no)	0.52	0.50	0	1

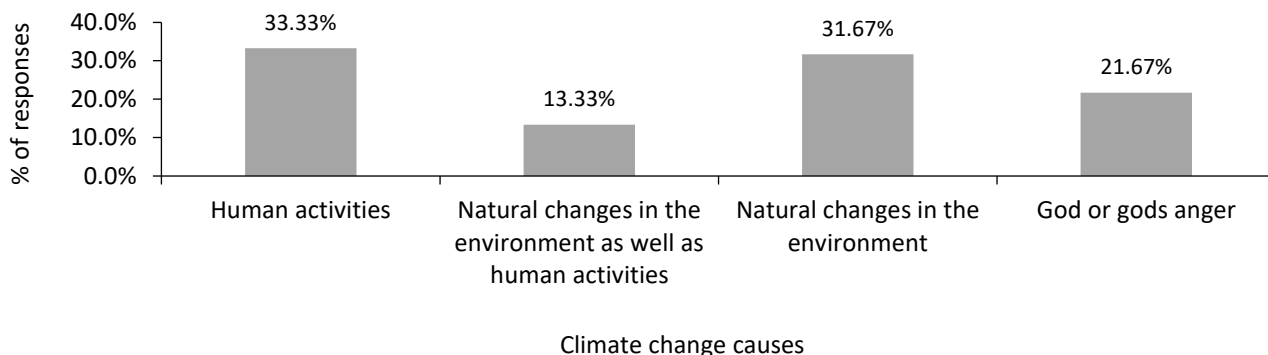


Figure 2. Farmers’ beliefs on climate change causes / Croyances des agriculteurs sur les causes du changement climatique

Therefore, the surveyed farm households have beliefs that are somewhat consistent with scientific knowledge on climate change. However, these findings suggest only 13.33% of them have beliefs which are in line with scientific knowledge on climate change; as mainly due to anthropogenic GHGs (Pörtner et al., 2022), while those believing that it is due to human activities are not far from this scientific knowledge.

It is striking that more than one-fifth of the farm households attributed climate change to God or gods’ anger, which means that the actions they will undertake to mitigate the adverse effects of changes in climate may differ from those of their counterparts (O’Neil, et al. 2022; Yegbemey, et al. 2020).

3.2. Determinants of farmers’ beliefs on climate change

The estimation results of the multinomial logit model of the determinants of farmers’ beliefs are presented in Table 2 with “climate change due to human activities” as the reference category. The model is overall significant and passes all the diagnostic tests. The findings reveal that the gender of the household head, the ethnic group of the household head, and the household size are significantly related to climate change beliefs. The likelihood of believing that climate change is attributable to natural changes compared with believing that climate change is due to human activities decreases with household size. The relative risk ratio was 0.88 and was significant at a threshold of 0.10. Keeping all other variables constant, if the household size increases one unit, the head of household is 0.88 times more likely to believe that climate change is Natural changes in the environment as compared to the belief that climate change is due to human activities (a 12% lower risk ratio or odds). Similarly, the likelihood to believe that climate change is attributable to God or gods anger compared with believing that climate change is due to human activities decreases with household size. This result is in line with that of Lokonon & Mbaye (2018) relative to

the association between household size and climate change perception. In the case of climate change beliefs, this is a new relationship that has not been discussed in previous literature: the relationship between household size and beliefs in climate change.

Having a male head in the household increases the likelihood of believing that climate change is caused by natural changes in the environment compared to conceptualizing climate change as due to human activities. Similarly, the gender of the household head (having a male household head) increases the probability of believing that climate change is caused by God or gods anger compared to thinking that it is due to human activities. This finding is not in line with that of McCright (2010) who found that a greater percentage of women (64%) than men believe that global warming is primarily caused by human activities.

