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Climate change perceptions and responsive strategies in Benin: the case of maize farmers

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Abstract
Climate change has become a global concern with important impacts in all regions of the world, especially in agriculture sector. In response, farmers take different adaptation strategies to minimise the negative impacts of climate change. This study provides answers to how farmers perceive climate change and what drives their adaptation decisions. To do this, data were collected from a random sample of 200 maize farmers in the municipality of Zè, Benin. Results indicated that almost all the maize farmers perceived change in climate variables. The adaptation strategies used by maize farmers in the municipality of Zè included adjustment in sowing time, use of improved crop varieties, crop and livestock integration and tree planting. Estimates of the multivariate probit model revealed that farmers' capacity to choose a specific adaptation strategy is affected by age, gender, marital status, education, experience in maize production, credit, distance to market, ownership of TV and agricultural training. These results suggest the need for institutional and technology support measures in adapting to climate change.

1 Introduction

Climate change has become a global concern with very noticeable impacts in all regions of the world (Mendelsohn et al. 2006; Tidjani and Akponikpè 2012, Roudier et al. 2011; IPCC 2014; Ali and Erenstein 2017). The fifth report of the Intergovernmental Panel on Climate Change (IPCC 2014) has shown that in the coming decades, climate change will intensify and will have significant economic, social and environmental consequences. Its impacts will weigh heavily on developing countries, particularly those in Africa, highly vulnerable to climate change (Mertz et al. 2009; IPCC 2014; Ali and Erenstein 2017). One of the most detrimental impacts of climate change is the decline in agricultural productivity, which in turn will reduce food availability and therefore pose a serious threat to food security and worsen poverty. However, climate change does not only lead to negative consequences on agriculture.

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Depending on the crops and the geographical units, climate change may positively affect crop production. For example, less productive agricultural zones such as humid forest or sub-humid agro-ecological zones may become more productive in the future (Seo et al. 2009). Also, in the mid and high latitudes, crop productivity could increase by 30% by the 2050s, particularly for cereals and cool season seed crops (Maracchi et al. 2005; Olesen et al. 2007; Gornall et al. 2010).

Benin, a coastal country, remains exposed to climate change and its impacts. Since the 1960s, climate change is characterised by a large rainfall deficit, often alternating with heavy rainfall and temperature increase as well as rising sea level (Tidjani and Akponikpè 2012). As a result, agricultural production is declining in the country. Although maize yield has increased from 743 kg/ha in 1980 to 1422 kg per hectare (ha) in 2011, it has fell down to 1376 kg per ha in 2016 (MAEP 2017; FAO 2018). In the municipality of Zè (study area), maize yield has decreased from 1818 kg/ha in 2011 to 968 kg/ha in 2016 (MAEP 2017). Since agriculture is a key economic sector in Benin, there is an urgent need to adopt adaptation strategies in order to respond to the impacts of climate change that threaten food security. Without climate change adaptation measures, agricultural production in Benin is expected to decrease by 5 to 20% in 2025 (Paeth et al. 2008; Yegbemey et al. 2014).

Previous works (Deressa et al. 2009, Gnanglé et al. 2011, Agossou et al. 2012, Ali and Erenstein 2017, Elum et al. 2017, Jiri et al. 2017) have shown that the impacts of climate change on agriculture vary from region to region as producers do not face the same challenges. Also, they perceive climatic events differently and therefore develop different strategies with regard to their perceptions of climatic phenomena. For instance, Ali and Erenstein (2017) found that adjustment in sowing time, use of drought-tolerant varieties and shifting to new crops were the three major adaptation practices used by farmers in Pakistan. In Ethiopia, farmers attempt to adapt to climate change using practices like crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock and tree planting (Deressa et al. 2009; Belay et al. 2017). Adoption of drought-tolerant varieties is the most common climate-response strategy used by farmers in South Africa (Elum et al. 2017).

