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"Climate change perception and adaptation strategy associated with farming techniques in Tamou district wester Niger" farmers

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The variability of climate parameters in most of agricultural areas in Niger represents a major risk for farmers. This work is aimed at analyzing farmer's perception and adaptation to climate change parameters in Tamou district. The study was conducted on seventy three (73) millet farmers from seven villages in Tamou, namely Allambaré, Bani Guiti, Guieme, Tollondi , Moli Haoussa and Welgorou. The sample was random and tables were built from the results of a brief survey of millet farmers. The results obtained showed that farmers appreciate changes in climae parameters through rainfall (92.6%) while 7.4% do not perceive this parameter as factor, wind (88.9%), and temperature (85.2%). The adaptations techniques include organic and mineral fertilizers (87%) adjustment of farming to rainfall calendar (96%), using improved seeds varieties (75%), crop diversification (49%), water and soil preservation techniques (34%) and rural migration (3.8%). These adaptations are identified in the rural community of Tamou by several factors: degree of experience importance in terms of agricultural practices, the supervision of extension agents, the number of workers per household, the property rights and a good annual income. These adaptations and determining factors must be taken into account by all stakeholders in decision making in Niger's agricultural policy to guarantee food securityfarmers.

Key words: Millet, farmers, climate parameters, perception, adaptation, Tamou.

INTRODUCTION

In the history of humanity, the need to understand the impact of climate variability has never been so great as in the 21st century, especially in the tropics where deforestation and species extinction are relatively more

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important and living conditions more precarious (Bush and Flenley, 2007). Disasters caused by phenomena related to climate change and disruption has a great impact on agriculture in developing countries (Frank et al., 2003).

Climatic factors are affected by temperature, wind, rain, and drought that people feel comfortable or not comfortable in the area because the planning and management are not well. Some of the studies show that there is the range of bioclimatic comfort zone which people feel comfortable with. Drought evaluation is very important as well as climatic ranges. Drought assessments give people an active scenario in the city to protect the damaging socioeconomic and politic problems.

Recent studies with drought stress using remote sensing shows monitoring of drought stress. It is envisaged that both current land uses and future potential future use will be affected by the negative consequences of possible sea-level rise. The morphological structure of low elevations suggests that the impacts of elevation can easily proceed to the interior (Cetin, 2015a, b; Cetin and Sevik, 2016; Cetin, 2016; Cetin et al., 2018a, b; Yucedag et al., 2018). The fourth report of the Intergovernmental Panel on Climate Change (IPCC, 2007) announces that poor communities will be the most vulnerable because of their low adaptive capacity and high reliance on resources that are very sensitive to climate change such as water resources and agricultural production systems. These variability risks and climate change, notwith-standing their global impact, it is poor regions like Africa and particularly West Africa which will suffer the most from climate change because of their high vulnerability.

Indeed, in this region, the gradual change in temperature and rainfall and the frequency of extreme weather hazards are expected to lead to crop losses, livestock death and other of productive assets. Such losses will not only threaten food production, but also access, stabilize and utilization of food resources (Hamani, 2007). The rural sector (agriculture, livestock, forestry) is the bedrock and driving force of the economy of Sahelian countries in general and Niger republic in particular.

Unfortunately, in Niger, in the last 30 years, the main climate factors (water, sunshine, temperature and wind) are highly variable and unpredictable, so that today, farmers cannot accurately predict the evolution of their activities even for a near future. This situation weakens the production systems and makes agricultural activity uncertain (Oumarou et al., 2016).

In Niger, climate change has been the subject of several national report, policies, strategies, research papers, articles, dissertations and thesis (Hamani, 2007; Oumarou et al., 2016; CNEDD, 2011; AGRHYMET, 2012). The most of these documents have highlighted the trends and risks that represent this phenomenon for the development of agriculture in Sahel in general, and in Niger in particular. These documents also highlighted a significant gap in the knowledge of the relations of strategies perception and the adaptation to climate change developed by local actors. This study aims to fill the gap of the work of partners at the local level with specific case of Niger.

MATERIALS AND METHODS

Zone of the study

The study was carried out in Tamou district (Figure 1). The study area is between 12° 28 ' N and 12° 50' N and 2° 06 'and 2° 24' S. The population is estimated at 89,782 inhabitants out of which 51.16% are men and 48.84% are women (INS 2014). The main ethnic groups are Fulani and Foulmangani. In this district, 80 to 90% of arable lands are sandy soils conducive to millet cultivation, lowlands (for example, the river basin and its tributaries) rich in organic minerals essential to sorghum cultivation. We also meet some lateritic plateau and hardened soils that are undergoing restoration, and are being exploited for agriculture and animal husbandary. It is one of the most watered region in Niger (500 to 700 millimeter of annual rainfall). Agriculture and livestock are the main economic activities of these populations. The choice of this study area is based on the fact that it constitutes a buffer zone for the “W “ National park of Niger (Figure 1).