Farmers’ beliefs about climate change are also related to the ethnic group of the household head. For example, individuals belonging to the Lokpa ethnic group, as compared to the Bariba ethnic group, are more likely to attribute climate change to natural changes in the environment compared to believing that it is due to human activities, with the relative-risk ratios being significant at the 5% level of significance. This insight aligns with previous studies that have emphasized the influence of spiritual beliefs on climate change perceptions (Chisale et al., 2022; Saleh Safi, et al. 2012). According to Chisale (2022), the presence of the believers in the cultural and spiritual causes of climate change presents a challenge to mobilize them toward implementation of climate intervention measures and forest management in Malawi. Saleh Safi (2012) assessed rural Nevada and climate change perception and found ethnic group as an important factor of individual socioeconomic vulnerability. In the case of climate change beliefs, this is a new relationship that has not been discussed in previous literature: relationship between ethnic group of the household head and beliefs in climate change.

The remaining variables such as experience, farm size, having agriculture as the only source of income and age do not significantly affect farmers' beliefs on climate change. The result of the last variable is surprising, as Heath (2006) found that older people tended to believe that the causes of global climate change are natural using the correlation method. One limitation of this paper is the lack of inclusion of religion as an independent variable. However, Haluza-DeLay, (2014) suggests the potential utility of religions engaging the issue of

human-induced climate change can be compromised by the perception that religious beliefs are often in conflict with scientific understanding. Those following modern religion believe on climate change, because both climate change and the religions modern concepts, but animists are expected to not believe or to think that it is God made, because of their traditional knowledge.

Table 2. Multinomial logit model estimation of Farmers' Beliefs on Climate Change (reference category: Human activities) / Estimation par modèle logit multinomial des croyances des agriculteurs sur le changement climatique (catégorie de référence : Activités humaines)

Variables	Coefficients			Relative-risk ratios		
	Natural changes in the environment as well as human activities	Natural changes in the environment	God or gods anger	Natural changes in the environment as well as human activities	Natural changes in the environment	God or gods anger
Gender (Reference category: Female)	-0.11 (1.80)	15.00*** (1.71)	14.79*** (1.56)	0.90 (1.61)	3260414*** (5583236)	2646883*** (4131816)
Age	-0.08 (0.06)	-0.04 (0.05)	-0.02 (0.06)	0.93 (0.05)	0.96 (0.05)	0.99 (0.6)
Ethnic group (Reference category: Bariba ethnic group)						
Lokpa ethnic group	2.33 (2.32)	4.48** (1.79)	18.13*** (2.17)	10.34 (24.03)	88.04** (157.84)	7.44e+07*** (1.62e+08)
Others ethnic group	0.01 (1.69)	2.57** (1.19)	15.69*** (1.56)	1.02 (1.71)	13.07** (15.52)	6526782*** (1.02e+07)
Household size	-0.03 (0.08)	-0.13* (0.08)	-0.22** (0.10)	0.97 (0.07)	0.88* (0.07)	0.81** (0.08)
Experience	0.08 (0.07)	0.08 (0.06)	0.10 (0.07)	1.09 (0.08)	1.09 (0.07)	1.10 (0.07)
Farm size	-0.21 (0.25)	0.13 (0.10)	0.04 (0.19)	0.81 (0.21)	1.14 (0.11)	1.04 (0.20)
Agriculture as the only source of income	1.53 (1.18)	0.24 (0.94)	0.51 (1.07)	4.64 (5.48)	1.27 (1.19)	1.67 (1.78)
Constant	0.44 (1.18)	-1.99 (1.52)	-16.36*** (2.60)	1.56 (3.85)	0.14 (0.21)	7.87e-08*** (2.05e-07)
Observations	60	Prob > chi2=0.00		Pseudo R2=0.25		

Note: Robust standard errors in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1%, respectively.

