Journal of Agriculture and Environment for International Development - JAEID 2018, 112 (1): 65-80
DOI: 10.12895/jaeid.20181.695

Perception of climate change impacts on agricultural production decisions: insights from the Banikoara commune of Benin

Ichaou Mounirou and Boris Odilon Kounagbè Lokonon

Centre de Recherche en Entreprenariat, Croissance et Innovation (CRECI), Faculté des Sciences Economiques et de Gestion (FASEG), Université de Parakou (UP), Parakou, Republic of Benin.

Corresponding author: odilonboris@gmail.com

Submitted on 2017, 9 October; accepted on 2018, 28 April. Section: Research Paper

Abstract: This article analyzes producers' perception of the impacts of climate change on agricultural production decisions. The data used are collected through a survey of 406 cotton producers in the Banikoara commune of Benin, and a Multinomial Logit model is used to analyze the determinants of this perception. More than half of the producers (50.25%) have a wrong perception of the impacts of climate change on the agricultural production decisions. The findings reveal that this perception is significantly explained by the number of male kids, the level of education, the changes in output prices, the State's support when risks occur, and the sources/origins of agricultural risks. The welfare of producers will be improved if agricultural policies are diversified and include weather-based crop insurance (individual as well as collective).

Keywords: Climate change, agricultural production decisions, environmental perception, Benin
JEL Classifications: Q15, Q51, Q54

Introduction

In Benin, the agricultural sector is heavily dependent on meteorological variability and is seriously threatened by climate change. Since the end of the 1960s, climatic variations occurred in Benin and reducing the mean annual amplitude of rainfalls of 180 mm (JVE, 2010). This situation has led to an intensification of droughts that occurred during the 1970s and the early 1980s. These climatic phenomena have had significant impacts on agriculture, forestry, water resources and ecosystems, by (i) a clear break in the rainfall series (1968-1972), with 1970 as the pivotal year; (ii) a general decline in average rainfall (about 15-30%), depending on the geographical areas; (iii) a high variability on the onset of the rainy season; (iv) a reduction in the number of rainy days and duration of rainy seasons; (v) a filling deficit for most dam reservoirs decreasing the water supply for the main cities, such as Parakou and Savalou, and a reduction in fish production; (vi) an acceleration of coastal erosion due to see level rise; (vii) an intrusion of salt water into the Cotonou lagoon and a threat to freshwater biodiversity.

All of these climatic trends have negative implications for agriculture and food security in Benin. The most affected crops are maize, sorghum, millet, rice, beans, cassava, yams and groundnuts. The impact of climate change on crops is indirect when it is the result of the modification in the soil nutrient contents producing yield reductions. The statistics of the *Agence pour la Sécurité et la Navigation Aérienne en Afrique et à Madagascar* (ASECNA) predicted a significant increase in temperatures of about 1-2° C by 2025, during both the dry and rainy seasons (ASECNA, 2015). Boko *et al.* (2012) reported that the inter-annual rainfall variability observed during the period 1951-2015 reveals that across the country (Benin) occurred short shortfalls, which were alternate with a few years characterized by short periods of rainwater excess. On an annual scale, the drop in precipitation is between 11 and 28%: while the annual rainfall was 1215 mm/year from 1961 to 1975, it was only 1090 mm/year after 1975. The deviations from the average temperature recorded each year during the period 1951-2010 are of the order of -0.6 to +0.8° C. They do not reveal either an upward or a downward trend in temperature. However, it should be noted that, with the exception of the littoral, a net increase of about 1° C in average air temperature is observed from 1995 (ASECNA, 2015).

In the livestock sector, climate change is manifested by the scarcity of pastures and the loss of animal weight, the reduction of farrowing, the emergence of new diseases and high mortality, changes in the seasons and the concentration of the number of breeders, as well as the multiplication of the conflicts with farmers. In addition to crops and livestock, the fisheries sector, providing 600,000 direct and indirect jobs in Benin, is not spared with the threat of disappearance of certain aquatic species, the salinity and acidity of the waters.

In the cotton producing zones of Benin, the peasants mainly practice rain-fed agriculture. Only about 0.5% of land are irrigated (MAEP, 2015). Climatic projections for cotton regions predict an increase in extreme precipitation and droughts, as well as high intra-seasonal rainfall variability. The negative effects of climate change in cotton producing zones in Benin are worsen by unsustainable management of natural resources and expose the different agricultural products to risks. Thus, crop yields and the resulting level of food security for the population are threatened.

