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WHEN BAOBAB FLOWERS AND RAINMAKERS DEFINE THE SEASON: FARMERS' PERCEPTIONS AND ADAPTATION STRATEGIES TO CLIMATE CHANGE IN WEST AFRICA

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ABSTRACT: Climate change is affecting the livelihoods of rural African populations. In fact, farmers, whose livelihoods depend on agriculture, are likely to bear the brunt of climate change impacts. The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change. The aim of this paper is to assess Beninese farmers' perceptions on climate and adaptation strategies for information and knowledge that may guide decision making and draw the attention on the need to integrate local knowledge in climate adaptation. Focus group discussions and semi-structured interviews were organized with 51 farmers representing diverse farming experiences and farmland positions. In order to make the link between farmers' perception on the seasons prediction regarding to plant observation, we identified and observed phenology phases of five Baobab and five cashew plants based on their geographical distribution in the study area. Collected data were analyzed by using the agricultural adaptation and perception model and the dynamic system of knowledge, perception and adaptation. The study shows that farmers have different perceptions of climate change, but at the same time are almost unanimous about the changing of rainfall frequency, which is described as "rain seasons start late and end early". The study revealed that the Baobab plants flowering phase seems to coincide with the rainy season and confirmed farmers' knowledge about good rainy season detecting. The article further lays out that farmers have developed a range of adaptation strategies, which are situated within the three distinguished spaces; the space of agricultural practices, the space of livelihood diversification, and the space of local culture and learning. The study suggests that understanding farmer's perceptions and practices and using them as a starting point for adaptation to climate change could help policy makers to formulate sustainable adaptation strategies.
Key words: adaptation strategies; climate change; farmers' perception; rainfall prediction

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INTRODUCTION

There is a lively debate about the causes of climate change and the scientific consensus on it. Different studies demonstrated that the scientific consensus is that climate change is caused by anthropogenic factors [1, 2, 3, 4, 5]. The much-cited recent study conducted by Cook et al. [2] found that 97% of the climate change scientists endorse the anthropogenic climate change consensus. Although others (among them [6,7]) questioned the quality of the data, the validity of the methods and the vagueness of the conclusions in the research conducted by Cook et al., the majority of the climate change scientists seems to agree that "human activities have warmed the planet to some unspecified extent"[6]. Whatever the exact extent is, and whatever the scientific consensus is actually about, the scientific views are not shared by everybody outside the scientific community. Farmers and scientists can express different perceptions on climate change. This paper addresses local farmers' perceptions on climate change and views on climate change that are embedded in local knowledge. It does not argue against the understandings of scientists, but wants to provide insights in how farmers living within specific cultural localities construct their own perceptions based on local knowledge and choose their own adaptation strategies accordingly.
Africa is one of the most vulnerable regions to climate change in the world due to the fact that continent economies and livelihoods are highly dependent on natural resources and rain-fed agriculture [8, 9].
IPCC [8], opinions that agricultural production and food security are severely compromised by climate change in many African countries. Several studies on climate have also showed that the temperature and the number of hot days have increased in Africa and farmers perceived decrease in rainfall and noticed delayed of rainfall and its early cessation [10, 11]. The adequate solution for African farmers seems to be adaptation, which is identified as one of the policy options to reduce the negative impact of climate change [12]. Adaptation is widely recognized as a fundamental component of any policy response to climate change. For adaptation to happen appropriately an understanding of farmers' perception is required. Documenting local perceptions of climate change is considered important from a policy point of view, since farmers' perceptions reflect community concerns [13] and focus on the actual impacts of climate change on people's lives [14].
Among adaptations, reported in literature planting different varieties of the same crop and changing dates of planting are important in Africa [15, 16]. Furthermore, due to the high importance of farmers to adapt to climate change, many agricultural adaptation options have been also suggested. They include a wide range of scales, stakeholders and strategies such as micro-level options, market responses, and institutional changes. Technological innovations like the development and promotion of new varieties of crops and advances in water management techniques have also been suggested [17]. Most of these options represent potential adaptation measures, but there is no evidence that these adaptation options are feasible, realistic, or even likely to occur. Adaptation to climate change is not only a function of technical solution since farmers' knowledge is recognized as valuable assets for building the resilience of rural livelihoods to climate change [18].

The drive of this study is to assess farmers' perceptions on climate and adaptation strategies for information and knowledge that may guide decision making and draw the attention on the need to integrate local knowledge in climate prediction.

Taking the above into account, this article addresses the following questions:

(1) How do farmers perceive climate change?
(2) What are the adaptations' strategies developed by farmers to deal with climate change?
(3) Where do farmers focus on in making decisions about climate change adaptation?

After introducing the conceptual framework that informs the research, we will discuss the method of data collection. The empirical data were collected in Savalou municipality of Benin Republic. The findings are then presented following the line of thinking as outlined in the conceptual framework and will be structured within different spaces with potential for climate change adaptation. Moreover, several aspects of farmers' decision-making process will be addressed. The paper closes with a discussion and a conclusion.