Sampling

Observation units are farms represented by the farm manager. A farm is a production unit characterized by unique management, and owned means of production (Yegbemey et al., 2014). A sample of 73 farmers was randomly selected in 7 villages using the random number table constructed from the results of a summary census of millet farmers. Table 1 shows the constitution of the study samples.

Data collection

Data collection was carried out through surveys conducted in the form of semi-structured interviews. At the village level, two types of surveys were carried out: focus group interviews and individual interviews. Focus group interviews were conducted with a group of farmers (key informants from the village) in each village. Therefore, during the surveys, interviews on the farmers’ perception, the evolution of the main climate parameters (rainfall, temperature, wind) and climate change (causes, manifestations and impactsimpacts) were organized with a group of farmersfarmers (all categories combined). Individual surveys were conducted with farmers separately. For this purpose, the main data collected include human and socio-economic factors, the perception of

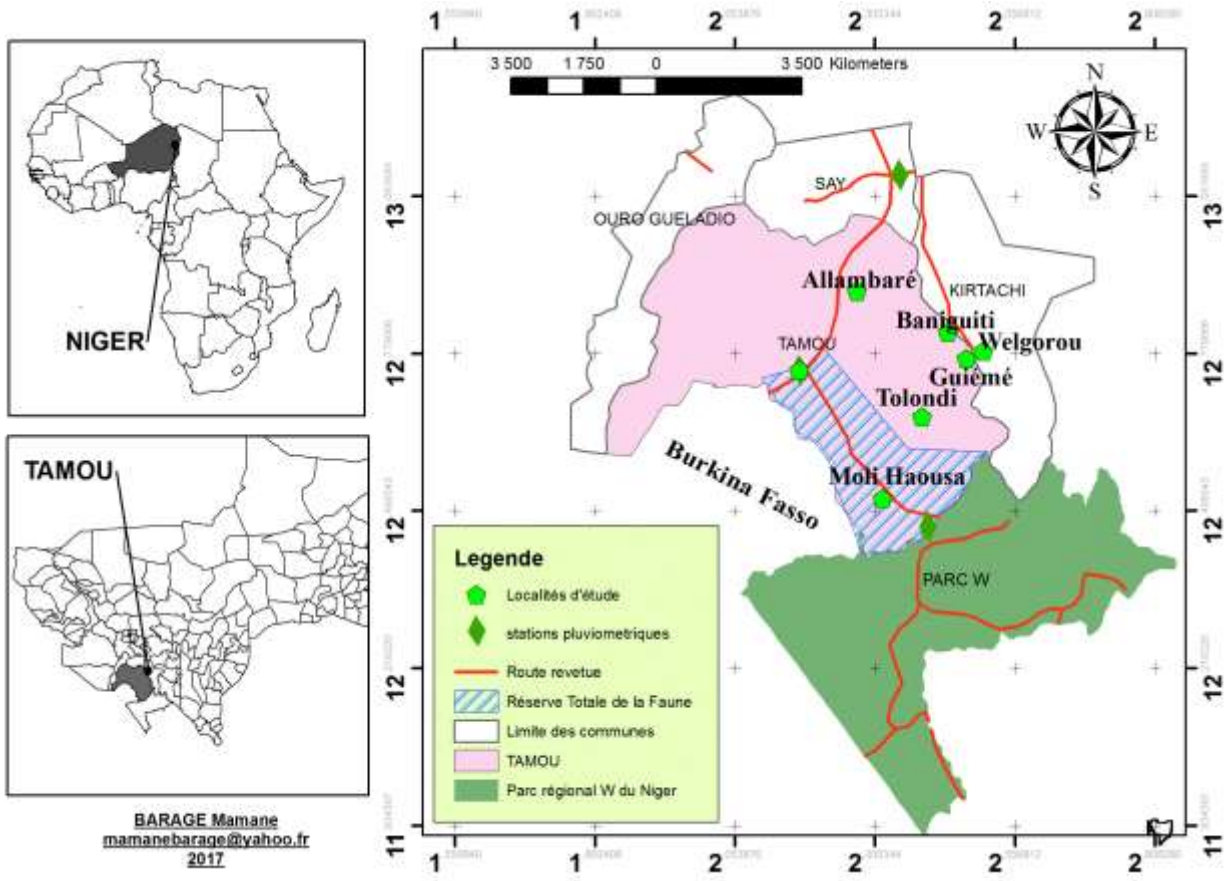

Figure 1. Presentation of the study area.

Table 1. Size of the study sample (field survey source).