Farmers' perceptions of the impact of climate change on agricultural production decisions in the above described context are of a particular importance. Indeed, if farmers are able to properly discern the impacts of climate change on their production decisions, then they will be able to take appropriate measures for extending their adaptive capacity to mitigate the negative impacts and seize opportunities arising from the positive effects. For Larimore (1969), environmental perception is related to the desirability of site characteristic as resource for exploitation such as suitability of soil for crop production. In addition, this author argued that environmental perceptions of the groups involved in change are worth to be investigated prior to planning implementation of the desired change. It is therefore necessary to analyze this perception and to identify its explanatory factors for adaptation policies' purpose. Most of the existing literature are related to analyzing and identifying the determinants of farmers' perceptions of climate change and attempting to link this perception to adaptation decisions (e.g., Deressa *et al.*, 2011; Moyo *et al.*, 2012; Okonya *et al.*, 2013; Kansiime *et al.*, 2014; Lokonon and Mbaye, 2018). It should be noted that there is a wide literature on assessing the impacts of climate change on agriculture (e.g., Seo *et al.*, 2009; Pinky and Rayhan, 2013; Lokonon *et al.*, 2015). However, do farmers perceive themselves these impacts on their agricultural production decisions? Indeed, risk perception is important in decision-making process. Consequently, this article studies the determinants of the perception of climate change impacts on agricultural production decisions in Benin focusing on the Banikoara Commune (see Figure 1).

Literature review

Risk and uncertainty are inherent in any economic activity and must be taken into account in decision taking. Already Knight, in 1921 focused on the role of uncertainty and risk at the heart of economic reflection. He thought that high levels of profit are linked to uncertainty; so there is a reward for individuals who bear risks. In the case of uncertainty, the possible benefits of decisions are known, but the probabilities associated with these benefits are unknown (Knight, 1921). The risk is related to the fact that the possible benefits of decisions and the associated probabilities are known (Knight, 1921). Recently, for Toma *et al.* (2012), the "risk is limited to situations where the decision maker may attach mathematical probability to any random events that can occur, while uncertainty refers to situations in which events cannot be expressed in precise mathematical terms of probabilities". Policy developments related to uncertainty and serious attempts to manage risk and uncertainty are recent. These developments are those of Gollier (2011) and Ben-Haim (2006), and put forward a very technical process to fill the lack of information in problems of this type. In this perceptual, Chevallier *et al.* (2011) proposed two theoretical approaches for decision making in a situation of ambiguity: a theoretical Bayesian approach, which consists in attributing objective or subjective probabilities to events and then applying preferences by referring to expected values or expected utility; a non-Bayesian approach, using a formal definition of ambiguity and different degrees of aversion to ambiguity. The latter approach can take many forms, depending on the structure of beliefs and priorities regarding probabilities, and on the trust that the decision-maker places on those beliefs.

The link between climate change and the agricultural sector is established by many authors, such as Parry *et al.* (1999). It is even acknowledged that one of the most vulnerable sectors to climate change is the agriculture (Cline, 2007). According to the Intergovernmental Panel on Climate Change, "vulnerability is the propensity or predisposition to be adversely affected" (IPCC, 2014, p. 39). This high vulnerability is more pronounced in developing countries in which agriculture is the mainstay of the economy. The capacity of countries to address climate change remains the crucial issue that needs to be addressed. As such, Smith *et al.* (2001) presumed that developing countries will be more vulnerable to climate change than developed countries and particularly Sub-Saharan Africa. It should be noted that climate change is characterized by changes in rainfall, changes in temperatures, extreme weather events such as hurricanes, floods and droughts, among others. Many economists have analyzed the impacts of climate change on agricultural production using approaches such as the Ricardian model, bioeconomic models, and so on (Ouédraogo *et al.*, 2008; Kurukulasuriya and Mendelsohn, 2008b; Nefzi and Bouzidi, 2008; Ouédraogo, 2012; Kurukulasuriya and Mendelsohn, 2008a; Mariara and Karanja, 2006; Massetti and Mendelsohn, 2012; Boko et *al.*, 2012; Roudier et *al.*, 2011). Overall, these studies conclude that agriculture will suffer from climate change, although the magnitude of the impacts differ across geographic units and across crops; some regions and crops may, potentially, benefit from climate change. For instance, the effect of climate change on crop yields depends on carbon fertilization. Gornall et *al.* (2010) showed that mid-latitude countries may benefit from increase in temperature, whereas at low latitudes increase in temperature may lead to the decrease in crop yields. For Kang *et al.* (2009), the positive effects of climate change on agriculture are related with the CO_2 concentration, crop growth period increases in higher latitudes and montane ecosystems. Future positive impacts of climate change on the Northern latitudes (Europe and Asia) foresee a gain in term of forest and shrub/woodland cover extension, while a loss of grass and tree covers would occur at tropical latitude (Tropic of Cancer) in Africa and South America.

