Chapter 4

Contrasting perceptions with climate change
Scientific observations in three West African contexts

Frédéric Kosmowski, *Richard* Lalou,
Benjamin Sultan, *Ousmane* Ndiaye,
Bertrand Muller, *Sylvie* Galle, *Luc* Seguis

Introduction

In parallel with measures to reduce greenhouse gas emissions, climate change adaptation has become a major research subject in recent years. Based on anticipation and resilience mechanisms, adaptation is aimed at 'managing the inevitable; when reduction seeks to avoid the unmanageable' (Tubiana *et al*., 2010). The study of perception is of major interest in particular in rural West Africa, where adaptation is more likely to be autonomous. Indeed, it is accepted that cognitive factors play a role in the adaptation process through the perception of changes, the perception of risks and the perception of adaptive capacities (Hansen *et al*., 2004; Grothmann and Patt, 2005; Weber, 2010). Normative information in questions of climate is clearly given by scientific expertise. However, learning about climate change from personal experience is a strongly shared experience and the resulting perceptions are often a prior condition for action (mitigation and adaptation), whether or not there has been access to scientific information.

Comparing perception and scientific observations is still a methodological challenge. Whether scientific knowledge or uninitiated knowledge is concerned, both are based on observation but involve very different tools for seeing reality and generalisation methods. As is underlined by Weber (2010), perception is based on the weather at a certain moment and the memory of it that is conserved; this is of course very different to knowledge of climate, which is based on a statistical distribution of the terrestrial atmospheric conditions in a given region and for a given period.

Furthermore, the lay public observes the weather using their human senses and interprets an unusual or extreme situation in relation to its experiences, memory, beliefs and expectations. Its perceptions are also often moulded more by the impacts of the climate than by the climate itself (Reckien *et al*., 2012; Leclerc *et al*., 2013). Several studies have shown that farmers take harvest losses or soil degradation into account to evaluate changes (West *et al*., 2008; Osbahr *et al*., 2011). This is doubtless why quantification is partly considered to be useless in many cultures (Berkes and Kislalioglu Berkes, 2008). In contrast, for scientists a climatic anomaly is an objectified statistical event that deviates from long series of averaged and projected measurements.

The cognitive processes involved in the assimilation of perceived information and in that of learned information are also different. Learning about climate change through personal repeated experience is based on mechanisms involving sensitivity, tangibility and immediateness and the resulting interpretations concern associative and affective principles (Weber, 2010). Using the climate event as a base rather than risk—especially when this is small—perception is also more volatile as it may change when the danger becomes more rare or when its impacts are less serious. Conversely, learning using statistical description assumes an analytic and intelligible approach and requires a longer period of assimilation.

So far, comparatively few studies have approached the comparison of perceptions of climate change with scientific observations. Several studies conducted in various sub-Saharan contexts reveal a divergence between perception of changes and the precipitations observed (Meze-Hausken, 2004; Gbetibouo, 2009; Osbahr *et al*., 2011; Mertz *et al*., 2012). In Burkina Faso, West *et al*. (2008) showed satisfactory perception of the long-term decrease in precipitation observed since the 1970s but not of the recovery of rainfall that occurred at the end of 1990. Osbahr *et al*. (2011) and Simelton *et al*. (2013) studied the perception of changes related to the beginning and end, but here again it was not possible to establish convergence.

Authors have found several reasons that account for these divergences. The notion of ‘optimal rainfall’ in which the rainfall pattern is judged by farmers is put forward by Meze-Hausken (2004) and Osbahr *et al*. (2011). From this angle, the perception of changes in the climate would be based on the rainfall required to cover family needs rather than ‘real’ rainfall. This leads to the staggering of expectations. Other authors stress the fact that recent events may influence perception of long-term precipitation trends (West *et al*., 2008; Mertz *et al*., 2012.). Finally, a third explanation is related to changes in farming systems. According to this view, divergences can be explained by the difficulty to differentiate changes in the farming system from those of changes in the weather (Simelton *et al*., 2013).