The theories of utility, behavioural and cognitive have been commonly used to explain farmers' decision to adapt to climate change (Seo and Mendelsohn 2008; Weber 2010; Ali and Erenstein 2017; Elum et al. 2017). Financial, cultural and policy barriers are main factors which could affect the choice of adaptation strategies (IPCC 2007, 2014). Lack of information on adaptation methods and financial constraints are the main barriers to adapt to climate (Deressa et al. 2009). Alauddin and Sarker (2014) reported that inadequate access to climate information and scientific research outcomes and limited irrigation facilities represent major adaptation barriers. Elsewhere, choice of climate change adaptation strategies is correlated with governance, civil rights, financial resources and education (De Jalón et al. 2014). Several studies (Hassan and Nhemachena 2008; Deressa et al. 2009; Nabikalo et al. 2012; Uddin et al. 2014; Belay et al. 2017; Jiri et al. 2017) indicated that socio-economic and institutional factors are the main determinants of African farmers' decision to adapt to climate change. A study by Kpadonou et al. (2012) highlighted the local dimension of adaptation to climate change and the importance of local knowledge in adaptation planning.

This study aims to analyse maize farmers' adaptation strategies to climate change in Benin. Specifically, it provides answers to the following research questions: (1) Do local maize farmers' perceptions of climate change support the global evidence of variability in rainfall and temperature? (2) What are the response strategies used by farmers? (3) What are the factors that influence maize farmers' decision to adopt a specific adaptation strategy? This paper contributes to increase knowledge on climate change response strategies in Benin. There is little evidence on how maize farmers in Benin adapt to climate change despite its effects on maize yield. Indeed, without adaptation strategies, maize yield is expected to decrease by 5 to 25% in 2050 (Jalloh et al. 2013).

Maize is one of the main staple food in Benin. It is produced by almost 85% of farmers and is among the priority sectors of the government of Benin to reduce food insecurity and poverty. In terms of methodology, the study provides a rigorous estimate of the determinants of climate change adaptation strategies by employing a multivariate probit model. This model is preferable to the simple/multinomial probit or logit model used in majority of studies (e.g. Nabikalo et al. 2012; Uddin et al. 2014; Ali and Erenstein 2017; Belay et al. 2017; Jiri et al. 2017). The advantage of multivariate probit model is that it simultaneously estimates the adaptation decisions and allows the unobserved and unmeasured factors (error term) of each equation to be correlated (Bahinipati and Venkatachalam 2015). In terms of policy, this study provides specific answers to support climate change adaptation policies in Benin.

2 Theoretical framework

Farmers try various strategies to adapt to climate change. These include soil and water management, crop management, improved seeds, calendar management, tree planting, irrigation among others (Hassan and Nhemachena 2008; Below et al. 2012; Yegbemey et al. 2014). We analysed the decision to adapt to climate change within the framework of expected utility maximisation (Seo and Mendelsohn 2008; Bahinipati and Venkatachalam 2015). Maize farmers are assumed to maximise their expected utility derived from the adaptation to climate risks. Let us consider a risk-averse farmer (F_i) that chooses a number of adaptation strategies (S_j) among j strategies. It is assumed that maize farmers that adapt to climate risks have higher expected utility compared with those who have not:

$$E(U\lfloor F(S_1)\rfloor) > E(U\lfloor F(S_0)\rfloor) \tag{1}$$

Since farmers face a finite choice set and utility is not directly observable, the decision to adopt a specific strategy can be expressed as follows:

$$U_i^* = \gimel X_i + \varepsilon \tag{2}$$

with $U_i = \begin{cases} 1 \text{ if } U_i^* > 0 \\ 0 \text{ otherwise} \end{cases}$

where U_i^* the latent variable representing the probability of the farmer i to choosing adaptation strategy j among others. X_i is the vector of independent variables influencing the adaptation decision, $\gimel$ is the vector of parameters to estimate and ε is the error term.

For a set of strategies, model (2) can be rewritten as follows:

$$\begin{array}{c} U_{i1}^* = \beta 1 X_{i1} + \varepsilon_{i1} \\ U_{i2}^* = \beta 2 X_{i2} + \varepsilon_{i2} \\ U_{ij}^* = \beta 3 X_{ij} + \varepsilon_{ij} \end{array} \tag{3}$$

with U_{i1}^*, U_{i2}^*, and U_{ij}^* representing the probability that farmer i respectively chooses the first, second or j^{th} strategy.