Village	Registered farmers	Sample size	Sampling rate (%)
Tamou	158	15	10
Allambaré	148	14	10
Bani Guiti	95	11	10
Guiémé	91	9	10
Tollondi	122	12	10
Molli Haoussa	52	5	10
Welgorou	66	7	10
Total	**732**	**73**	**10**

changes in climate parameters, adaptation strategies, and their determinants. To evaluate data trend, the triangulation of information was done between data from focus groups and individual. For most part, the data from the focus groups made it possible to complete and deepen the data from the individual surveys. The farmers factors questions focused on sex, age, marital status, main and secondary activities, level of education, experience in agriculture, the farm size, mobilized means of production, number of available agricultural assets, average number of employees per day, cultivated area, level of income, and

production of millet.

Data processing

On the basis of the response given, a farmer is considered to perceive climate change if and only if:

(1) He perceived at least one change of at least one climate parameter over the last ten years.
(2) He was able to identify the parameter (s) from which he perceived the change (s); and
(3) He was able to describe the change (s) he perceived.

In doing so, the variable "perception of climate change" was later treated as a dummy dichotomous variable considering the value of 1 if the farmer perceived climate change and the value 0 otherwise. Consequently, a farmer is considered to be adapting to climate change if and only if:

(1) He has adjusted his farming practices in order to adapt his production system to the previous change (s) he would have mentioned; and
(2) He has adopted at least one adaptation strategy. This variable was then treated as a dummy dichotomous variable taking the value of 1 if the farmer applies one of the strategies and the value 0 if otherwise.

Finally, an "external adaptation strategy consolidates the endogenous strategies" if and only if:

(1) The farmer has affirmed that it improves his technical performance of development and / or the diffusion of techniques adapted to the new conditions.
(2) It improves the profit of his activities, the complementarity and contribution in his initiatives
(3) It corrects the negative impacts felt in the conduct of the exploitation, and especially reinforces the profitability of the activities.

The collected data were processed using Microsoft EXCEL spreadsheet and statistical package for social sciences (SPSS) version 20.

RESULTS

Demographic and socio-economic factors of farmers

The demographic and socio-economic factors of farmers are summarized in Table 2. Ninety-six percent (96%) of the respondents are male, and 42% are illiterate. Most of those who have received formal education have a primary school certificate. For 94.3% of respondents, agriculture is the main activity and 5.7% are agro-pastoralists. In addition to agriculture, 49% of the farmers are engaged in a secondary activity between handicrafts, gathering, logging, livestock raising and petty trading. The organization of farmers of the study zone, especially the village development committees, was initiated by the projects and non-governmental organizations (NGOs) working in the area. These village structures promote access to inputs (fertilizers and cowpeas' pesticides), agricultural loans and training provided by extension agents in the locality to about 68% of farmers. Access to land is based on inheritance, purchase and, leasing. Access to land through these modes confers different property rights. For example, 86% of respondents said they own their land. The average number of farm workers per household is 4 and the experience in farming practices ranges from 12 to 60 years (Table 2).

Perception of changes in climatic parameters by farmers

The majority of farmers surveyed in the study area saw changes in climate parameters from 2004 to 2016. These changes mainly concern rainfall (92.6%), temperature (85.2%), wind frequency and duration (88.9%). These parameters are shown in Figure 2A. All farmers who have seen climate change have also experienced changes in rainfall (the decrease in rainfall amounts to 81%, and increasingly random and sporadic rainfall at 81% floods. Farmers then noted the seasonal shift with a tendency to reduce length of the rainy season (88%), a delay in the stabilization of the seasons (86%) and the increase frequency of floods and droughts (77%). These results revealed that rainfall trends affect the Western part of Niger and more specifically Tamou district. Concerning the temperature, 85.2% of respondents perceived thermal variations manifestation by the increament of the hot dry season (96%) or the increase in high temperature waves (88%). In addition, 96% of the farmers surveyed perceived other changes such as stronger winds (93%), dusty winds at the beginning of the raining season likely to cause damage to the seedlings, the eratic frequent strong winds likely to cause severe lodging of cereals during cultivation, etc. In addition, some farmers have noted changes such as the sharp decline of certain woody food plant species (*Parkia biglobosa*, *Adansonia digitata* and *Vitelaria paradoxa*) (Figure 2).

Perception of the causes and impacts of changing climate parameters

Perception of driven factors

According to interviewees, changes in climate parameters are linked to human factors (62%) and natural factors (100% of respondents). These perceptions

Table 2. Demographic and socio-economic factors of farmers.