Using these analyses, we examine the perception of recent climate changes by the people of West Africa and compare them with scientists’ observations. As the climate and its present dynamics are not uniform at the scale of the continental region, we focused on three countries in order to cover a broad range of geo-climatic zones. Niger, with three climate strata ranging from desert areas in the north to the beginning of the semi-arid zone in the south, is covered entirely and provides climate perceptions from all inhabited environments. The two other countries involve smaller zones and are both strictly rural. In Benin, the study was conducted in the north—in the Sudanian-Guinean zone. In Senegal, the pluviometric status of the area examined lies between those of the other two countries and is in a semi-arid tree savannah zone.

The light shed by these three contexts and all the areas where people live was used to assess, in comparison with scientific observations, the ability of populations to detect recent climate changes. We also try to understand how these populations succeed in perceiving the reality of the climate, in particular according to their social and professional features and determinations of their environment. The central hypothesis of this work is that individuals detect climatic changes better when they have strong links with their natural environment.

The context of the research

In Benin, the study was conducted in the Djougou local administrative area at the southern border of the Sudan-Guinea zone, where average rainfall is 1100 mm per year (Fig. 1a). Some 22% of Djougou village area is farmed and more than 50% of the land is savannah. The rest is forest (JUDEX *et al*., 2008). The study zones cover a total of 155 km^2. Every household in the two transects was surveyed. These families live from rainfed agriculture on small areas. Mainly family labour is used; the majority of households are polygamous and large. The households studied possess an average area of 10 hectares. The study area runs along Route Nationale 6 on either side of the town of Djougou (fig. 1a)

In Senegal, the zone studied is the Niakhar population and health-monitoring unit. This is in a dry, semi-arid zone (cumulated rainfall 500 to 650 mm per year since the mid-2000s) between the towns of Fatick in the south and Bambey in the north (Fig. 1b). The study zone is in the groundnut area (centre-west part of Senegal) and covers 30 villages with a population of approximately 45,000 in 2013 and an area of 200 km^2. Average population density is 215 persons per km^2, with villages displaying densities approaching or exceeding 400 persons per km^2 (DELAUNAY *et al*., 2013).

The farmers in this zone are entirely devoted to crop and livestock farming combined in a system that is exceptional in West Africa (PÉLISSIER, 1966; LERICOLLAIS, 1999). Fields are generally in flat areas with sandy, permeable soil that is easy to plough and loosen. However, these soils generally display low water-holding capacity and mediocre fertility, generally leaving at their edge a small proportion of low-lying zones with sandy-clayey soil (5 to 10% clay) with greater fertility and better water-holding capacity. However, this soil is less permeable and hardens quickly after the rains. Almost all the farms (95%) grow rainfed crops—mainly millet and groundnut—on small areas (a little less than 5 ha on average). Households are large (13 persons) and family labour is mainly used.

Figure 1.
a) Map of the north of the commune of Djougou (Benin)
showing the northern and southern transects
b) map of the observation zone in the district of Niakhar in the Fatick region in Senegal.
This observation zone incudes 30 villages.

The Nigerien national survey, used in our study for perceptions of climate, covers all the bioclimatic strata of the country from the desert zone in the north to the Sudanian-Sahel and Sudanian zones in the south (Fig. 2). Niger is a land-locked country with an area of 1,267, 000 km², three-quarters of which consists of desert. The southern fringe of the country, with more than 90% of the population, has the greater part of non-mining natural resources (salt, water, vegetation and fauna). The climate is Sahelian overall with distinction made between four climatic zones. The Saharan zone (65% of the country) with less than 100 mm of rainfall per year, the Sahel-Saharan zone (12.2% of the country) with 100 to 300 mm of rainfall per year, the Sahel-Sudanian zone (21.9% of the country) with 300 to 600 mm of rainfall per year and the Sudanian zone (0.9% of the country) where rainfall is greatest at over 600 mm per year.