CONCEPTUAL FRAMEWORK

Bringing together the three concepts of perception, knowledge and adaptation in relation to climate change has been on the agenda for a while (see for instance [19,20,21,22,23,24,25,26,27,28,29,30]). Our work relates to these studies. We will first clarify our way of defining the central concepts and then look at the specific relationship between them. The theoretical framework will be constructed by forming a conceptual triangle of perception, knowledge and adaptation. We build here on the Agricultural Adaptation and Perception (AAP) model [22].
Farmers need to perceive that the climate is altering before they can adapt to it. Perceptions by farmers are therefore seen as the starting point of adaptation.

People's perceptions of the world depend on their environment through a complex network of mental answers learned and preserved by collective factors like cultural codes, beliefs, languages, religion, values etc. and more individual factors such as emotion, self-esteem, personal experiences, theoretical knowledge, intuition, prejudice etc. [31]. The connection between these elements determines the way people internalize new situations. In line with Leeuwis [32] and Van Aalst et al. [33] we consider farmers' perceptions as interpretations of observations in connection to existing knowledge. Perceptions are dynamic and differ according to the quality of the observations that are made and the amount and quality of the existing knowledge. Therefore, farmers' perceptions are important in efforts to understand climate impacts and in developing and implementing strategies to adapt.

Taking account of farmers' knowledge in climate change adaptation receives great attention from social scientists since this knowledge complements the analysis of climate change by providing data from different spatial scale [34]. For example, in Burkina-Faso, local rainfall forecasts rely on observation and interpretation of some trees, animals, and sky before starting farming activities [35]. Maddison [26] showed in a study carried out in Ghana, Burkina and Niger, that some farmers use to detect seasons based on plant phenological observations. Thus, the phenological phases reflect the characteristics of the climate. Farmers' knowledge on phenological plant and others can therefore provide important insights into processes of detecting rainfall season. Terdoo and Adekola [30] state that in the context of African rural communities, knowledge and perceptions of climate change are critical for at least three reasons: (1) the majority of the people is uneducated and at the same time agriculture is currently the world's main cause of climate change, alone accounting for nearly 25% of global emissions [36], (2) most people fingered as the cause of climate change are most vulnerable and are often too poor to adapt, and, (3) many African governments acknowledge that farmers are very knowledgeable in regard to climate change issues. A significant body of literature exists relating to farmers' knowledge in predicting the climate in Africa. However, there are still deficits of information and knowledge on how plants phenology, rainmakers and others specifics in Benin (West Africa) define the season as adaptation strategies to climate change. Farmers' knowledge as it forms a whole with observations, interpretations and perceptions is thus a central concept in our research.

Positioning the concept of adaptation, includes reviewing adaptive capacity, potential and strategies. Doss and Morris [37] found that the way indigenous people think and behave in relation to climate condition, as well as their values and aspirations have a significant role to play in adapting to climate change. Adger et al. [38] argue that farmers' decisions to adapt to climate change or not is not simplistic because it depends on climatic stimuli as well as on other issues, such as their personal, economic and political motivations. People's various capacities are central to their adaptive potentials and thus to the strategies they implement and the activities they employ. As emphasized by Smit and Skinner [17], adaptation is a complex societal process of activities, actions, decisions and attitudes that reflect existing social norms and processes. But in all cases "perception is a necessary prerequisite for adaptation" [26]. The perceptions of the effects of the chosen adaption strategy and actions can again in combination with the gained knowledge lead to adjusting the actions. This transforms the triangle of perception, knowledge and adaptation into a dynamic system in which new observations lead to new knowledge and new actions.

The AAP model centralizes the adaptive potentials and obstacles as they relate to farmers' climate change perceptions and responses. The following four dimensions are distinguished in the model: (1) non-climatic determinants of vulnerability; (2) general trends in livelihood strategies; (3) perception of climatic trends, and; (4) climate impacts in agriculture. The model uses these dimensions to capture the fifth dimension of potentials and obstacles for adaptation. We build on this model and address all five dimensions, but we do not address all dimensions in an equal way. We specifically focus on perceptions of farmers in interaction with knowledge and investigate their combined influence on adaptive potentials. The dynamic system of perception, knowledge and adaptation recognizes that adaptation is based on perception and knowledge, and thus assumes that the potential for adaptation is based on the existing adaptive capacity, which then again informs the choice of adaptation strategies.

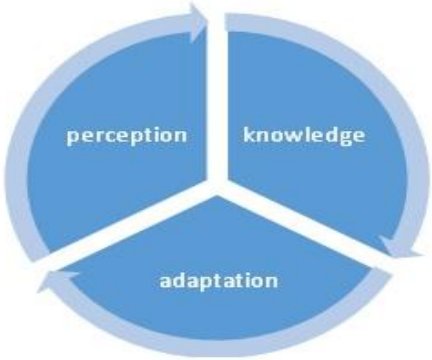

Fig. 1 Climate change: The dynamic system of perception, knowledge and adaptation

METHODS

The study was conducted in Savalou municipality of Benin Republic (7°35 to 8°13 N; 1°30 to 2°6 E), which is located in the Guinea zone and is characterized by moist woodland and savannas [39]. The climate is a climate of transition between the subequatorial bimodal climate and the Sudan-Guinean climate. The long rainy season starts normally in March and finishes in July and the short rainy season occurs from September to November. Rains are uncertain depending on the year and the region can suffer from flood or drought. In Benin, the major production activity is rain-fed agriculture, meaning highly dependent on climate conditions and employs approximately 80% of the population and provides about 70% of export incomes and 40% of the Gross Domestic Product [40]. The study area is one of the largest agricultural production zones in the country and belongs to the agro ecological area n°5 that is one of the most affected areas by climate variation and change [41]. It is also a transition area in terms of rainfall uncertainties between the southern and northern part in the country. Monthly precipitation and temperature data of the study area were obtained from the Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar in Benin and presented in the Figures 2 and 3.