Qualitative variable		Total	Percentage (%)
Head of household	Man head of household	70	95.90
	Female household head	3	4.10
Marital status	Married	70	95.90
	widow	3	4.10
Level of education of the respondent	Literate	31	42.3
	Koran	15	21.2
	Primary	11	15.4
	Secondary	4	5.8
	Superior	10	13.5
Main mode of access to the land	Heritage	70	95.90
	Leasing	2	2.7
	Purchase	1	1.3
Annual income	50 000 à 100 000	42	57.7
	200 000 à 500 000	31	42.3
Main activities	Agriculture	69	94.3
	Agro pastoralism	4	5.7
Secondary activities	Craft	4	6.1
	Cueillete	6	8.2
	Wood exploitation	3	6.1
	Other (small shops)	58	79.4
Membership in an organization	Membre d'une organisation villageoise	68	93
Contact with a technical office	-	37	50.6

Quantitative variables	Minimum	Maximum	Average	Standard deviation
Age (year)	35	82	52	13
Household size	2	25	12	10
Area exploited (ha)	5	20	7	6
Annual millet production monetary value (thousand FCFA)	20	300	84	68
Experience in agricultural practices (year)	12	60	35	13
Number of farm assets	1	10	4	2

of the causes of changes in climate factors are recorded in Table 3.

Impacts perception of the impacts of changes in climate factors by farmers

Interviewees noted the degradation of soil quality (15%), loss of seedlings (30%), delay in crop growth (92%), production lost (37%) and emergence of new insects pests (14%) as the main immediate impacts of climate change. These different perceptions of farmers about the impacts of changes in climatic factors are shown in Table 4. The impacts of changes in climatic parameters were also seen through the analysis that growers make on their crop fields (Figure 3). For this purpose, they noted

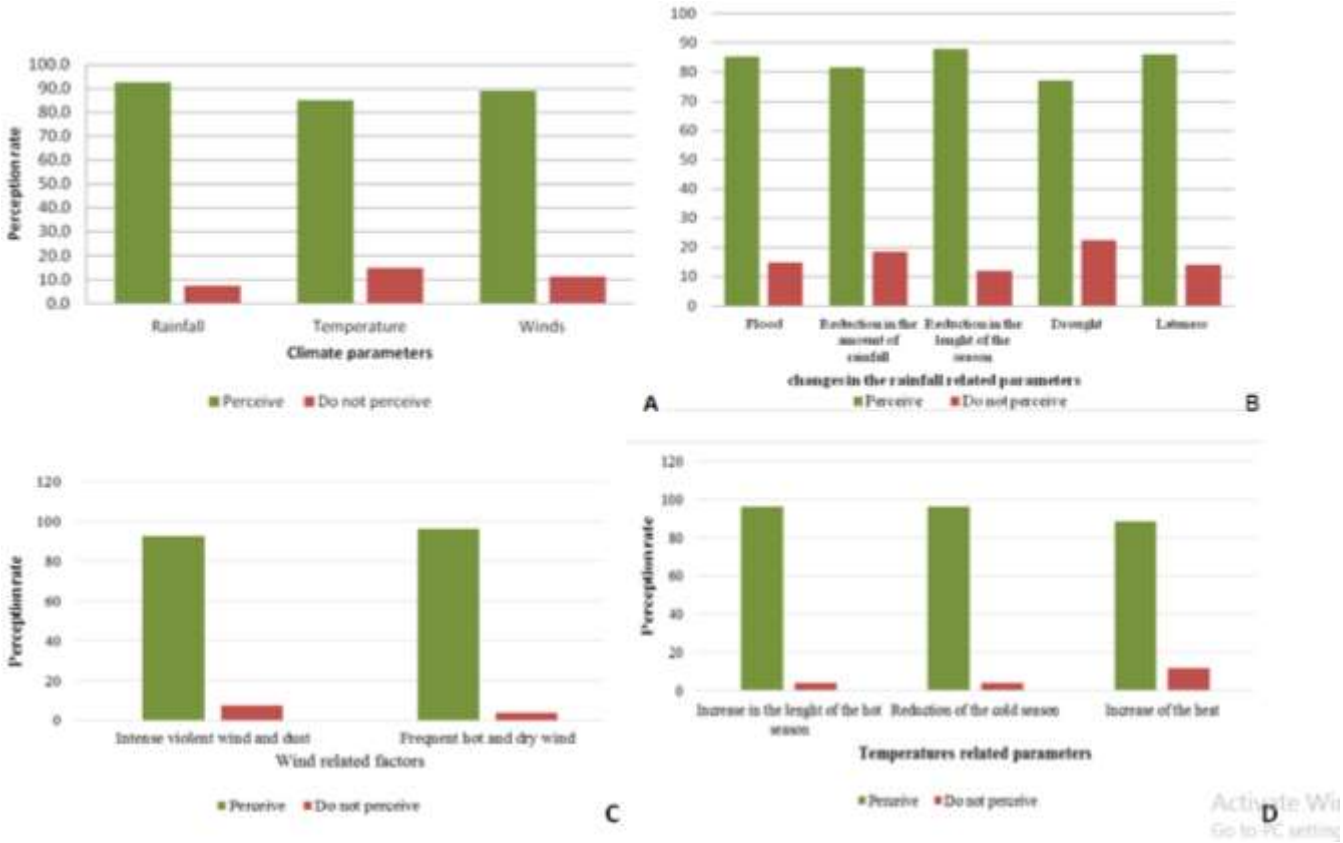

Figure 2. Perception of changes in climatic parameters by millet farmers.
(A) Change of climate parameters; (B) change in rainfall related parameters; (C) Change in wind related parameters; (D) Change in temperature related parameters.
Source: Field survey.