It is therefore necessary to uptake adaptation measures to mitigate the negative impacts of climate change. However, authors such as Deressa *et al.* (2009), Maddison (2007), and Mortimore and Adams (2001) showed that African producers do not have sufficient adaptive capacity to potentially improve crop productivity or diversification. Gordier (2006) explained the risks actually affect the behavior of farmers: in the absence of mechanisms to reduce or assign risk to improve their situation, they have the choice between two conventional attitudes, not aimed at managing risk but avoiding it. However, the development of adaptation strategies depends on the perception of climate change (Deressa *et al.*, 2011). Thus, farmers need to be aware of climate-related risk and uncertainty before taking adequate measures. Much of the works, as aforementioned, have focused on analyzing the perception of climate change and its potential link to decision-making on adaptation strategies (e.g., Deressa *et al.*, 2011; Moyo *et al.*, 2012; Okonya *et al.*, 2013; Kansiime *et al.*, 2014; Lokonon and Mbaye, 2018). The findings are in the sense that farmers perceive climate change even though this perception is not always consistent with historical climate records. Therefore, the perception of the impact of climate change on agricultural production must be analyzed, which is the subject of this paper.

Risk perception is important in the decision-making process (Williams and Noyes, 2007). Cohen and Etner (2008) showed that past experience have a cumulative effect on decisions: an individual can maintain constant its insurance demand after one occurrence of the loss and modify it only after two, or more consecutive loss events. The existing literature reveals that factors such as gender, age and education level of the household head, access to extension services, and social capital are important in risk perception in agriculture (e.g., Deressa *et al.*, 2011; Moyo *et al.*, 2012; Okonya *et al.*, 2013; Lokonon and Mbaye, 2018).

Material and methods

Data

This article uses part of the data from the Socio-Demographic and Economic Survey carried out in the Commune of Banikoara (Figure 1) by the Ministry of Agriculture, Livestock and Fisheries (MAEP) in 2016. This Commune is subdivided in ten districts: one urban district (Banikoara-Marou) and nine rural districts (Founougo, Gomparou, Goumori, Kokey, Kokiborou, Ounet, Somperékou, Soroko and Toura). The Commune of Banikoara covers 4,383 km^2. A total of 500 agricultural producers were involved in the two waves of the survey, during the harvest and the post-harvest period, between October 2015 and September 2016. After cleaning, the dataset contains 406 observations.

Model specification

The main aim is to estimate the probability for a given producer to belong to a perception category[1]. The producer (or the household) chooses a perception category among four possible options (wrong, fair, fairly-good, and good). We assume that there is not natural order (ranking order) in the different perception categories. The producer i ($i \in \{1,\ldots,N\}$) chooses the perception category j ($j \in \{0,\ldots,3\}$)) about the

1 Perception category refers to the type of perception related to the impact of climate change on agricultural production decisions.

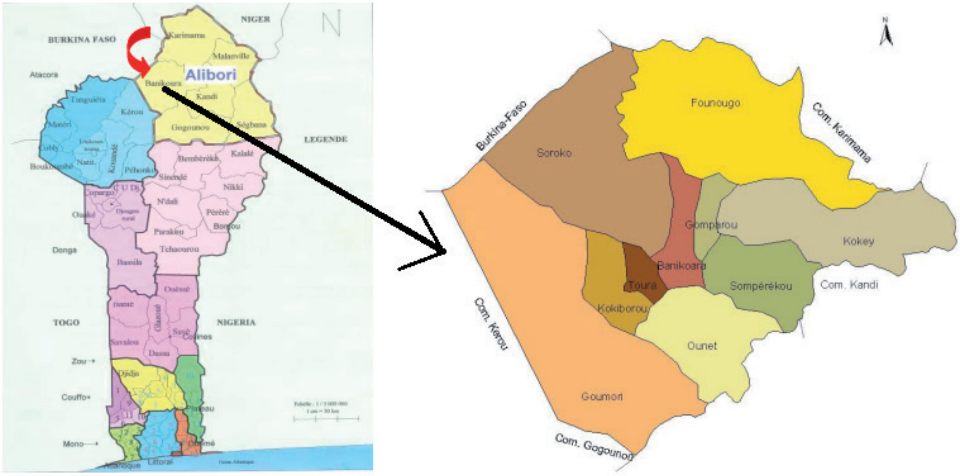

Figure 1 - Map of the Commune of Banikoara
Source: INSAE (2016)