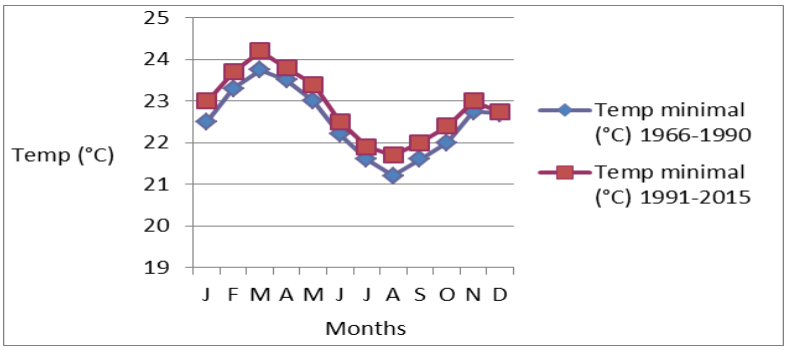

Fig. 2 Rhythm of minimal temperatures during periods 1966-1990 and 1991-2015

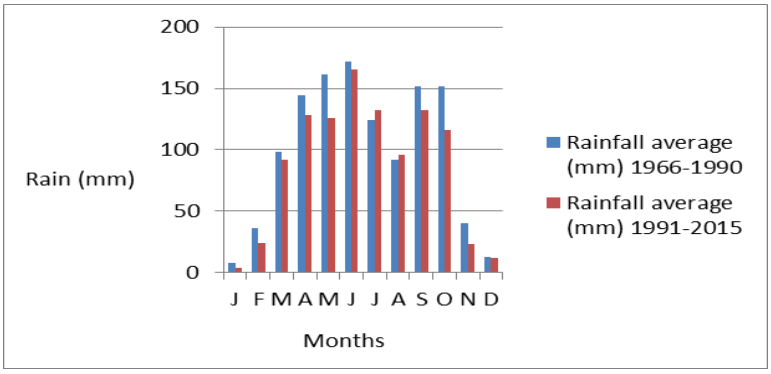

Fig. 3 Rhythm of average rainfall during period 1966-1990 and 1991-2015

During the research we organised focus group discussions and semi-structured interviews with 51 farmers representing diverse farming experiences and farmland positions (Table 1). Farmers' selection based on their experiences is justified by previous studies, which revealed that farmers' perceptions of climate change are dependent on years spent in farming activities [42, 43]. Alessa et al. [44] reported that older people had a tendency to report more change than younger people. Farmers' selection also took into account the farming altitude and gradient since farmers are differentially affected by climate depending on the location of their fields [45]. In this study slope plot is defined as a stretch of ground forming a natural incline or any farmland whose surface forms an angle with the plane of the horizon.

Table 1. Characteristics of participating farmers

Farmland position	Focus group discussion based on farming experiences		Household interviews (10+ years of farming experiences)	Total
	10 -19 years	20+years		
Sloping plot	4	5	15	24
Bottom of slope	4	5	18	27
Total	8	10	33	51

The focus group discussions and the interviews were complemented with observations as the first author joined some farmers in their daily activities. The initial results were presented and discussed with farmers involved, community leaders and rural service delivery staff members.

During the research, we also observing some plants phenology phases in line with Lieth and Radford [46] who showed that plants phonological phases such as leaves or flowers bloom etc. represent a response to a particular set of climate condition. Therefore, in order to make the link between farmers' perception on the seasons prediction regarding to plant observation, we identified and observed phenology phases of five Baobab and five cashew plants based on their geographical distribution in the study area.

RESULTS

Building on the AAP model and the dynamic system of knowledge, perception and adaptation we will first discuss the perceptions of farmers that we found and then discuss the adaptive potentials and actual strategies as outcomes of the research. Based on the perceptions that were found in the research (the first part of the results), the following spaces with potential for adaptation were identified (the second part of the results):

1. The space of agricultural practices. This space incorporates the various agricultural practices that can be used to respond to climate change. It includes for instance changes in cropping systems and crop rotation.
2. The space of livelihood strategies. This space incorporates the various activities farmers can potentially choose from to generate income and secure basic necessities. It includes non-farm as well as farm activities.
3. The space of local culture and learning. This space consists of locality-based local cultural specifics. Learning is seen as an important instrument to maintain, share and update local, culturally specific knowledge.