4. Conclusion and policy implications

Due to the importance of climate change beliefs in shaping adaptive measures, this paper investigated the extent of these beliefs as well as the factors associated to them in the Sudan Savannah Zone of Benin, a region heavily reliant on rain-fed agriculture, using a multinomial logit regression. The findings paint a diverse picture: 33.33%, 31.67%, 21.67%, and 13.33% of the farm households believed that climate change is due to human activities, to natural changes in the environment, to God or gods anger, and to both human activities and natural changes in the environment, respectively.

The analysis unveiled intriguing associations: climate change beliefs are related to the gender and the ethnic group of the household head, and household size. In a striking contrast, male-headed households are more likely to attribute climate change to natural phenomena or divine intervention compared to their female-headed counterparts. Similarly, the Lokpa ethnic group and others ethnic groups, exhibited different beliefs compared to the Bariba ethnic group. However, household size was found to decrease the likelihood to believe that climate change is due to natural or divine causes compared to believing that it is due to human activities.

Armed with this knowledge, it becomes imperative to disseminate information that climate change is largely a consequence of anthropogenic greenhouse gases (from human activities). This can enable those that believed that climate change is attributable to natural changes in the environment to be consistent with the scientific knowledge on the causes of climate change as found as the IPCC (Pörtner *et al.*, 2022). This crucial information should be tailored to reach those who attribute climate change to natural changes or divine will, as they might otherwise rely solely on prayers and sacrifices as adaptation measures, overlooking practical and scientifically-supported strategies.

Moreover, special attention must be given to raising awareness among male-headed households, the Lokpa and other ethnic groups regarding the actual causes of climate change, fostering a deeper understanding and potentially transforming their adaptive approaches. Future research may probe deeper into the link between farmers’ beliefs on climate change and adaptation decisions, as well as exploring innovative methods for communicating climate science to diverse audiences.

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Data analysis	Bonou A., Lokonon B.O.K.
Funding acquisition	Bonou A.
Methodology	Bonou A., Lokonon B.O.K.
Project management	Bonou A.
Supervision	Singbo A.G.
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Writing – review & editing	Singbo A.G., Egah J.

CONFLICT OF INTEREST

The authors have declared no conflict of interest. The funders had no role in the design of the study, the collection, analyses, or interpretation of the data; nor in the writing of the manuscript or in the decision to publish the results.