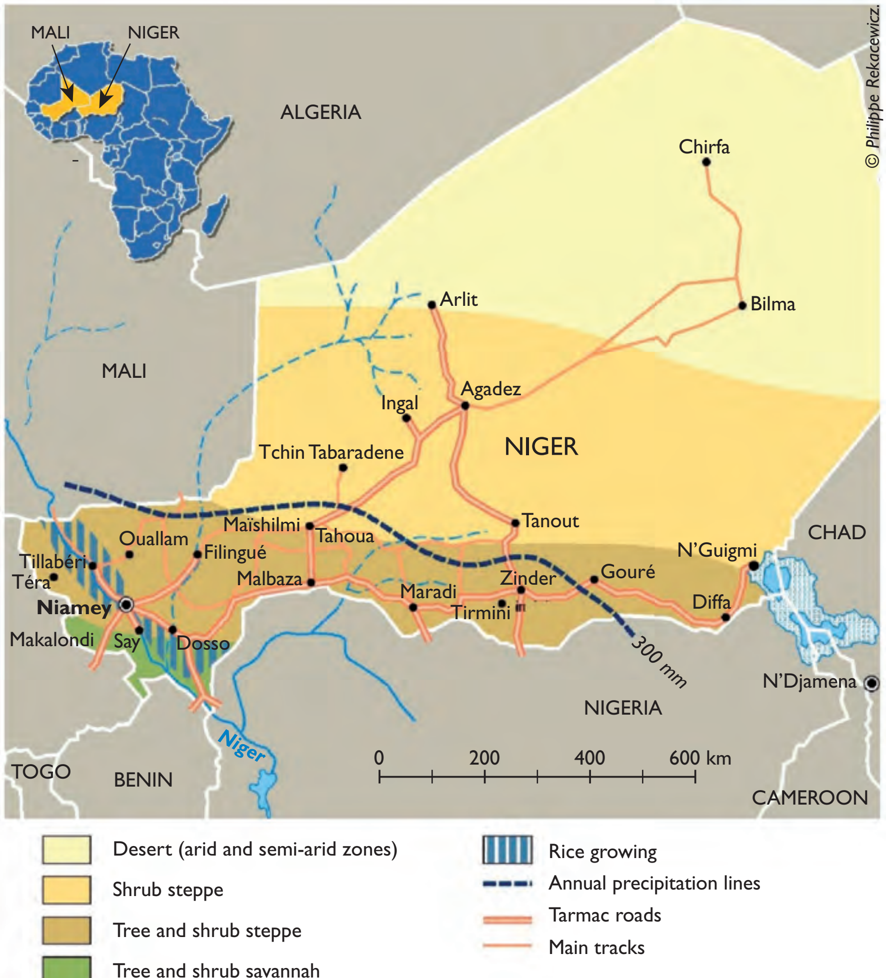

Figure 2.
Map of the bioclimatic zones of Niger.

Niger is one of the poorest countries in the world. The economy is based essentially on subsistence agriculture and livestock farming. Nearly 84% of the population lived in rural areas in 2010 and the primary sector employs nearly 87% of the population. Animal husbandry and crop farming are the second and third largest sources of income in Niger. Agriculture is found in the south in 15% of the country but involves nearly three-quarters of the national population. Most of Niger farming is on small farms with no mechanisation and sometimes with animal draught. Average farm size is 5 ha for 12 persons, of which 6 work on the farm. Millet, sorghum, cassava, beans and rice (the latter grown in river flood recession areas) are for local consumption. Cash crops (groundnuts and cotton) are found in the wetter southern zone. Animal husbandry is found in arid and semi-arid areas throughout the northern part of the country. It involves mainly cattle and sheep with transhumance for long distances.

Material and methods

Our comparison of the perception of the population and scientific observations of the climate is based on a questionnaire collected at local or national scales. This qualitative perception of the climate—old and recent—is then compared with temperature and rainfall figures from the meteorological and synoptic stations closest to the homes of the persons questioned (national networks). For sites where climate change is marked, analysis of the perceived climate is continued by the modelling of the factors associated with good perception by persons questioned in the survey.