This categorisation of adaptive potentials follows on from the empirically observed perceptions in combination with existing (local) knowledge and will be used to capture the results of the actual adaptation strategies that the farmers implement. With identifying these Spaces of Adaptive Potential (SoAP) we build upon spaces of change [47] and Spaces of Intercultural Communication (SoIC) and Spaces of Intercultural Learning (SoIL) [48,49]. The findings section ends with reviewing some aspects of farmers' decision making processes regarding adaptation strategies.

Farmers' perceptions of climate change

Perceptions of climate change

Farmers have different perceptions of climate change, but they were almost unanimous on the changing of rainfall frequency, which is described as "*rain seasons start late and end early*". The damage to crop and decline of yield is also identified. The growth and development of plants is mentioned as "*strongly disturbed*" during these last years and the land no longer supports good production. Impacts of climate change perceived pertained to agricultural production and most of the farmers complained about difficulties to plan agricultural activities ahead of time due to frequent variability of climate during the latest years. Decrease and unequal distribution of precipitation were reported and farmers explained this perception by the way they observed the rainy season in their environment. These changes in rainfall are often manifested by more precipitation in certain locations and much less or not all in other places. This phenomenon is becoming very frequent and raises a lot of worries among farmers. Temperatures also became increasingly higher, and farmers indicate, *"Even under trees the heat is unbearable*". The fading of the crop plants in the fields is shown as the consequence of strong and persistent heat during the cropping season. For farmers, cloudy times dropped with the detriment of very sunny times. "*We could work under the sun before, but now it is not possible any more*" is one of the remarks farmers made to explain the increase in temperature.

Farmers reported changes in frequency of drought, field flooding and field erosion. Farmers' explanation about changes in drought frequency was linked to the serious delay of the rainy season that they observed in the last years. After a long time of delay, the rainy season starts with a high intensity of rainfall leading to erosion and flood of field, but this period of rain is often very short with a lot of damage to the crops. Furthermore, all respondents highlighted that 5 years ago there was a terrible flood, which gravely affected farmers' livelihood and created a lot of homeless people in the community. This situation was confirmed during the validation meeting. Before the onset of the rains and before starting of the cropping season, it was noticeable that the weather became a growing concern in the community. The delayed start of the rainy season was a good entry point to discuss climate issues. In general farmers did not complain about the amount of rainfall, rather they complained about the timing of the rains. According to farmers, their area has medium rainfall because the rains in a normal year are sufficient to assure them of a good harvest. However, they felt that the yield could increase if there would be more rainfall with less wind.

Farmers use local names to describe the rains in relation to the cropping season: *Zofinkplodji*, *Houésin*, *Gbojadji* and *Nugblédji*. Most of climate change impacts perceived by farmers are related to agricultural production, which leads to deep uncertainties and food insecurity. However, farmers also highlighted the issue of community cohesiveness as a result of theft increase; reduction in education, wellbeing and development, social and economic impacts, which affect community livelihood. Social transformations like rural youth depopulation were mainly reported by respondents that we could call 'young people' because of their relatively short length of experiences in farming activities. Faced by climate uncertainties, young farmers feel discouraged to engage in farming activities in which they are not sure to earn a living. Most of them decide to leave the community to look for a job. Some respondents mentioned an increase of theft of household properties as a final result of climate change or as a direct result of poverty of affected farmers. During the focus group discussions, theft as an impact was not recorded because of its sensitive nature. However, 21% of the farmers with at least 20 years of farming experiences highlighted it, and it was confirmed in 43% of the household interviews while only 8% of the 'young'-category mentioned it (10-19 years of farming experience). Household surveys reported that some lazy farmers gave up completely on farming activities due to climate uncertainties and started to steal.

Climate change impacts on the human capital of the households are considerable. During informal discussions, certain farmers confirmed they had removed at least one child from school during these last five years for financial reasons. An increase in rural poverty was also perceived as a result of climate variability and change impact. Farmers recognized their income depends mainly on agricultural production, which is affected by climate risks. Table 2 gives an overview of the perceptions of the impact of climate change in this study.

Table 2. Perception of impact of climate change

Perceived Impacts	Focus group discussion based on farming experiences		Households interviews (n=33)
	10-19 years (n=8)	+ 20 years (n=10)	
Rainy seasons start late and end early	100	90	94
Damage to crop/ decline of yield	87.5	100	100
Decrease and unequal distribution of precipitation	87.5	100	97
Rural youth depopulation	87.5	80	72.7
Increase of poverty	75	60	63.6
Increase in temperature	75	80	84.8
Change in drought frequency	62.5	70	75.8
Field flooding	62.5	60	45.5
Field erosion	50	40	15.2
Increase of precipitation	12.5	0	0
Increase of theft	12.5	20	42.4
No change in precipitation	0	0	0
Decrease in temperature	0	0	0
No change in temperature	0	0	0

Perceptions of causes of climate change

Farmers have varied perceptions of the causes of climate change as shown in Table 3.