REFERENCES

- Adjacou, D. M., Houehanou, T. D., Gouwakinnou, G. N., & Natta, A. K. (2022). Connaissances ethnoécologiques des variétés locales de *Mangifera indica* L. dans l'Atacora au Bénin: usages, diversité et perceptions du changement climatique. *Annales de l'Université de Parakou-Série Sciences Naturelles et Agronomie*, 12(1), 15-28.
- Agossou, F. (2012). Impact économique du changement climatique sur l'agriculture au Bénin. Mémoire de Master. Université d'Abomey-Calavi. Maîtrise (2012). https://www.memoireonline.com/05/19/10788/m_Impact-economique-du-changement-climatique-sur-l-agriculture-au-Benin29.html#toc70. Consulted on January 2, 2023.
- Azadi, Y., Yazdanpanah, M., & Mahmoudi, H. (2019). Understanding smallholder farmers' adaptation behaviors through climate change beliefs, risk perception, trust, and psychological distance: Evidence from wheat growers in Iran. *Journal of environmental management*, 250, 109456.
- Arbuckle, G. J., Prokopy, L. S., Haigh, T., Hobbs, J., Knoot, T., Knutson, C., et al. (2013). Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern Union States. *Climatic Change*, 117(2013), 943-950. <https://doi.org/10.1007/s10584-013-0707-6>
- Chisale, H. L., Chirwa, P. W., & Babalola, F. D. (2022). Awareness, Knowledge and Perception of Forest Dependent Communities on Climate Change in Malawi: A Case of Mchinji and Phirilongwe Forest Reserves in Malawi. *Journal of Sustainable Forestry*, 1-18.
- Coase, R. H. (1960). The Problem of Social Cost. *Journal of Law and Economics*, 3, 1-44. <https://doi.org/10.1086/674872>
- Debela, N., Mohammed, C., Bridle, K., Corkrey, R., & McNeil, D. (2015). Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, South Ethiopia. *SpringerPlus*, 4(1), 1-12.
- Deressa, T. T., Hassan, R. M., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *Journal of Agricultural Science*, 149, 23-31. doi:10.1017/S0021859610000687
- Di Falco, S., & Veronesi, M. (2014). Managing Environmental Risk in Presence of Climate Change: The Role of Adaptation in the Nile Basin of Ethiopia. *Environ Resource Econ*, 57, 553-577. <https://doi.org/10.1007/s10640-013-9696-1>
- Di Falco, S., & Veronesi, M. (2013). How Can African Agriculture Adapt to Climate Change? A Counterfactual Analysis from Ethiopia. *Land Economics*, 89(4), 743-766. DOI : 10.1353/lde.2013.0043
- Di Falco, S., Veronesi, M., & Yesuf, M. (2011). Does Adaptation to Climate Change Provide Food Security? A Micro-Perspective from Ethiopia. *American Journal of Agricultural Economics*, 93(3), 829-846. doi: 10.1093/ajae/aar006
- Dunlap, R. E., & Scarce, R. (1991). Poll trends: Environmental problems and protection. *The public opinion quarterly*, 55(4), 651-672.
- Fosu-Mensah, B. Y., Vlek, P. L., & MacCarthy, D. (2012). Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. *Environ Dev Sustain*, 14, 495-505. <https://doi.org/10.1007/s10668-012-9339-7>
- Greene, H. W. (2012). *Econometric Analysis*. New York: Prentice Hall.
- Haden, V. R., Niles, M. T., Lubell, M., Perlman, J., & Jackson, L. E. (2012). Global and Local Concerns: What Attitudes and Beliefs Motivate Farmers to Mitigate and Adapt to Climate Change? *PLoS ONE*, e52882. doi:10.1371/journal.pone.0052882

- Haluza-DeLay, R. (2014). Religion and climate change: varieties in viewpoints and practices. *Wiley Interdisciplinary Reviews: Climate Change*, 5(2), 261-279
- Heath, Y., & Gifford, R. (2006). Free-market ideology and environmental degradation: The case of belief in global climate change. *Environment and behavior*, 38(1), 48-71
- Jooste, B. S., Dokken, J. V., Van Niekerk, D., & Loubser, R. A. (2018). Challenges to belief systems in the context of climate change adaptation. *Jàmbá: Journal of Disaster Risk Studies*, 10(1), 1-10.
- Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C. Y., & Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature climate change*, 5(11), 1014-1020. DOI: 10.1038/NCLIMATE2728.
- Lokonon, B. O., & Mbaye, A. A. (2018). Climate change and adoption of sustainable land management practices in the Niger basin of Benin. *Natural Resources Forum*, 42(2018), 42-53. DOI: 10.1111/1477-8947.12142
- Lokonon, B. O., Savadogo, K., & Mbaye, A. A. (2015). Assessing the impacts of climate shocks on farm performance and adaptation responses in the Niger basin of Benin. *African Journal of Agricultural and Resource Economics*, 10(3), 234-249. DOI: [10.22004/ag.econ.211670](https://doi.org/10.22004/ag.econ.211670)
- Maddison, D. (2007). *The Perception of and Adaptation to Climate Change in Africa*. Washington, D.C.: The World Bank, Policy Research Working Paper No. 4308.
- MAEP. (2017). Plan Stratégique de Développement du Secteur Agricole (PSDSA) 2025 et Plan National d'Investissements Agricoles et de Sécurité Alimentaire et Nutritionnelle PNIASAN 2017 - 2021. Cotonou: Ministère de l'Agriculture, de l'Élevage et de la Pêche.
- McCright, A. M. (2010). The effects of gender on climate change knowledge and concern in the American public. *Population and Environment*, 32, 66-87. <https://doi.org/10.1007/s11111-010-0113-1>
- MCVDD. 2014. Stratégie de développement à faible intensité de carbone et résilient aux changements climatiques 2016 - 2025.84p. Ministère du Cadre de Vie et du Développement Durable.
- Menapace, L., Colson, G., & Raffaelli, R. (2015). Climate change beliefs and perceptions of agricultural risks: An application of the exchangeability method. *Global Environmental Change*, 35, 70-81. <https://doi.org/10.1016/j.gloenvcha.2015.07.005>.
- Nago, S.G. A.; Gnohossou, P.; Sagbo, R. R. S. & Bokonon - Ganta, E. (2019). Perception du changement climatique et stratégies locales d'adaptation dans la pêche de la Réserve de Biosphère de la Pendjari, Bénin. *Afrique Science*, 15(3), 114-127.
- O'Neil, G. M. M., Tovihoudji, G. P., Ollabodé, N., Akponikpè, P. I., & Yabi, J. A. (2022). Perception des producteurs des changements climatiques et stratégies d'adaptation dans les systèmes de culture à base de maïs (*Zea mays*) au Nord-Bénin. *Annales de l'Université de Parakou-Série Sciences Naturelles et Agronomie*, 12(1), 1-14.
- Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., ... & Birkmann, J. (2022). Climate change 2022: Impacts, adaptation and vulnerability. *IPCC Sixth Assessment Report*, 37-118.
- Saleh Safi, A., James Smith Jr, W., & Liu, Z. (2012). Rural Nevada and climate change: Vulnerability, beliefs, and risk perception. *Risk Analysis: An International Journal*, 32(6), 1041-1059. DOI: 10.1111/j.1539-6924.2012.01836.x