3 Empirical approach

3.1 Analytical framework of farmers' perceptions of and adaptation strategy to climate change

Farmers' perceptions of climate change were obtained from individual maize producers selected. They expressed their perception of climate change on a series of climatic variables (temperature and rainfall) with regard to the manifestations of climate change observed in the area. They were asked to provide their observations in the patterns of temperature and rainfall over the past 20 years. A three-point Likert scale (agree, neutral, disagree) was used. Results were analysed using descriptive statistics including frequencies and percentages.

Similarly, the identification of climate change adaptation strategies was done in two stages: Firstly, we identified in the literature (Hassan and Nhemachena 2008; Deressa et al. 2009; Below et al. 2012; Yegbemey et al. 2014; Ali and Erenstein 2017; Belay et al. 2017) the different adaptation strategies adopted by farmers. Then, a respondent answers "yes" if he/she used the strategy and "no" otherwise. Farmers were also asked if they used other non-listed coping strategies. Results were analysed using descriptive statistics. The different strategies used by the producers were classified on the basis of frequencies. The strategy with the greatest frequency was therefore the most common strategy used by maize producers.

3.2 Analytical framework for determinants of adaptation strategies

Let consider the model (3) described above. Assuming that the error terms are independent and normally distributed, each of the equations in model (3) can be estimated separately using a probit model. However, adaptation strategies are not mutually exclusive (Bahinipati and Venkatachalam 2015); then, the unobserved errors terms for the probit model would be correlated (Mittal and Mehar 2016). To account for this, a multivariate probit model (MVP) was estimated. This model provides more efficient estimates because it controls for the selection bias associated to adoption (Bahinipati and Venkatachalam 2015; Mittal and Mehar 2016). The general form of the multivariate probit model is as follows:

$$Y_{ij} = \beta_j \ X_{ij} + \varepsilon_{ij} \tag{4}$$

where Y_{ij} is the probability that a farmer i chooses strategy j ($j = 1, \ldots\ldots,4$). X_{ij} is the vector of the exogenous variables that affect the adoption decision. β_j is the vector of the parameters to be estimated. Equation (4) was estimated by the simulated maximum likelihood method (Cappellari and Jenkins 2003) which used Geweke-Hajivassiliour-Keane smooth recursive conditioning simulator procedure to evaluate the multivariate normal distribution.

3.3 Choice of independent variables

Variables used in the multivariate probit model were selected from the literature. These variables fall into three categories, namely socio-demographic characteristics, farm characteristics and institutional variables:

(1) The socio-economic characteristics comprise age, gender, marital status, level of education, farming experience, ownership of TV, ownership of radio and agricultural training (Deressa et al. 2009; Jiri et al. 2017; Ali and Erenstein 2017).

(2) The farm characteristics include farm size and land ownership (Hassan and Nhemachena 2008; Deressa et al. 2009; Alauddin and Sarker 2014).
(3) The institutional variables comprise education, credit and access to market (Ndamani and Watanabe 2015; Ali and Erenstein 2017; Belay et al. 2017).

4 Data and descriptive statistics

The study was conducted in Benin in the municipality of Zè (Fig. 1), located in the sub-humid Guinean zone with majority of population depending on agriculture for their livelihood.

The municipality of Zè belongs to the agro-ecological zone VI which is located in the sub-humid Guinean zone (INSAE 2012; Amegnaglo et al. 2017). In this zone, the rainfall regime is often disturbed causing changes in the annual production cycles (Houngbo 2015). Agricultural production is characterised by small farm sizes because of high land fragmentation (Amegnaglo et al. 2017) and population density of 164 inhabitants per km^2 in 2013 (INSAE 2013). The main crops cultivated are maize, cassava, potatoes, pineapple, tomatoes, pepper and legume. Zè is one of the poorest municipality in Benin with 65% of poor (INSAE 2015). Over the 11 districts of the municipality of Zè, four were randomly selected including Tangbo-Dodji-Bata, Hekanme, Sedje-Denou and Tangbo-Djevie. Two villages were randomly selected from each district making a total of 8 villages covered by the survey. Twenty-five farmers were randomly selected using the list of maize producers provided by the Chief of the village. In total, 200 maize farmers were interviewed. Farm level data were collected in May, 2017.