Table 3. Perceptions of causes of climate change

Perceptions of causes	% of respondents based on farmland position	
	sloping plot (n=24)	bottom of slope (n=27)
Lack of respect of divinities and social norms	45.8	48.2
Don't know	33.3	40.7
Deforestation	20.8	11.1
Total	100	100

Lack of respect of divinities and social norms by community members was perceived to be the main cause of climate change. Indeed, the municipality of Savalou is a zone where beliefs are very strong and people associate climate change with a work of God. Farmers thought that climate change is the divine punishment and the manifestations of the prophesied end of the world. Thus, instabilities in rainfall would be the consequence of the lack of respect for divine laws while rainfall stability would be a standardization of the bonds, which binds humans to God. Other farmers made a link between the climate change and the lack of respect for social norms.

This is also perceived as a disobedience to the divinities. It is strongly perceived that the divinities guarantee a good cropping season. Farmers who have their field at the bottom of slope mainly mentioned lack of respect of divinities and social norms. Another cause of climate issues that came out of the focus groups is the bad faith of certain men who claim to be rainmakers. These 'lords of the rain', according to a popular name, would have control of the space-time distribution of the rain throughout the seasons. Satisfaction of the requirements (financial and/or material) of these rainmakers is supposed to impact on the cropping season quality.

Concerning access to information, 40.7% of the respondents who have their field at bottom of slope stated that they do not have any information about climate change causes. This answer was also given by 33.3% of the respondents who have their field on the slope. Deforestation was also mentioned as one of the causes. Among the category of farmers who reported deforestation as cause, 20.8% and 11.1% respectively had their fields on the slope and at the bottom of slope.

Spaces of adaptive potential

The main adaptation strategies to climate change can be situated within the three distinguished spaces; the space of agricultural practices, the space of livelihood diversification, and the space of local culture and learning. Within these three spaces, this section presents the main adaptation strategies that were found. These strategies are in line with the overview that is provided by Table 4.

The space of agricultural practices: Crop calendars, crop rotation and re-planting

Changing the crop calendar and crop rotation are adaptation strategies reported by 40.8% and 37.5% of the farmers who have their fields at the bottom of slope and on the top of slope respectively, while the rest of the farmers in both categories focused on six other types of adaptation strategies. According to farmers, they have changed the crop calendar and started sowing from the second decade of April whereas previously, it was done at the end of March. Indeed, the farmers who started sowing from April would have a strong probability of a good yield contrary to those who sowed very early. Changing of crop rotation is also one of the local innovations to deal with changing climate patterns. This change of crop rotation appeared after the introduction of soya and rice into the farming system and the abandonment of other crops. So, the rotations of maize –beans, maize-groundnut, etc., gave way to other types of rotation such as maize-soya. With the previous rotation, there was a relay culture between the maize and cotton: maize planted at the beginning of season and cotton interspersed in the maize before its harvest. But currently, each speculation (maize, cotton etc.) has its own plot due to the shortness of the rain.

During the focus group discussions, some farmers, especially the older persons or ones with longer experience reported that they have changed their planting decisions, which were based on improved hybrid seed for greater productivity advised by extension workers to focus on endogenous varieties of crop. They recognize that local varieties of crop are less productive, but are more resistant to climate variability and change. As stated by one of the farmers:

> *"for me, the change of climate that we observe nowadays and that affects our livelihood is a great thing to come from God to save the heritage left by our ancestors. To survive, we have to go back and be aware of our own reality and take care of our local seeds and crops which are becoming extinct".*

Farmers become used to plant the same crop on different fields and re-sowing as strategy of adaptation to climate change by hoping that the rain rhythm is going to correspond to the phases of growth of at least one culture with regard to its land and planting date. This strategy of adaptation was the second ranked local innovation reported by 20.8% of farmers who have their field on the slope. At the same time this practice constituted the fourth local innovation mentioned by 14.8% of farmers who have their field on the bottom of slope.

The space of livelihood strategies: Diversification and migration

Livelihood diversification is one of the adaptive strategies focussing on non-farm activities that are not dependent on climate conditions such as setting up small businesses. These activities are carried out more by men. As far as women are concerned, they pointed to the need to create value added products and the desire to engage in cassava processing because no matter what the variability of rainfall is during a season, cassava trees survive. However, they highlighted the need for equipment and capital. Crushing of the stones and hills was also mentioned as livelihood diversification activities being carried out, especially by women.

Due to climate uncertainties and its impacts on farmers' livelihoods, which lead to lack of daily food and the money to buy it, farmers began to migrate. Thus, farmer migration, especially by young people to the surrounding towns by looking for jobs, has become popular. They are involved in various income generating activities like motorcycle taxi services, petrol selling on the roads, security guard activities etc. Some of these young people return to the village sick because of the living conditions during the migration periods. Livelihood diversification activities and migration as practices of adaptation to climate change were reported by 20.3% of the farmers who have their field on the slope and 18.5% of the farmers who have their field at the bottom of slope.