Table 3. Perception of the factors of changes in climateby farmers.

Type of factors	Perception rate (%)	Rate of non perception (%)
Human factors from the perspective of non-compliance with society's standards	62	38
Natural factors (related to climate change)	100	0

Table 4. Perception of the impacts of changes in climate factors by farmers.

Type of effect	Perception rate (%)	Rate of non-perception (%)
Degradation of soil quality	75	15
Loss of seedlings	70	30
Drying of crops (delay in crop growth)	8	92
Occurrence of new insect pests	86	14
Decrease in agricultural production	63	37

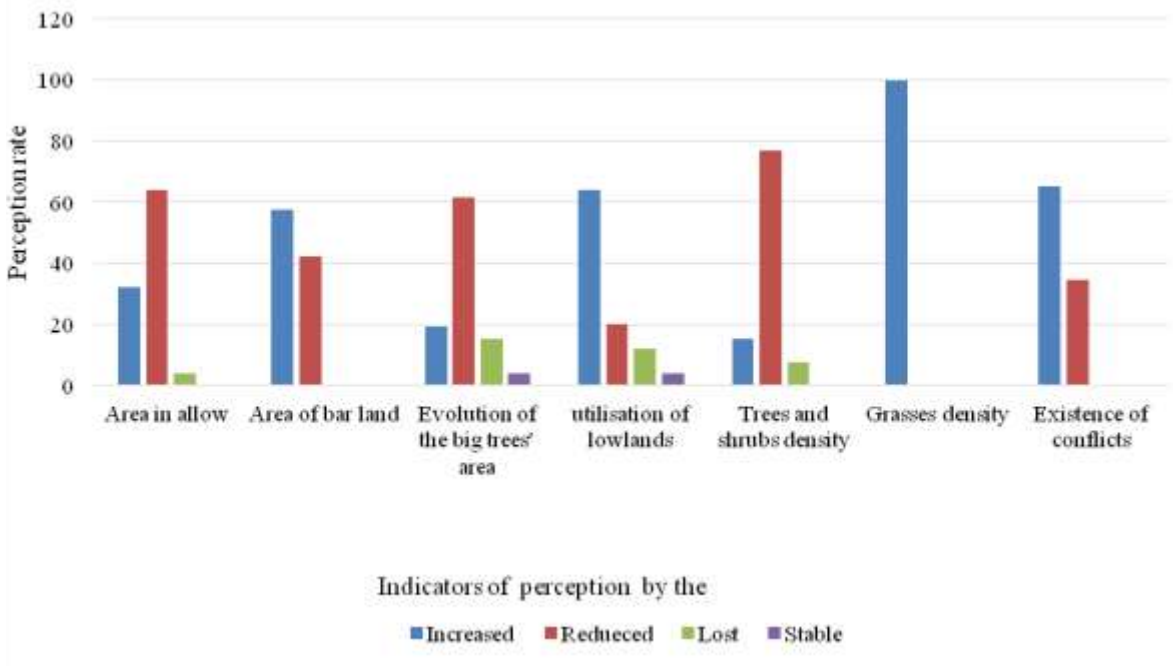

Figure 3. Perception of farmers on certain socio-environmental indicators of climate variability and change in the study area.
Source: Field survey.

the increase of denuded areas in the culture beds (68%), the decrease in the density of ligneous (77%) and herbaceous (68%). Parallel to this more precarious environmental context, 41% of farmers questioned noted the increase in conflicts related to the management of natural resources and the over-exploitation of lowlands in favorable areas (Table 4).

Adaptation to changes in climate parameters by farmers

To address the adverse impacts of climate change, 96% of farmers in rural Tamou district have developed various adaptation strategies, either individually or collectively, based on endogenous knowledge. Individual strategies are grouped into six groups (Figure 4). In fact, the adjustment of the farming calendar, the use of improved seeds, the diversification of crops, the practice of water and soil conservation / soil defense and restoration techniques, especially the Zai by digging small holes of water while placing the excavated sand in a circular arc downstream of the hole so as to capture the rainwater to the benefits of sown plants and the organic and mineral fertilizers are used respectively by 96, 75, 49, 34 and 87% of respondents respectively. Almost all the farmers surveyed (96%) do not migrate; for the minority who migrate, respondents say they give up millet farming and try their chances in big cities like Say, Niamey, Maradi and Cotonou. As for the collective strategies, it is essentially the prayers that are made on great occasion of gatherings such as Friday prayers, marriages and naming ceremonies to implore the mercy of God.