Table 1 presents the summary statistics of the surveyed respondents. The mean age for the selected farmers was 43 years. Majority (75%) of farmers were male indicating that male were

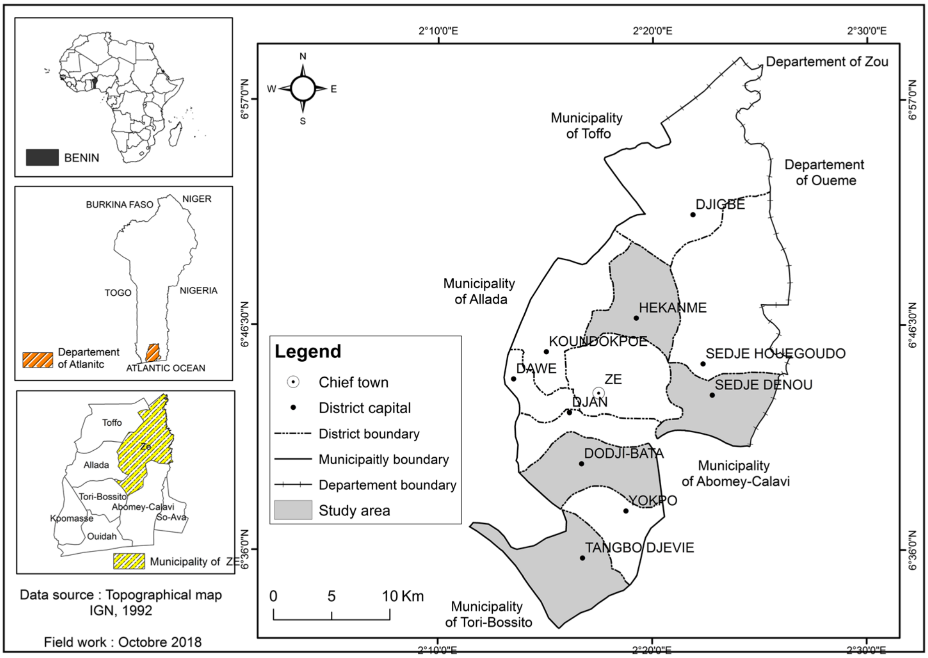

Fig. 1 Map of study area

Table 1 Description of variables

Variable	Description	Mean	Std. dev
Age	In years	42.6	9.97
Gender	Dummy (1 if male and 0 otherwise)	0.75	0.43
Marital status	Dummy (1 if married and 0 otherwise)	0.79	0.40
Education	Dummy (1 if at least primary education)	0.18	0.38
Experience	In years	17.37	11.30
Farm size	In hectares	2.43	1.51
Use of fertiliser	Dummy (yes = 1)	0.56	0.49
Use of improved seed	Dummy (yes = 1)	0.6	0.49
Access to credit	Dummy (yes = 1)	0.30	0.46
Amount of credit	In CFA	62,300	119,320.6
Distance to market	In km	2.23	1.14
Ownership of TV	Dummy (yes = 1)	0.20	0.40
Ownership of radio	Dummy (yes = 1)	0.85	0.35
Land ownership	Dummy (1 if owner of land, 0 otherwise)	0.27	0.44
Agricultural training	Dummy (yes = 1)	0.56	0.49

more involved in maize production than female. About 18% of farmers had completed at least primary education. This suggests that few farmers in the study area have access to formal education. On average, farmers had about 17 years of experience in maize production. None of them reported being a member of a farmer-based organisation (FBO) or using herbicide. However, 56% applied fertiliser and 60% adopted improved maize varieties. The average maize farm size was 2.43 ha. Three main land tenure arrangements were identified. These include own land, family land and leasing. The study makes difference between own land which are under full control of a farmer and family land which belong to the entire family and are under the control of the family head. It was observed that 27% of the respondents had their own land while 70% used family land and 3% rented the land. About 30% of farmers received credit, indicating poor access to credit by the maize farmers in the municipality of Zè. The average distance to market was estimated at 2.23 km. Majority (85%) of farmers owned radio while only 20% own TV. About 56% of farmers have participated in agricultural training on production and soil management practices.