The space of local culture and learning: Ritual offerings, prayer, weather forecasting and social learning

Ritual offerings and prayers are part of farmers' local answers towards climate change adaptation since farmers reported lack of respect for divinities and social norms as the main causes of climate change. Under the responsibility of rainmakers, farmers are offering sacrifices to ancestral spirits and to "*vodoun Xêbiosso*" (God of thunder and harvest who controls the rain). For the older, ancestral ceremonies are a time to discuss serious rainfall issues, which affects both individuals and the community at large. Farmers who are not involved in the traditional religion also organize prayers imploring God's forgiveness in the different churches. Ritual offering and prayer is an adaptation strategy reported by 16.2% and fourth in ranking of farmers whose field is on the slope. This practice ranked second by 18.5% of respondents whose field is at bottom of slope.

Table 4. Adaptation strategies

Adaptation strategies	Adaptation strategies based on farmland position (%)	
	Field on slope (n=24)	Field at the bottom of slope (n=27)
Change the crop calendar to take into account the rainfall changes and crop rotation	37.5	40.8
Planting same crop on different land , and re-planting	20.8	14.8
Livelihood diversification (development of non -farm activities)	20.3	18.5
Ritual offerings and prayer	16.2	18.5
Rainfall prediction	4.17	3.7
No adaptation	0	3.7

Farmers have several ways of reading the signs, or indicators, of a good cropping year (Table 5). Several local culture based ways of forecasting were mentioned by farmers. Understanding the indicators, or signs, was often considered by the less experienced farmers without this knowledge as an endogenous practice known and practiced by the old and wise. The farmers identified as "local forecasters" who use the signs as rain predictors are often the rainmakers. They recognize that sometimes the signs give incorrect indications like meteorological prediction does as well and only God knows the good cropping season. According to farmers and based on their everyday experience, Baobab trees are more predictable than others. Some farmers believe that trees are less predictable than stars, because stars "live" with God. Farmers refer to local indicators that predict the approach of starting of the rainy season, which is the most critical moment of farming activities. This information helps farmers in their decision making to know when to start preparing their fields.

Farmers' observations and interpretations of climate phenomena have guided seasonal activities in local communities. For example, by observing of local indicators like Baobab tree phonology, farmers change their cropping system and adjust planting dates to coincide with the onset of the rains. In such a situation, farmers change from cotton production to maize and cowpea when the indicators show the starting of late rain season. Yam and cassava are also included in farmers' changing cropping system since they are drought tolerant crops. Farmers' rainfall prediction method has a social legitimacy in rural communities even though scientific meteorology has not acknowledged it as effective or relevant. Table 5 gives an overview of farmers' indicators for predicting seasons and the indicated order of reliability.

Table 5. Indicators for predicting seasons

Indicators or signs	Prediction cropping seasons	Reliability ranking
Baobab tree (*Adansonia digitata*)	Good season: a lot of flowers and leaves on the tree in the beginning of rainy season. Good season: flowers are opened and remain for a long time on the tree in the beginning of rainy season.	1
Stars	Good season: a huge star is visible in the west around 5 p.m. to 8 p.m. during a certain period of the dry season.	2
First rains direction in the season	Good season: first rains of the season are coming from the east. Bad season: first rains in the season are come from the west.	3
Cashew tree (*Anacardium occidentalis*)	Good season: a lot of flowers on the tree in the beginning of rainy season.	4
Dew	Bad season: a lot of dew in the beginning of cropping season.	5

Faced with diverse stressors, farmer complaints and a deep collective feeling of climate uncertainty, a community meeting was organized several times in order to discuss climate issues. During these 'social learning'-meeting that brought together men and women as well as youth and elders, there was much information sharing and increased farmer understanding on climate change. The social learning gave the community a space of potential to become:

- aware of climate change: Farmers acquired information and feedback on their concerns;
- interested in adaptation to climate change: Farmers were interested and motivated to learn about information regarding their peers' personal experiences, practices, and knowledge, and;
- involved in active experiential learning: Farmers later became actively engaged in experiential learning such as planting Panicum C1 against erosion.

While further investigating the social learning process in Savalou, respondents reported that they do not conduct formal planning to get together for discussion and information sharing but they used to meet often through other channels such as market place, church, funeral ceremonies etc.

Decision making processes

In the study community, farmers report not to receive any information from the government or NGOs about climate change. They recognize the presence of some NGOs and extension workers who are working with them, but none of these institutions has advised them on climate change. Farmers frequently receive advice on crop production, especially cotton and rice. Farmers' strategies of adaptation to climate change are mainly based on local knowledge. Some of respondents have learned from radio programmes that the planting of trees could help them to mitigate climate change.

At the onset of the rainy season, farmers make decisions about what, when, and where to plant. Farmers' decision making focused on:

- Availability of wetland: Farmers who had wetland access were less worried about rainfall compare to those who did not. Whatever the rainfall that season, the farmer who planted on wetland has "*something to feed his fa*mily" at the end of the day.
- Rainfall prediction: Although some farmers did not believe the local indicators of rainfall because of they did not always coincide with the outcomes, it played an important role in farmers' decision making under this climatic issues.
- Availability of short cycle of crop varieties and labour force: The farmers' concern here is related to money.

Farmers' access to rural services, such as extension agents and credit influenced their behaviour on adaptation to climate change. Table 6 sets out the limits of adaptation.