Determinants of farmer's adaptation to changes in climate parameters

The determinants of the different strategies developed by farmers to cope with changes in climate parameters are numerous. Among these factors, being a member of farmers' organization, experience in farming practices, a good level of training, access to technical information, the number of active farmers, the right of ownership and a good annual income are of great importance. In the field of agriculture, 31.4% of farmers benefited from supervision, compared to 68.6%. With regard to livestock farming, 50% of the farmers questioned said they benefit

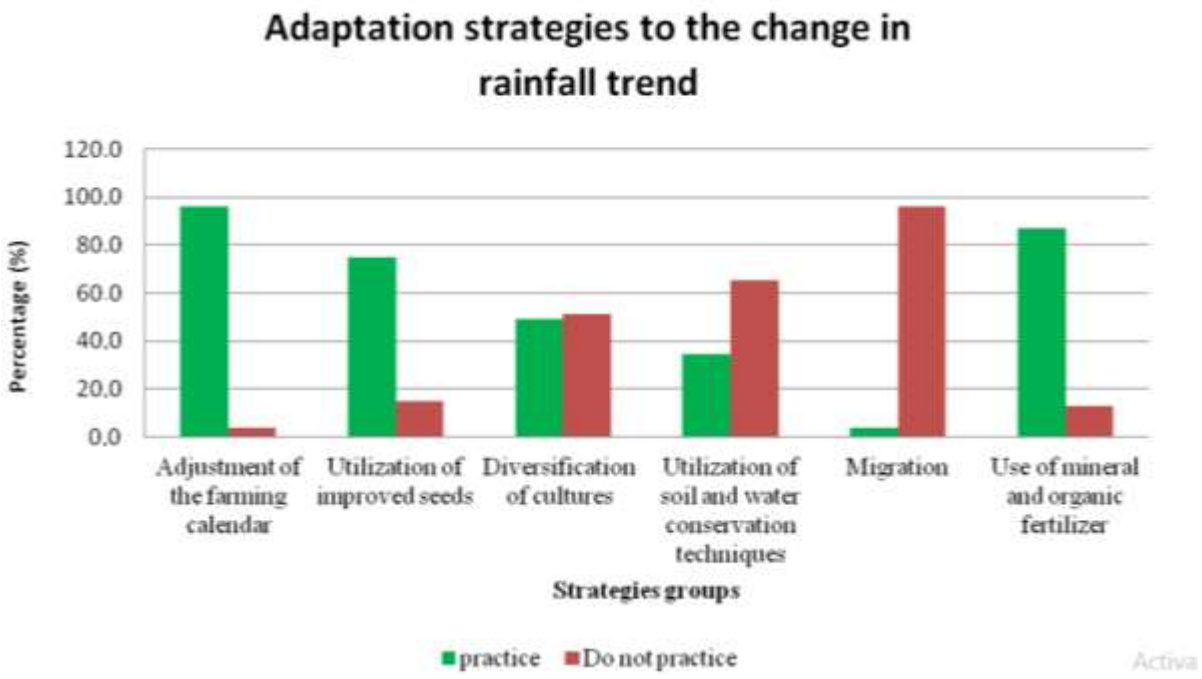

Figure 4. Groups of adaptation strategies developed by farmers.
Source: Field survey.

from the supervision of technical services and development partners operating in the area. As for environmental management, only 22% of the farmers questioned claimed to have benefited from supervision. The different coaching received by farmers were tremendous in the choice of farmers' adaptation strategies to changes in climate parameters are presented in Figure 5.

DISCUSSION

Demographic and socio-economic factors of farmers

In the rural Tamou district, agriculture is the main economic activity of the population (94.3% of farmers). Production is in rainfed crops for some crops and irrigated for others. Apart from agriculture, other secondary activities such as breeding, crafts, logging and gathering are practiced. Concerning the farms of the zone, they have an average size of 12 people, higher than the national average which is of 7 people. The low income of the majority of farmers reflects the level of poverty in which the population is staggering. This poverty is rooted in the poor yield of agricultural activities. In addition, land ownership methods in the area are by inheritance, gift, purchase and loan or lease. Inheritance is the most popular form of tenancy in all types of farms. The small sizes areas cultivated also reflect a land problem that is rooted in the population increment and the massive influx of people from other parts of the country into the area. The age range of the farmers surveyed is between 35 and 82 years old. Three-quarters of the farmers surveyed are over 45 years old. More than 40% are illiterate and the 60% are divided between primary level, Koranic school and literacy classes.