5 Results and discussion

5.1 Farmers' perceptions of and adaptation strategy to climate change

Nearly all (99.5%) the maize farmers perceived change in climate variables (Table 2). About 98% of farmers reported change in temperature with 94.5% observing increase in temperature against 4.5% that perceived decrease in temperature. Almost all (99.5%) the farmers revealed that drought occurs every year during the crop production season due to decreasing rainfall pattern. For instance, all the farmers reported that there had been a decrease in rains frequency, and 96.5% observed late onset of rains. Farmers had access to climate change information through the media, particularly radio (85%) and TV (20%). This finding highlights the importance of mass media in providing climatic information to rural communities.

Majority (96%) of the farmers adopted strategies to cope with climate change effects on maize production. The strategies identified include changes in production techniques through

Table 2 Maize farmers' perception of long-term changes in climate variables

Climatic phenomenon	Frequency	Percentage
Change in climate	199	99.5
Change in temperature	196	98.0
Increased temperature	189	94.5
Decreased temperature	09	04.5
Change in rainy season	197	98.5
Decreased rains frequency	200	100
Late rains arrival	193	96.5
Drought	199	99.5

the use of improved varieties, planting trees, adjusting cropping calendar by changing planting dates and integrated crop-livestock systems (Table 3). Most of the respondents (93.5%) used tree planting in response to global warming (variability of temperature). This provides natural shade for the crops during the extended dry periods (Belay et al. 2017). Adjustment in sowing time was adopted by 70% of farmers to respond to late rainfall and floods while 62.5% used improved maize varieties as strategy for rainfall variability. Farmers also practiced crop and livestock integration (51.5%). Additionally, some farmers used more than one strategy (Table 3) to get the benefit of complementarity among coping strategies. Tree planting and adjustment in sowing time, and tree planting and improved crop varieties are the most common combination of strategies used by farmers. Overall, our results substantiate previous findings (Deressa et al. 2009; Alauddin and Sarker 2014; Ali and Erenstein 2017; Elum et al. 2017; Belay et al. 2017). Maize producers who did not adapt to climate change invoked among other reasons, lack of willingness and financial constraints as the main barriers to adaptation.

5.2 Determinants of farmers' adaptation strategies to climate change

Results of the multivariate probit model are presented in Table 4. The model is globally significant as indicated by the significance of the Wald χ^2. The likelihood ratio test (Prob = 0.000) indicated that the null hypothesis of the absence of correlation between the individual equations is strongly rejected. This confirms the correlation assumption of error terms between equations and justifies the use of multivariate probit model instead of estimating each equation separately. The pairwise correlation between the adaptation strategies equations in the MVP

Table 3 Adaptation strategies by maize farmers in the municipality of Zè

Strategy	Frequency	Percentage
Single strategy		
Adjustment in sowing time	140	70
Adoption of improved varieties	125	62.5
Crop and livestock integration	103	51.5
Tree planting	187	93.5
Use of irrigation	00	0.0
Combination of strategies		
Tree planting and adjustment in sowing time	129	64.5
Tree planting and improved crop varieties	123	61.5
Tree planting and crop and livestock integration	98	49.0
Adjustment in sowing time and improved varieties	95	47.5
Adjustment in sowing time and crop and livestock integration	67	33.5