Table 6. Limits of adaptation

Perceptions of limits of adaptation	% of respondents / farmland position	
	Field on slope (n=24)	Field at the bottom of slope (n=27)
Lack of cooperation with research institutions and development workers on climate change	45.8	55.6
Lack of credit and government support	20.8	26.6
Lack of water	29.2	14.8
No limits or barriers	4.2	0
Total	100	100

DISCUSSION

Perception

A large number of farmers perceived changes in climate such as changes in the timing and distribution of rainfall and in temperature. Their perceptions of climate change focused on rainfall pattern, which reflect precipitation and temperature data obtained from meteorological stations, which show a decreasing trend in precipitation and an increasing trend in temperature between 1966 and 2015 (Figure 2 and 3). Therefore farmer's perception appears to be in line with meteorological record data. FAO [50] shared this view and argued that farmers' perception of climate change corresponds to the evidence of changes provided by climate monitoring stations.

This comparing method is supported by Vedwan et al. [51], and Hageback et al. [52] who argued that one possible way of testing farmers' perceptions is by comparing the meteorological data with farmers' perceptions on rainfall patterns. It is however worthwhile to notice that where meteorological data are indicated in mm / month, Savalou farmers talk about different types of rain with vivid descriptions in relation to the precipitation, the smell, the spectacle itself as exemplified:

> "*since the first visit of the pope John-Paul II in Benin the "Houéssin" (water of the year, which launches the beginning of the rainy season and announces the start of the major rainy season) has disappeared and has given place to another type of rain called "Gbojadji" (Rain which chooses the area it will humidify. It falls selectively in the area)".*

Respondents' perceptions may have been based on recent flood events, as it is observed that peoples' perceptions are often based more on recent, short-term trends rather than long-term changes. Smit et al. [53] shared this view and highlighted that while farmers report to be observing climate change; their perceptions are more related to recent experience. In the study village, the last flood event five years ago and last drought situation two years ago observed by respondents could be determinant factors, which influence their perceptions. However, the way farmers expressed their perception highlighted the past experience and showed erratic rainfall patterns and an increase in the amount of warm days. The research carried out in other regions of Benin revealed similarities in perception like irregular rainfalls, shortening of cultivation season, occurrence of violent winds, and an increase of temperatures [43]. Most of the farmers reported that the lack of respect for divinities and social norms are the major cause of climate change. This finding is contrary to the United Nations Framework Convention on Climate Change [54], which attributed climate change impacts to human activities. Farmers have different perceptions of the real causes of climate change. For example, few of them recognized deforestation as a cause of climate change. Though deforestation is reported as cause of climate change, this awareness did not imply that farmers are willing to stop cutting or starting to plant trees. Far from being convinced of this cause, farmers reported deforestation because they have learned it from media.

Adaptation

All respondents identified changes in crop calendar and crop rotation as an adaptation strategy of climate change (Table 4). Deressa [15] shared this result highlighting that the common adaptation strategies of climate change in agriculture include the use of changing planting dates, rotation of crop and new crop varieties that are more suited to drier conditions. However, the changing in crop calendar to take into account the rainfall changes assumes that farmers have some indicators for detecting the rainy season in order to prepare the fields. The Baobab plants phenology observation during the research revealed that the plants flowering phase coincides really with the rainy season and confirmed farmers' knowledge. Regarding the cashew plant, its flowering time varies significantly and can occur at any time except during the peak of the dry season.

With the previous situation of crop rotation within the community, there was a relay culture of the maize and cotton: maize at the beginning of season and cotton in the maize field before the maize harvest. But currently, each crop has its own plot due to the shortening of rainy season. This situation leads to an increase in production loads and thus a need for more financial support in this circumstance. This climate related issue also leads farmers to go back to endogenous crops, which are recognized, as less productive but more resistant to rainfall variability. One question that could arise from this farming strategy is how to bridge local knowledge and scientific knowledge in the process of adaptation to climate change. Farmers are conducting this practice hoping that the rhythm of seasonal changes is going to correspond to the phases of growth of at least one crop. Planting the same crop on different land and re-planting appears as the second most important adaptation strategy for farmers who have their field on slope. At the same time, this practice constituted the fourth most important adaptation strategy for farmers who have their field at the bottom of slope. This difference could mean that this strategy is not relevant for a field at the bottom of the slope.

Farmers' livelihood diversification as an adaptive strategy focused mostly on non-farm activities, which are not dependent on rainfall, such as setting up small businesses. Livelihood diversification received the greatest number of mentions in most other studies [16], but in this study only 20.3% of farmers who have their field on the slope and 18.5% of farmers who have their field at the bottom of the slope mentioned it. This fact could mean that livelihood diversification depends on farmers' financial capacity, new skills or market drivers. Due to rainfall uncertainties and its impact on farmers' livelihoods that lead to lack of daily food and the money to buy it, farmers turned towards migration as a strategy. Arendse et al. [55] shared this view and stated that the transformation of social structures and social practices is sometimes more difficult to directly link to climate risks. As much as climate change leads to greater uncertainty and livelihood insecurity, temporary migration is a classic example of a social adaptation to climate change.