Perception of farmers on changes in climatic parameters

The results obtained by this study revealed that the farmers interviewed in the study area have a real perception of the changes in climate parameters that have occurred in recent years. Firstly, farmers affirmed that rainfall varies from year to another year. The rains start late to stop early with the presence of drought periods. In addition, the rain becomes more and more random, and often in small quantities, though, some intense storms may cause floods. They also noted that

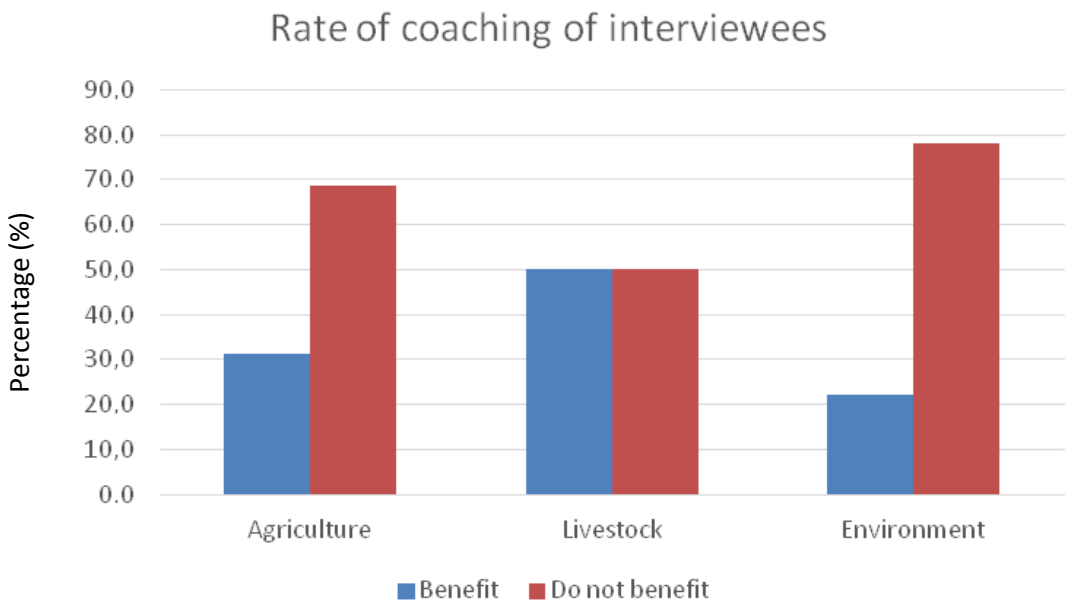

Figure 5. Management rate of millet farmers.
Source: Field survey.

the general trend of the rainy season period shows a reduction. Thus, rainfall disturbances affect the rural Tamou district which often has an impacts on agricultural production. Secondly, the farmers pointed out that the temperatures are rising and that is causing an increase of the heat which finds its sources in the changes of the extremes of temperatures characterized by long warm periods. On the other hand, the reduction of the duration of the cold period was also noted. Finally, farmers perceive warmer, drier, more violent winds, accompanied by dust and deflation, which represents a serious problem in the growth of the first seedling. The results of this study confirms those of Djenontin (2010) and Dedjan (2010), who observed in Northern part Benin republic that local people perceived climate change in their environment through the delay in the start of rainfall, drought spelts during the rainy season, poor spatial distribution of rainfall, strong winds, and excessive heat. These results are also in line with those obtained by the AGRHYMET Regional Center (2012), Lona (2011) and CNEDD (2009) in central Niger and those of Gnanglé et al. (2011) in Benin, Yegbemey et al. (2014) and Doumbia et al. (2013). The results of this study confirmed those of Gado (2012) and Oumarou et al. (2016), who observed in central Niger that local people perceived climate change in their environment through violent storms, irregular rainfall, recurrate droughts, disruption in the duration of the different seasons of the year, sowing periods, gradual disappearance of biodiversity, decrease in crops yields and the modification of the grasses. The results also corroborated those of Maddison (2007) and Mertz et al. (2009), which reveal that people are aware of climate variability and identify wind, lack and excessive rainfall as the most noticeable factors.

Causes of changes in climate parameters

From the perception of the people who were questioned, the perceived climate changes seem to be attributed either to divine causes that is to say natural, or to upheavals of social norms. The issue of population growth and pressure on the environment is never indexed as such. However, this could have an important role since the investigations showed that the population of the rural Tamou district has as main activities like agriculture, the livestock, and the wood exploitation. In addition, according to INS (2014), this population is estimated at 89,782 inhabitants, out of which 51.16% are men and 48.84% are women, whereas it was formerly only 33,788 inhabitants (RENACOM, 2004). The rainfall varies over 30 years (1980 to 2010) between 1200 mm and 600 mm with an average of 710.5 mm. These different causes have already been highlighted by AGRHYMET (2012),

CNEDD (2009) and Oumarou et al. (2016).