Table 4 Multivariate probit estimate of adaptation strategies

Variables	Adjustment in sowing time	Use of improved varieties	Crop and livestock integration	Tree planting
Age	− 0.189**	− 0.040	0.034	− 0.137
	(0.079)	(0.071)	(0.064)	(0.116)
Age square	0.002***	(0.0008)	− 0.0003	0.0013
	(0.0009)	(0.071)	(0.0007)	(0.0013)
Gender	0.237	0.451*	− 0.045	− 0.107
	(0.237)	(0.237)	(0.224)	(0.312)
Marital status	0.504**	0.499*	− 0.089	− 0.765**
	(0.239)	(0.272)	(0.237)	(0.372)
Education	0.461*	− 0.039	0.071	− 0.121
	(0.279)	(0.265)	(0.237)	(0.352)
Experience	− 0.006	0.026*	− 0.001	0.039
	(0.012)	(0.014)	(0.012)	(0.025)
Farm size	− 0.058	− 0.027	− 0.128	− 0.033
	(0.105)	(0.119)	(0.095)	(0.156)
Amount of credit	0.002*	0.014***	− 0.001	0.076***
	(0.001)	(0.005)	(0.001)	(0.024)
Distance to market	− 0.83	− 0.048	0.254**	0.536**
	(0.105)	(0.119)	(0.104)	(0.251)
Ownership of TV	− 0.153	− 0.449	0.929***	− 0.114
	(0.354)	(0.340)	(0.330)	(0.595)
Ownership of radio	− 0.098	− 0.082	0.267	− 0.652
	(0.374)	(0.372)	(0.348)	(0.654)
Land ownership	− 0.471	0.495	0.113	0.315
	(0.299)	(0.382)	(0.281)	(0.446)
Agricultural training	− 0.114	0.617**	0.662***	0.528
	(0.223)	(0.243)	(0.220)	(0.342)
Constant	4.352**	− 0.453	− 1.498	4.059
	(1.743)	(1.56)	(1.412)	(2.903)
Correlation measures				
Improved varieties adoption	0.182			
	(0.123)			
Crop and livestock integration	− 0.195*	− 0.684***		
	(0.114)	(0.132)		
Tree planting	− 0.260	0.441***	− 0.292*	
	(0.171)	(0.112)	(0.160)	
Log likelihood: − 339.06	Wald χ^2 (52) = 178.69		Prob > χ^2 = 0.000	
Likelihood ratio test	χ^2 (6) = 37.07		Prob > χ^2 = 0.000	

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$; values in parenthesis are standard errors

model indicated that four correlation coefficients out of six are significant. Positive correlation indicates complementarities and negatives correlation reveals substitutability among the adaptation strategies. The results revealed that farmers who practiced crop and livestock integration tended to not use improved seed, adjustment in the sowing time, and tree planting. Those who adopted tree planting were likely to use improved crop varieties, suggesting a complementarity between tree planting and use of crop varieties.

Age of the farmer is negatively correlated with the adjustment in sowing time as climate change adaptation strategy. This is similar to Ali and Erenstein (2017). However, age square turned out to be positively associated. A unit increase in farmer's age decreases the probability of adjusting the sowing time up to 47 years, after which the probability increases. This inverse relationship suggests that older farmers are more likely to change sowing time compared with younger farmers, because they are more experienced. Deressa et al. (2009) found that age increases the probability to use planting trees and irrigation as an adaption strategy, while Belay et al. (2017) found a negative relationship between age and tree planting. The results also suggest that male farmers adapt more promptly to climate change. This is in line with previous studies (Deressa et al. 2009; Jiri et al. 2017) that found male farmers more likely to use improved crop varieties as climate change strategy compared with female farmers. Nabikalo et al. (2012) argued that adaptation to climate change by female heads is influenced by more liquid household assets, while for male heads, this is influenced by real estate, especially land. Married farmers are more likely to adjust the sowing time and use improved crop varieties, but less likely to plant trees compared with non-married farmers. This indicates that married farmers are more oriented to short-term adaptation strategy to climate change, perhaps because of the various responsibilities like feeding their family.

Consistent with previous findings (Deressa et al. 2009; Temesgen et al. 2014; Ali and Erenstein 2017; Belay et al. 2017), education increases the probability of adapting to climate change. Table 4 indicates that educated farmers are more likely to adjust in sowing time as an adaptation strategy. We also found that more experienced farmers are more likely to use improved maize varieties as an adaptation strategy to climate change. Experienced farmers may have more information and farmer-to-farmer interactions which can increase the likelihood of the use of adaptation strategies (Nhemachena and Hassan 2007; Bahinipati and Venkatachalam 2015). A positive relationship was also observed between the amount of credit and adaptation to climate change. A 1% increase in the amount of credit received increases the likelihood of adjustment in sowing time, use of improved varieties and tree planting. Availability of credit is therefore important in the process of adaptation to climate change. This result supports previous findings (Deressa et al. 2009; Temesgen et al. 2014; Ndamani and Watanabe 2015) who argued on the importance of institutional support measures in reducing the climate change impacts.