impacts of climate change on production decision, which maximizes her satisfaction U_{ι}^{*}. For each perception category *j*, the satisfaction is decomposed in a part determined by a set of characteristics X_{ι} and a stochastic part ε_{ij}:

$$U_{\iota}^{*}=X_{\iota}'\beta_{j}+\varepsilon_{ij}, \quad j=\{0\ldots3\} \qquad (1)$$

where refers to the vector of characteristics of producer and those related to her household, is the vector of parameters to be estimated. Let be the variable capturing the different perceptions of the impacts of climate change on agricultural production decisions. As aforementioned there are four perceptions categories which can take the following values in the same order there are mentioned "{0; 1; 2; 3}". Owing to the fact that we assume there is no natural order among the perception categories, the appropriate model would be a multinomial probability model. In this paper, we opt for the Multinomial Logit. Thus, this model helps to estimate the likelihood to belong to categories 1, 2 and 3 relatively to reference, which is 0. For the producer, the satisfaction associated to the choice can be specified as follows:

$$U_{ij}='\, Z_{ij}+\varepsilon_{ij} \qquad (2)$$

In this expression, Z_{ij} is a vector of individual characteristics, β is a vector of parameters to be estimated and ε_{ij} is the error term. If the producer selects the perception category, one considers as the maximal satisfaction among those related to the categories. Therefore:

$P(U_{ij}>U_{ik})$, k≠j ; j , k=0,1,2,3 (3)

This model can be operational if and only if, we assume that the error terms are independently and identically Welbull distributed:

$F(\varepsilon_{ij})=\exp(e^{-\varepsilon_{ij}})$ (4)

In this case, the difference between the errors follows a logistic distribution. According to Nerlove and Press (1973), we can thus write:

$$P(Y_i = j) = P(U_{ij} > U_{ik})k \neq j \tag{5}$$

$$Prob(Y_i = j)\frac{e^{\beta'_j z_I}}{\sum_{k=0}^{2} e^{\beta'_k z_i}} \text{ with } j = 0{,}1.2.3 \text{ et } \beta_0 = 0.$$

$$U_{ij} = \beta'_i + \varepsilon_{ij} \tag{6}$$

The normalization of β_0 (β_0=0) helps to guarantee the identification of other parameters to be estimated. The estimated coefficients of this model are difficult to be interpreted without transformation. By deriving the previous equation, it is possible to obtain the marginal effects of the explanatory variables on the likelihoods of the different perceptions:

$$\delta_j = \frac{\delta p_j}{\delta z_i} = P_j[\beta_i - \textstyle\sum_{k=0}^{2} P_k\beta_k] = P_j[\beta_i - \bar{\beta}] \tag{7}$$

δ_j describes the effect of a unit change of a variable on the probability that a producer selects the alternative *j*. These are hard to be interpreted directly, but only by emphasizing that a given option with respect to the reference option. As illustration, in equation (7), if β_{ij}>0 then an increase in the variable X_i leads to an increase in the likelihood to choose the alternative instead of the alternative j = 0.

After estimating the model, validation tests must be conducted: first, the assumption of the independence of the irrelevant alternatives, according to which the ratios of probabilities between alternatives are independent, has to be checked. Long and Freese (2006), having observed that these tests can yield to contradictory results, do not encourage their use.

The variables of the model (selected following the literature review) as well as descriptive statistics are presented in Table 1.