Surveys were conducted in Benin and Senegal to appraise perceptions of climate, to define the social and professional characteristics of persons and the features of the environment that determine convergence with observed scientific data. The same protocol was used at the two sites (Niakhar in Senegal and Djougou in Benin). The surveys were performed between July 2013 and March 2014 in rural areas and using samples chosen at random from exhaustive survey bases: 1,102 households in Benin and 1,065 in Senegal. Two questionnaires were used for each household surveyed—the first for the head of the household and the second for a farmer chosen at random among those in the household that had cultivated a field during the three preceding years. This person could be the head of the household. The data used in Niger were those of the *Enquête nationale sur les conditions de vie des ménages et sur l'agriculture* (National Household Living Conditions and Agriculture Survey) (ECVM/A-2011) conducted from July 2011 to January 2012. Available free of charge, the data are drawn from the LSMS-ISA project implemented by the World Bank in collaboration with the Institut National de la Statistique of Niger (http://go.worldbank.org/V0810DTAC0). The sample was designed to be representative at national and regional levels and for agricultural, agropastoral and pastoral zones. The survey used a random two-stage sampling of 4,045 households in both town and country.

In Benin and Senegal, the 'household' questionnaire submitted to the head of the farm was designed to collect data on farming practises during the preceding rainy season. It also provides information about the economic status of the household, activities other than farming and the sociocultural characteristics of the head of the household. The 'individual' questionnaire was focused on certain cash crops such as groundnuts and watermelon and on beef fattening. More than 25 questions concerned perceptions of the present climate (during the preceding 10 years) and the past climate (20 years ago) and knowledge of climate change. These questions provided information about perceptions of the levels, calendars and evolution of rainfall, temperature and wind. In Niger, the household and crop/livestock questions were divided into 13 and 8 sections respectively. The crop/livestock sections of the questionnaire were focused on questions of access to land, farming systems (rainy and dry seasons), livestock, forestry, agricultural equipment and inputs and climate change. The latter section consisted of 11 questions on the climate as perceived during the previous five years and 13 questions on the farming strategies implemented because of perceived changes in temperature and rainfall. The environment of residence and the type of professional activity are used in the survey to check that the accuracy of perception of the climate depends on the links between persons and their environment.

An explanatory climate perception model was developed using data from the Senegal survey and completed by routine data collection at the Niakhar observation site. Data analysis was performed in two stages. The first consisted of establishing a perception indicator and a number of predictors. Perception of the climate is considered to be 'good' if the replies to the climate survey match the observations made over the last 10 years. If the description of the climate is accurate for at least 7 of the 8 criteria below, the farmer is considered to have a good perception of the climate. In the last 10 years, the climate should display the following pattern:

− increased rainfall;

− a longer rainy season;

− a late start of the rains;

− a late end of the rains;

− strong variation in rainfall from one year to the next;

− an increased number of violent heavy rainfall events;

− increased maximum temperature;

− increased minimum temperature.

The average duration of seasonal migration and the caste that persons belong to (guelwars, farmers, craftsmen and griots) are two indicators constructed by processing demographic monitoring data (Niakhar observation site). The other variables are from the survey using a questionnaire (ESCAPE-Senegal).

In order to check that Serer farmers in Senegal do not have identical perceptions of climate changes (although they are—overall—subjected to the same meteorological conditions and are all farmers), we evaluated the effect of their sociocultural and economic features on the accuracy of their perception of the climate. Among individual and household variables, the model uses 1) whether the respondent is a man or a woman, 2) his/her education; 3) the number of years of experience in farming, 4) the cumulated duration of seasonal migration during the last 10 years, 5) paid extra-agricultural work, 6) the caste of the respondent, 7) the ethnic group of the respondent, 8) membership of agricultural associations, 9) the use of meteorological information in his/her farming practices and 10) respondents living in a village in the north of the observation zone. The model was tested using binary logistic regression and STATA® 13. Finally, we refined the model (analysis of residues) by removing outliers and observation that weight on the model in an exaggerated manner (levers and influencing factors). The model thus edited explains 34% of variance and gives correct adjustment of the data (Hosmer-Lemeshow adjustment test).