Impacts of climate change

The impacts of climate change are also perceived by the farmers interviewed. They are expressed by lower soil quality. This decline in fertility could be explained by erosion and nutrient removal through continuous cultivation over years without input from the farmers. The lost of seedlings could be associated with rainfall scarcity, the deflation, the silting and the heat. The lost of production and the delay in crop growth could be caused by insufficient rainfall, decline in soil fertility, insects, wind, and heat. This findings corroborates the results of AGRHYMET (2012) and AMOUKOU (2011) in other growing areas in Niger.

Adaptation of farmers to changes in climate parameters

Facing the real threat posed by changes in climate parameters, the farmers interviewed developed a variety of strategies, some of which fall within the framework of prevention, others of mitigation or management of the impacts of climate disturbances.

The objective of the strategies for crop diversification and adjustment of the farming calendar (the use of short period varieties) is to reduce the length of the cropping period. In fact, by reducing the time of crops development so as to align with the period of the highest frequency of rainfall, these strategies could help in minimizing the risk of significant drougth occurrence in the area. The most used techniques of soils and water conservation techniques are Zaï and half-moons with the aim of increasing the cropping area superficies and mostly the farms yield. Thanks to development projects carried out by the government and its partners most of these strategies have been introduced in the area.

In the sector of rural development including agriculture, environmental management, and livestock breeding, the farmers affirmed that, agents of decentralized services, non-governmental organizations (NGOs), and projects, have successessfully triggered a dynamic of sustainable self-management of the natural resources of their lands. The perceptible impacts of this supervision are the reduction of certain harmful activities such as clearing of new farmlands, the excessive cutting of wood, the picking of certain of woody food species, etc.

In addition, the new activities practiced relate to the practice of assisted natural regeneration, market gardening and prayers which are customary practices that well characterize African societies. These findings confirm the results of Gnanglé et al. () in Benin, Doumbia et al. (2013), Amoukou (2009), Yegbemey et al. (2014) and Oumarou et al. (2016). Farmers developing no adaptation strategy mentioned, among other things, the lack of information on adaptation strategies and financial constraints as the main barriers to adaptation. These results are corroborated by the observations of Deressa et al. (2009).

Determinants of producer adaptation to changes in climate parameters

According to the results obtained at the scale of the rural Tamou district, several factors influence millet farmers in the perception of changes in climate parameters and adaptation strategies developed. Indeed, some are specific to farmers and others are favored by the environment. This diversity may be related to a specific context of the farmer or its particular factors.

It is in order of importance agricultural practices experience coaching of the extension agents, the number of agricultural assets per household, property rights and a good annual income. This result shows that the most experienced farmers perceive climate change faster and adapt more quickly. Indeed, the number of years spent in the practices of agricultural activity allows the producer to master the entire production process and the factors that influence the various stages of this process. These results confirmed the results obtained by Maddison (2007), Derressa et al. (2009), Gbetibouo (2009) and Oumarou et al. (2016) who came to the conclusion that experience in agriculture is a key determinant of the farmer's level of perception and adaptation to climate change. It should also be noted that the experience increases the farmer's ability to diversify crops, adjust the farming calendar and use more effective land use and management techniques to address climate change.

Through farmers' organizations, farmers are enlightened on the current climate variability as well as the present and future consequences on agricultural activities and the environment. They build relationships among themselves that serve as channels for sharing experiences that can trigger climate change adaptation initiatives. This result also shows that the contact between the farmer and the extension agent seems to be more beneficial, because the farmer obtains from the latter information on the evolution of the climate, the innovative agricultural techniques in progress and technical advice so as to facilitate adaptation to changes in climate factors. For example, sowing periods are widely discussed with extension agents. The importance of extension in the

perception and adaptation of farmers to climate change had been already highlighted in the work of Maddison (2007), Gbetibouo (2009) and Deressa et al. (2011). Other studies such as those conducted by Oumarou et al. (2015) and Yegbemey et al. (2014) have also shown that extension is an important motivating factor in the use of best practices for sustainable management of the environment.

Conclusion

Millet farmers in the rural Tamou district perceive the change in climate parameters (rainfall, temperature and wind) and develop various strategies to adapt to them. For these farmers, climate change is reflected in rainfall and temperature disruptions, high winds, and the lost of some species of trees and animals species. The causes of these changes are human and natural. The impacts of changes in climate parameters are dominated by a decrease in soil fertility, lost of seedlings, delay in crop growth and lost of production. The main adaptation strategies developed as a response to the change in climate parameters are crop diversification, the adjustment of cropping practices and the farming calendar. The main factors favoring the use of adaptation strategies are supervision of extension agents, the number of farm workers per household, property rights, experience in farming practices and a good annual income. In addition, the various adaptation strategies developed by farmers and their determinants, such as holding regular public awareness, training, exchange and knowledge-sharing sessions on future climate conditions and adaptation to climate change could constitute potential tools which could be used by all stakeholders and directed towards the farmers' organizations of through the extension services. These findings would be taken into account by the government, researchers and policy/decision makers in the development of agricultural policies in general and millet production in particular.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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