Table 1 - Description of variables and descriptive statistics

Variables	Description	Units	Frequencies/ means
Perception	The perception of the impact of climate change on agricultural production decisions	0=Wrong	50.25
		1=Fair	31.28
		2=Fairly-good	11.08
		3=Good	7.39
Age	Age of the producer	Years	36.87
Agricultural labor used	Agricultural labor used by the producer	Number of persons	5.98
Number of sons	Number of male kids of the producer	Number of persons	2.85
Number of daughters	Number of female kids of the producer	Number of persons	3.17
Education level	Formal education level of the producer	0=None	63.55
		1=Primary	18.72
		2=Secondary	10.10
		3=Superior	7.64
Agricultural cooperative	Member of an agricultural cooperative	0=No	67.49
		1=Yes	32.51
Extension services	Access to extension services	0=No	72.17
		1=Yes	27.83
Price of cotton	Evolution of the price of cotton	0=Weak	56.90
		1=Fair	33.00
		2=Good	10.10
Other agricultural products	Evolution of the level of the prices of other agricultural products	0=Weak	50.25
		1=Fair	32.51
		2=Good	17.24
State support	State support when a risk affecting agriculture occurs	0=In-kind	68.47
		1=Material of construction	17.00
		2=Seeds and inputs for the following campaign	14.53
Sources of agricultural risks	Sources or origins of agricultural risks	0=Rural roads	30.05
		1=Low prices of agricultural products	11.58
		2=Floods	11.58
		3=Conflicts between producers and pastoralists	14.29
		4=Precipitations	4.43
		5=Insects or rodents	28.08

Variables	Description	Units	Frequencies/ means
Agricultural risk management	Activities to mitigate the consequences of agricultural risks	0=Bordering commerce	57.88
		1=Commerce of informal fuel	21.18
		2=Motor taxi	9.11
		3=Casual activities	11.82
Land use of food crops	Land allocated to food crops	Ha	8.04
Land use of cotton	Land allocated to cotton	Ha	3.82

Results and discussion

The estimation results of the Multinomial Logit model are presented in Table 2. The wrong perception of the impacts of climate change on agricultural decisions is taken as the reference category. The model is overall significant, suggesting that the explanatory variables included in the model significantly explain the perception of the impact of climate change on agricultural production decisions. In addition, diagnostic tests (Wald tests and the hypothesis of the independence of irrelevant alternatives) are conclusive. The Wald test is carried out in order to test the overall significance of the model. This test suggests that the explanatory variables explain the perception globally and significantly at the 1% level of significance. Moreover, it is necessary to question the relevance of distinguishing alternatives if certain explanatory variables tend in the same direction. The findings reveal that the number of male kids, the level of education, the changes in the price of other agricultural products, the State support for risks on agricultural production, sources or origins of agricultural risks are the main factors that significantly explain producers' perceptions of the impact of climate change on agricultural production decisions. These factors affect the different categories of the model. The other explanatory variables included in the model do not significantly affect the perception of the impact of climate change on agricultural production decisions.

The likelihood of perceiving fairly the impact of climate change on agricultural production decisions relatively to having a wrong perception decreases with the number of male kids of the producer. The relative risk ratio is 0.889. This result indicates that as the number of male kids increases, the likelihood of having a fair perception (relative to having a wrong perception) is decreasing. The ratio of relative risk of having a fairly-good perception to a wrong perception is 2.565 for producers with primary education level, relative to those with no formal education. This finding suggests that the level of schooling is important in the perception of the impact of climate change on agricultural production decisions. Indeed, the level of education allows producers to be able to detect a change in climatic conditions and to be able to link this change to agricultural production decisions. Actually, the skills required to interpret the meteorological data may be linked to the level of schooling. Producers with average changes in the prices of other agricultural products are more likely to have a fairly good perception of the impact of climate change on agricultural production decisions compared to having a wrong perception relatively to producers with low changes in the prices of these products. The relative risk ratio of this variable is 2.362. Thus, the change in the prices of other crops other than cotton is decisive for detecting the implication of climate change on agriculture. As these products are largely destined for the domestic market, the rise or fall of their prices is linked to climatic conditions, *ceteris paribus*.

Table 2 - Estimation results

Explanatory Variables	Fair perception		Fairly-good perception		Good perception	
	RRR	P>|z|	RRR	P>|z|	RRR	P>|z|
Age	1.000	0.890	1.006	0.687	1.019	0.309
Agricultural labor used	1.037	0.268	1.026	0.567	1.011	0.848
Number of sons	0.889**	0.049	0.998	0.979	1.087	0.419
Number of daughters	1.075	0.153	0.952	0.568	1.020	0.837
Education level (Reference: None)						
Primary	0.917	0.789	2.565**	0.025	0.460	0.266
Secondary	0.825	0.658	1.634	0.414	0.428	0.296
Superior	0.954	0.911	2.396	0.177	0.398	0.398
Agricultural cooperative	1.063	0.820	0.887	0.737	0.681	0.397
Extension services	1.001	0.998	1.419	0.386	1.602	0.311
Price of cotton (Reference: Weak)						
Fair	0.995	0.985	0.761	0.486	0.968	0.943
Good	0.894	0.789	0.641	0.450	0.970	0.966
Other agricultural products (Reference: Weak)						
Fair	0.910	0.729	2.362**	0.031	1.099	0.849
Good	0.791	0.506	2.065	0.154	0.735	0.624
State support (Reference: In-Kind)						
Material of construction	0.748	0.384	0.243*	0.053	0.894	0.841