Climate change in the region

As illustrated in chapters 1 and 2, West Africa has experienced major climatic upsets since the 1950s. In the Sahel in particular, LEBEL and ALI (2009) showed that the great drought at the end of the 1960s triggered a long dry period that lasted for nearly three decades, followed by a recovery of rainfall in the last decade of the 20th century, although substantial regional disparities were observed (Chapter 2 of this book). Although very few studies have focused on the temperature changes in West Africa (FONTAINE *et al.*, 2013), it is nonetheless clear that the temperature has increased considerably in the Sahel since 1950 (Chapter 1 of this book). Warming is distinctly greater at night than during the day as a result of the effects of water vapour, clouds and aerosols (Chapter 1 of this book). But it is important to set out these regional trends at a local scale characterising what African population feel and experience as regards climate. Changes in precipitation and temperatures observed since 1965 at the three survey sites in Benin, Senegal and Niger are shown in Figure 3.

Minimum temperatures expressed as annual means increased considerably at the three sites, with very positive linear trends, during the period 1965-2013. In 50 years, minimum temperatures have increased by + 1.2°C at Djougou, + 1.8°C at Bambey and + 1.4°C at Niamey, which is considerable. The trend is not as clear for maximum temperatures, even though an increase of nearly 1°C is seen at Djougou and Bambey. These results are strongly coherent with the observations for the Sahel as a whole (see Chapter 1).

Regional trends with abnormally dry conditions are observed at these three locations in West Africa during the 1970s and 1980s, followed by a wetter period. However, this general pattern includes noteworthy differences that cannot fail to influence perception of the climate by local populations. These differences include the observation that the driest years differ from one location to another: 1972, 1982 and

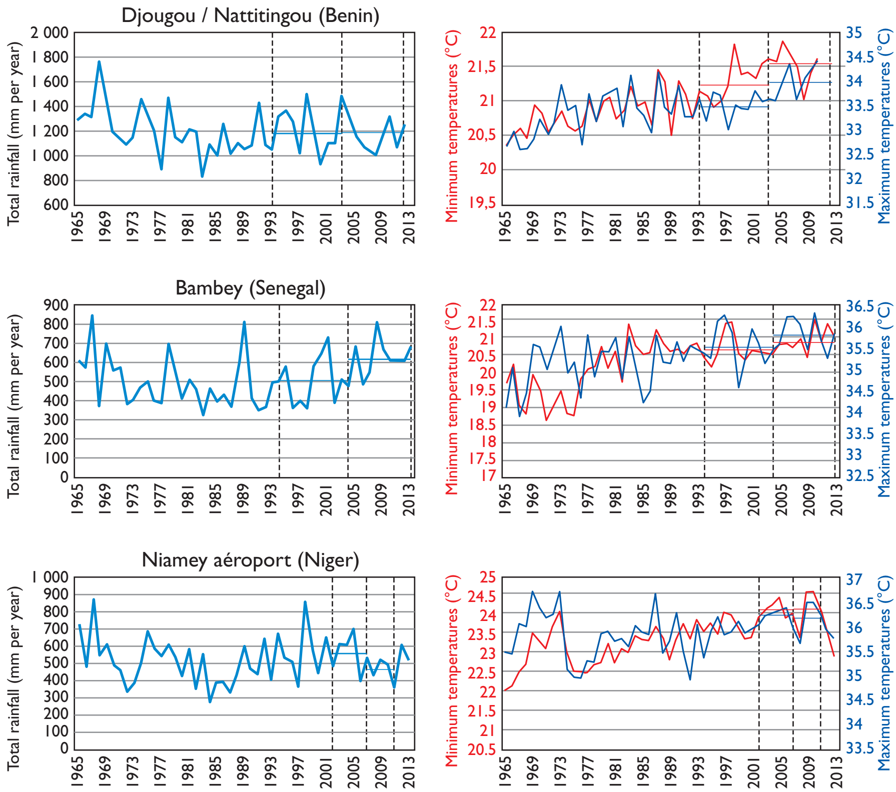

Figure 3.
Evolution of rainfall and temperatures observed since 1965
at the three survey sites in Benin, Senegal and Niger.
The vertical lines indicate the separation between two periods:
the present period preceding the survey and the historical reference period.