The need to create adaptive capacity to climate change is becoming a core concern for farmers. The collective or social learning activities, ritual offering and prayer are the second most important adaptation strategy identified by farmers whose farmland is at bottom of slope, while it constituted the fourth those who have their field on slope. Farmers' awareness of climate change and social learning leading to collective action can contribute to the formation of local networks with surrounding villages or communities. The strengthening of a local network could be a good point of entry to create more space with potential for adaptation to climate change. Even though farmers' reports on impacts of climate change vary, it is clear that this change affects them collectively. Therefore, developing strategies that call for collective action could offer a solution, as it is often easier to build capacity and introduce a new adaptation strategy or technology through an organized group of farmers [56]. Smit et al. [57] also argued that effort should be made to build adaptive capacity through social learning, which can increase the ability of farmers to cope with climate change.

The natural environment provides a large source of local practices about weather conditions to farmers who have learned from their grandparents to read and interpret its signs, or who can draw from their own daily experiences. As presented in Table 5, farmers used several local culturally based ways (trees, direction of rain, dew, stars etc.) of forecasting. This result corresponds with a study carried out by Roncoli et al. [35] who found that local rainfall forecasts rely on observation and interpretation of specific phenomena, such as trees, animals, and sky, or they may be spiritually manifested in the form of divination. However, he also notes that understanding the indicators or the signs was not possible for every farmer. Only some old and wise community members have this knowledge. Generally, elderly male farmers are considered to know more than younger men or women farmers [35], but knowledge varies greatly among elders as well. When everyone is not able to predict rainfall, social learning by experience sharing could be an appropriate strategy to inform people about rainfall season variation.

Decision making

The first important decision that farmers make at the onset of the rainy season is about what, when, and where to plant. The farmers' decision making is influenced by type of field, the availability of wetland, rainfall predictions and availability of improved varieties of crops and labour force. Thus, farmer production strategies especially seek to manage uncertainties and reduce losses by diversifying field locations and cropping systems.

The most important limitation of farmers' adaption to climate change is lack of information and knowledge. This limitation was reported by all respondents. These findings are in line with [35], who pointed out some factors, which affect farmers' ability to adapt. These factors include accessibility and usefulness of climate information, the policy and institutional environment, and the socio-economic position of the household. Therefore, farmers' access to rural services, such as extension agents and credit, can influence their behaviour on adaptation to rainfall pattern changes.

CONCLUSIONS

This paper concludes that the dynamic system of perception, knowledge and adaptation is valuable in better understanding how farmers perceive climate change and choose for specific adaptation strategies. The paper demonstrated how perceptions interact with local knowledge, what potential spaces farmers have to choose adaptation strategies from, and how they actually make decisions regarding which strategies to implement.

Comparing precipitation and temperature trends from meteorological recorded data to the research data show that Savalou farmers' perception of climate is in line with climatic data records, but also in line with local knowledge. Indeed, farmers are able to recognize that there has been a decrease of rainfall and the temperatures have increased. Despite the fact that farmers' perceptions of climate change causes is not homogeneous, they reported that climate is changing, as has been found elsewhere in Benin [43]. Climate change impacts observed by farmers pertained mostly to agricultural production. Thus, the decline of yield was mainly identified and lack of water, erosion, and hot temperatures constituted main factors used to explain this decline on the sloped plots. On low lying plots, excess of water following sometimes by flooding are the stated major causes of decline of yield. These situations lead to serious loss of harvest and bad quality of products. The result of these phenomena was explained by the dropping of farmers' income.

The spaces of adaptive potential are limited by lack of information and knowledge and lack of credit or financial support; a fact which suggests that farmers may be willing to adapt but that they do not have financial support or any technical information about climate change in order to do so. However, farmers have made changes in their farming practices to cope with climate change through their own improvisation and real time management of climate variability as highlighted by [58,59]. Furthermore, historically, farmers whose livelihoods depend on rainfall agriculture have autonomously developed ways to adapt to climate change [50]. Anticipatory and planned adaptation is an urgent concern for farmers due to an increasing level of damage and the growth of risks.

This study revealed that the Baobab plants flowering phase seems to coincide with the rainy season and confirmed farmers' knowledge about good rainy season detecting. Local knowledge plays a crucial role here. However, it is recommendable to conduct further studies on Baobab plants in different agro-ecological zones and similar predicting mechanisms that align with farmers' perception of the environment. These kinds of perceptions form the basis for decision making about adaptation strategies.

The descriptive local names of rains and the high level of divine causes that farmers use to explain their perceptions of climate change possess an immediate relevance for the understanding of farmer's practices. Using perceptions, local knowledge and local cultural practices as a starting point for adaptation to climate change will also support policy makers to explore and to come up with sustainable adaptation strategies. The findings and the eager participation of farmers in this study articulate the need for further studying and enhancing spaces of adaptive potential. These spaces define the framework of opportunities to catalyse and induce innovations with smallholder farmers for increasing their adaptive capacity towards implementing sustainable adaptation strategies. Facilitating exposure and engagement in arenas where the climate change is debated will enable farmers and their communities to reflect and act on their perceptions and influence their existing and alternative responses.

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