Seeds and inputs for the following campaign	1.067	0.846	0.687	0.447	1.136	0.837
Sources of agricultural risks (Reference: Rural roads)						
Low prices of agricultural products	0.813	0.620	0.636	0.463	0.506	0.312
Floods	1.270	0.565	2.146	0.168	0.495	0.337
Conflicts between producers and pastoralists	1.046	0.906	0.711	0.557	0.131*	0.069
Precipitations	2.885*	0.073	0.600	0.661	1.86e-06***	0.000
Insects or rodents	0.722	0.333	1.099	0.833	0.703	0.463
Agricultural risk management (Reference: Bordering commerce)						
Commerce of informal fuel	0.799	0.473	1.762	0.164	0.603	0.396
Motor taxi	1.272	0.549	0.647	0.600	0.986	0.984
Casual activities	0.700	0.370	0.605	0.428	0.410	0.257
Food crops land use	0.969	0.319	1.008	0.862	0.958	0.403
Cotton land use	1.044	0.156	1.003	0.954	1.032	0.589
Constant	0.782	0.709	0.088***	0.004	0.150	0.139
Reference category	Wrong					
Observations	405					
Log pseudolikelihood	-429.536					
Wald chi2	1636.89					
Prob>chi2	0,000					
Pseudo R^2	0,074					

Note: *, **, ***: significant at 10%, 5%, and 1%, respectively.

Producers that benefited from building material as State's support are less likely to have a fairly-good perception compared to having a wrong perception relatively to their counterparts that benefited from in-kind supports. The results of the estimations suggest that the relative risk ratio is 0.243. Thus, in spite of the good perception of the State support in the event of agricultural losses, the behavior of producers, which is based on the low perception and decision of agricultural production, remains unchanged, in most of the cases. This result explains the fact that, in the case of agricultural losses, the State support is so low to compensate for agricultural losses.

The findings suggest that the farmers who believe the sources of agricultural risks are from the conflicts between crop producers and pastoralists are less likely to have a good perception compared to having a wrong perception than those that believe that the risks are related to the inadequacy of rural roads. Moreover, producers who believe that rainfall distribution is the basis of agricultural risks are more likely to have a fair and a good view of the consequences of climate change on agricultural production decisions, compared to those who think they are related to rural roads, in relation to wrong perception. It should be noted that the relative risk ratio associated with fair perception is higher than that associated with good perception. Access to extension services does not affect significantly the perception. This finding may be due to the fact that the ratio of the extension officers to cotton producers is low in the research area. Moreover, political and institutional incentives to boost cotton production to the detriment of food crops may also explain the non-significance of the effect of access to extension services. It should be noted that the findings are in some extent in line with those found in the literature related to climate change perception (e.g., Deressa *et al.*, 2011; Moyo *et al.*, 2012; Okonya *et al.*, 2013; Lokonon and Mbaye, 2018).

Conclusion and policy implications

In the cotton zones of Benin, peasant ethno-meteorological perceptions of climate change and the decisions about agricultural production are based on local knowledge and experiences. This paper analyzed the determinants of farmers' perception of the impacts of climate change on agricultural production decisions, using a Multinomial Logit model. Based on a social survey, the findings show that agricultural producers in this area do not clearly perceive the effects of climate change. Actually, 50.25% of producers have a wrong perception of the impact of climate change on agricultural production decisions. Severe thunderstorms, irregular rainfall, recurrent droughts, disturbance in the length of the rainy seasons and sowing periods, disappearance of temporary water points, gradual disappearance of biodiversity, yields declining, changes in the forage system, significant changes in landscape physiognomy, diversity in agricultural risk sources, and its ineffective management represent the salient facts characterizing the current changing in term of climate and crop production. The estimation results revealed that this perception is significantly explained by the number of male kids, the level of education, the changes in output prices, the State's support when risks occur, and the sources/origins of agricultural risks.