- Satoguina, H. (2016). Impact économique du changement climatique sur la production de maïs et d'igname au Bénin. *Annale des Sciences Economiques et de Gestion*, 15(2). <http://www.annalesumng.org/index.php/seg/article/view/54>
- Silvestri, S., Bryan, E., Ringler, C., Herrero, M., & Okoba, B. (2012). Climate change perception and adaptation of agro-pastoral communities in Kenya. *Reg Environ Change*, 12(4), 791-802. <https://doi.org/10.1007/s10113-012-0293-6>
- Vodounou, J. B. K., & Onibon Doubogan, Y. (2016). Agriculture paysanne et stratégies d'adaptation au changement climatique au Nord-Bénin. *Cybergeo: European Journal of Geography [En ligne], Environnement, Nature, Paysage*, document 794, mis en ligne le 15 novembre 2016. DOI:10.4000/cybergeo.27836
- Sodjinou, E., & Hounkponou, S. K. (2019). Impact des changements climatiques sur les revenus des ménages agricoles au Bénin: Evidence basée sur l'application du modèle Ricardien. *Annales de l'Université de Parakou-Série Sciences Naturelles et Agronomie*, 9(1), 43-54.
- Wheeler, S., Zuo, A., & Bjornlund, H. (2013). Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. *Global Environmental Change*, 23(2013), 537-547. <https://doi.org/10.1016/j.gloenvcha.2012.11.008>
- Whitmarsh, L., & Capstick, S. (2018). Perceptions of climate change. In *Psychology and climate change* (pp. 13-33). Academic Press.
- Yegbemey, R. N., Imorou, S. E. H., Aïhounton, D. G. B., Yabi, J. A., Kinkpe, T. A., & Atchikpa, M. (2020). Déterminants de l'adaptation des agriculteurs aux changements climatiques dans les zones du Nord Bénin et du Sud Niger. *Annales de l'Université de Parakou-Série Sciences Naturelles et Agronomie*, 10(2), 31-42.
- Yirga, C. (2007). The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia (Doctoral dissertation, University of Pretoria).

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