Distance to market is also important in explaining the choice of adaptation strategy by farmers. The results indicate a positive relationship between distance to market and use of crop and livestock integration and tree planting as adaptation strategies. This is an indication that remoteness from market favours crop and livestock integration and tree planting. Similar results were found by Hassan and Nhemachena (2008) who suggested that more market integration would be an important area for public investment in adaptation infrastructure. Ownership of TV and agricultural training were positively associated with the likelihood of using improved maize varieties and crop and livestock integration. Since climate information can be shared through these two channels, this result suggests that access to climate information is important for adaptation decisions and options.

The study provides empirical support on the perception of climate change and the responses of local producers in Benin. We also show that maize farmers are already adapting to climate change in Benin. We find that farmers use a range of coping strategies to climate risks. However, it is observed that none of the surveyed farmers used irrigation (Table 3). This can be explained by the low use of irrigation in the country. Indeed, the irrigated land represents approximately 0.8% of the total cultivated area in Benin (FAO 2018). Water management and the promotion of irrigation cannot be overstated to reduce the vulnerability of agriculture to climate change. The use of irrigation is important for increasing crop yield (Nonvide 2017; Nonvide 2018). This calls for proper policy for the provision of irrigation facilities in the country.

Since adaptation measures depend on resources constraint and socio-economic and institutional factors, the next question is about the sustainability in the adaptation strategies. Are these strategies socially and environmentally sustainable? How to increase their sustainability? As Eriksen and Brown (2011) pointed out, little attention has been paid to the implications of climate responses for social equity and environmental integrity. In addition, not every response is necessarily a good one

(Eriksen et al. 2011). Yegbemey et al. (2017) found that among the climate change adaptation measures, on-farm diversification and land use change strategies appear to be sustainable options in Northern Benin, while other strategies such as migration (to another agro-ecological zone), prayers and access to credit appear to be unsustainable. Some of the local practices especially the use of indigenous plant resources in dryland areas may represent a more environmentally sustainable option of adaptation to drought and climate change (Eriksen and Brown 2011; Gachathi and Eriksen 2011). However, these strategies give very low income and become mechanisms of the poor rather than being able to contribute to reduction of social inequity (Eriksen and Brown 2011). Climate adaptation method can be sustainable if it is less costly to establish, and flexible to places and seasons (Agyei 2016). This raises the importance of farmers' adaptive capacity for sustainability in the adaptation strategies, which should be the focus of future studies. It would be interesting to look at the outcomes of climate change adaptation strategies.

6 Conclusion

This study analyses farmers' adaptation strategies to climate change among maize farmers in Benin based on a cross-sectional survey data collected from a random sample of 200 maize producers in the municipality of Zè, Benin. First, the results indicated that farmers perceived change in climate variables and are aware of climate change. Second, the adaption strategies used are adjustment in sowing time, use of improved crop varieties, crop and livestock integration and tree planting. Third, a multivariate probit model was estimated to determine the factors that affect the use of the adaptation measures by farmers. Socio-economic and institutional variables such as age, gender, marital status, education, experience in maize production, credit, distance to market, ownership of TV and agricultural training were found to be the main determinants of climate change adaptation strategies.

To increase the effectiveness of the adaptation strategies, the study suggests the establishment of an early warning system that would allow farmers to be informed of possible climatic disturbances. A perfect combination of the information provided by the agrometeorological services and local knowledge would help farmers to adapt better to weather variability. Community media will be involved in the implementation of this policy especially in the dissemination of agrometeorological information. Promoting reforestation and agroforestry would be one of the techniques that can enable farmers to reduce the harmful effects of strong winds and improved soil fertility. More market integration would also be an important area for public investment in climate change adaptation infrastructure. There is a need to improve the provision of farm credit and farmers' education. The latter can be done through regular training. On the basis of an effective participatory approach, there is a need for research to develop drought-resistant crop varieties that are not only adapted to the current climatic conditions but also meet producers' preferences. In addition, research must take into account the diversity of the effects of climate change in relation to the different landscape.

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