It would be important to raise the level of education of producers to provide them with cognitive capacities to detect the effects of climate change on agricultural production decisions. Raising the level of education would help to strengthen the skills required to perceive the implications of climate change on agricultural production decisions in order to take up appropriate adaptation measures. Moreover, policy makers may think about designing programs that target farmers with kids, to provide them right information, which has the potential to improve their awareness of the impacts on climate change on agricultural production decisions. These kinds of programs will also be beneficial for those who believe that the sources of production risks are from the conflicts between crop producers and pastoralists and those that benefit from building material as State's support. Given that some producers are able to perceive the implications of climate change on agricultural production decisions, the promotion of insurance could be beneficial to the agricultural sector. Therefore, policy makers may develop a range of methods with effective risk management instruments, which would induce agricultural producers to choose their own type of insurance.

References

ASECNA, 2015. Annuaires des statistiques sur les pluviométries, les températures et l'humidité au Bénin. Agence pour la sécurité de la Navigation Aérienne en Afrique et à Madagascar, Cotonou.

Ben-Haim Y., 2006. Information-Gap Decision Theory; Decision under Severe Uncertainty. 2nd Edition, Academic Press, London.

Boko M., Kosmowski F., Vissin W. E., 2012. Les Enjeux du Changement Climatique au Bénin: Programme pour le Dialogue Politique en Afrique de l'Ouest. Konrad-Adenauer-Stiftung, Cotonou, 65 p.

Chevallier J., Etner J., Jouvet P. A., 2011. Bankable Emission Permits under Uncertainty and Optimal Risk-Management Rules, Research in Economics, Vol. 65: 332-339.

Cline R. W., 2007. Climate change and agriculture: Impacts estimates by country. Centre for Global Development and Peterson Institute for International Economics.

Cohen M., Etner J., 2008. Dynamic Decision Making when Risk Perception Depends on Past Experience. Theory and Decision, Vol. 64 (2-3): 173-192.

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, Vol. 149: 23-31.

Deressa T. T., Hassan R. M., Ringler C., Alemu T., Yesuf M., 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change, Vol. 19 (2): 248-255.

Gollier C., 2011. Discounting and risk adjusting non-marginal investment projects. European Review of Agricultural Economics, Vol. 38 (3): 297-324.

Gordier J., 2006. Proposition d'organisation des outils de gestion du risque de marché au bénéfice des filières cotonnières africaines. Agence Française de Développement, Paris.

Gornall J., Betts R., Burke E., Clark R., Camp J., Willett K., Wiltshire A., 2010. Implications of climate change for agricultural productivity in the early twenty-first century. Phil. Trans. R. Soc. B., Vol. 365: 2973-2989.

INSAE, 2016. Cahiers des villages et quartiers de ville du département de l'Alibori. Institut National de la Statistique et de l'Analyse Economique (INSAE), Cotonou.

IPCC, 2014. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In: Field C. B., Barros V. R., Dokken D. J., Mach K. J., Mastrandrea M. D., Bilir T. E., Chatterjee M., Ebi K. L., Estrada Y. O., Genova R. C., Girma B., Kissel E. S., Levy A. N., MacCracken S., Mastrandrea P. R., White L. L. (Eds.), Climate Change 2014: Impact, Adaptation, and Vulnerability. Cambridge University Press, Cambridge and New York, NY.

JVE, 2010. Développement Durable au Bénin, Contexte Environnemental au Bénin en Matière de Changements Climatiques. Cotonou.

Kang Y., Khan S., Ma X., 2009. Climate change impacts on crop yield, crop water productivity and food security – A review. Progress in Natural Science, Vol. 19: 1665-1674.

Kansiime M. K., Wambugu S. K., Shisanya C. A., 2014. Determinants of Farmers' Decisions to Adopt Adaptation Technologies in Eastern Uganda. Journal of Economics and Sustainable Development, Vol. 5 (3): 189-199.

Knight F. H., 1921. Risk, Uncertainty, and Profit. Houghton Mifflin Company, New York.

Kurukulasuriya P., Mendelsohn, R., 2008a. A Ricardian analysis of the impact of climate change on African cropland. AfJARE, Vol. 2 (1): 1-23.

Kurukulasuriya P., Mendelsohn R., 2008b. How Will Climate Change Shift Agro-Ecological Zones and Impact African Agriculture? World Bank Development Research Group Sustainable Rural and Urban Development Team.

Larimore E. A., 1969. Environmental and Spatial Perception: An Approach to Research in African Rural Geography. Canadian Journal of African Studies, Vol. 3 (1): 276-280.

Lokonon K. O. B., Savadogo K., Mbaye A. A., 2015. Assessing the impacts of climate shocks on farm performance and adaptation responses in the Niger basin of Benin. AfJARE, Vol. 10 (3): 234-249.

Lokonon K. O. B., Mbaye A. A., 2018. Climate Change and Adoption of Sustainable Land Management Practices in the Niger Basin of Benin. Natural Resources Forum, Vol. 42 (1): 42-53.

Long J. C., Freese J., 2006. Regression Models for Categorical Dependent Variables Using Stata, Second Edition, STATA Press.

Maddison D., 2007. The Perception of and Adaptation to Climate Change in Africa. World Bank Working Paper 4308.

MAEP, 2015. Annuaire Statistique des Productions Agricoles et la Relance du Secteur Agricole au Bénin 2014-2015. Ministère de l'Agriculture de l'Elevage et de la Pêche, Cotonou.

Mariara J. K., Karanja F. K., 2006. The Economic Impact of Climate Change on Kenyan Crop Agriculture: A Ricardian Approach. Third World Congress of Environmental and Resource Economics.

Massetti E., Mendelsohn R., 2012. The Impact of Climate Change on US Agriculture: a Cross-Section, Multi-Period, Ricardian Analysis, in Ariel Dinar and Robert Mendelsohn (Ed), Handbook on Climate Change and Agriculture, Edward Elgar.

Mortimore M. J., Adams W. M., 2001. Farmer adaptation, change and "crisis" in the Sahel. Global Environmental Change, Vol. 11 (1): 49-57.

Moyo M., Mvumi B.M., Kunzekweguta M., Mazvimavi K., Craufurd P., Dorward P., 2012. Farmer Perceptions on Climate Change and Variability in Semi-Arid Zimbabwe in Relation to Climatology Evidence. African Crop Science Journal, Vol. 20 (s2): 317-335.

Nefzi A., Bouzidi F., 2008. Evaluation de l'impact économique du changement climatique sur l'agriculture au Maghreb. Disponible sur le lien http://www.ps2d. net/media/Nefzi-Bouzidi.pdf. Consulté le 12/04/2017.

Nerlove M., Press J., 1973. Multivariate and Log Linear Probability Models in Econometrics. Center for Statistics and Probability, Northwestern University, Discussion Paper No. 1.

Okonya J. S., Syndikus K., Kroschel J., 2013. Farmers' Perception of and Coping Strategies to Climate Change: Evidence From Six Agro-Ecological Zones of Uganda. Journal of Agricultural Science, Vol. 5 (8): 252-263.

Ouédraogo M., 2012. Impact des changements climatiques sur les revenus agricoles au Burkina Faso. Journal of Agriculture and Environment for International Development, 3-21.

Ouédraogo S., Belemviré A., Maïga A., Sawadogo H., Savadogo M., 2008. Etude du Sahel Burkina Faso. Evaluation des impacts biophysiques et socioéconomiques des investissements dans les gestions des ressources au nord et du plateau centre du Burkina. Rapport de synthèse, 94p.

Parry M., Rosenzweig A., Iglesias C., Fisher G., Livermore M., 1999. Climate change and world food security: a new assessment. Global Environmental Change, Vol. 9: 51-67.

Pinky S. B., Rayhan M. I., 2013. Climate change impact on crop productivity: a bio-economic analysis. Bulletin of Environmental and Scientific Research, Vol. 2 (4): 11-15.

Roudier P., Sultan B., Quirion P., Berg A., 2011. The impact of future climate change on West African crop yields: What does the recent literature say? Global Environmental Change, Vol. 21: 1073-1083.

Seo N. S., Mendelsohn R., Dinar A., Hassan R., Kurukulasuriya P., 2009. A Ricardian Analysis of the Distribution of Climate Change Impacts on Agriculture across Agro-Ecological Zones in Africa. Environ Resource Econ, Vol. 43: 313-332. doi: DOI 10.1007/s10640-009-9270-z

Smith B. J., Schellnhuber H. J., Mirza M. Q., 2001. Vulnerability to climate change and reasons for concern: A synthesis. In C. Hope, & S. K. Sinha (Ed.), Climate change 2001: impacts, adaptation and vulnerability. Contribution of the Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, Cambridge University Press, 914-967.

Toma S-V., Chitita M., Sarpe D., 2012. Risk and Uncertainty. Procedia Economics and Finance, Vol. 3 (2012): 975-980.

Williams J. D., Noyes M. J., 2007. How does our perception of risk influence decision-making? Implications for the design of risk information. Theoretical Issues in Ergonomics Science, Vol. 8 (1): 1-35.