1984 in Niamey and 1977 and 1983 in Djougou, even if in the Sudanian-Sahelian context of Djougou it is difficult to talk in terms of drought as for Niger. It is also seen that the return of rainfall is observed in a very specific manner at each location. At Djougou, after a practically linear decrease from 1965 to 1983, rainfall increased rapidly and stabilised at around 1,200 mm per year from the beginning of the 1990s. No noteworthy change in cumulated rainfall for the last 20 years. The recovery occurred late at Bambey, with cumulated rainfall remaining small at around 450 mm per year between the early 1970s and the end of the 1990s and then increased rapidly, reaching an average of over 600 mm per year during the last 10 years, i.e. an increase of nearly 50% in 20 years. But in Niamey, although rainfall recovered after the great drought that lasted until the early 2000s, a significant decrease in cumulated annual rainfall has been observed during the last 10 years, even though there is still strong inter-annual variability.

Analysis of cumulated annual rainfall alone is not enough to show the reality faced by rural populations in the Sahel. The work by INGRAM *et al*. (2002) and by KLOPPER *et al*. (2006) showed that the most crucial variables for farming strategy in Africa are the start and the end of the rainy season, together with rainfall distribution within the monsoon season (intra-seasonal distribution). Indeed, the choice of sowing date is crucial in the strategy of a farmer who must be sure that sowing will not be followed by too long a dry period and that the crop reaches maturity at the end of the rainy season. In addition, a dry period during the critical phases of crop development can have serious repercussions on yield, even if cumulated rainfall for the season (total rainfall during the monsoon season) is substantial.

Analysis of the evolution of the features of the rainy season (beginning, end, length, number of days of rain, dry intervals) was conducted for each of the three locations for comparison with perceptions by the population (Table 1). Only the analysis of start of the rains is illustrated in this chapter (Fig. 4). Numerous methods exist for determining the date of the start of the rains (MARTEAU *et al*., 2011; SULTAN *et al*., 2005) and can give different mean dates depending on the criterion or thresholds chosen. Here, we used the method described by LIEBMANN and MARENGO (2001) and recently applied in Africa by BOYARD-MICHEAU *et al*. (2013). The method has the advantage of relying on rainfall anomalies and not on thresholds, and can therefore be applied to the three regions, even if rainfall conditions are completely different. In Benin, where the method shows that the rains start on 1 May, recent data are lacking to analyse changes to the start of the rainy season. A significant correlation was noted for Bambey between cumulated rainfall and the date of the start of the rains (R = - 0.48), which means that 25% of annual rainfall variation is accounted for by fluctuations in the start of the rainy season. Particularly early starts have also been observed since 2008, accompanying the high cumulated rainfall recorded in recent years. In Niger, even if there is no significant correlation between the cumulated annual total and the start of the rainy season, as is also shown by MARTEAU *et al*. (2011), the rainy season has become increasingly late since beginning of the 1990s.

Table 1.
Synthesis of the evolution of rainfall at the three locations for recent years covered by surveys.
Daily data for recent years in Benin are lacking.
In Niger, where the surveys covered recent trends in the whole country, very similar conclusions were obtained by using satellite rainfall estimates (FEWSNET) with resolution of 0.1 degree.

	Cumulated annual rainfall	**Start**	**Finish**
Djougou (Benin)	Stable	*NA*	*NA*
Bambey (Senégal)	Increase since 1996	Early start since 2008	Late end since 2009
Niamey (Niger)	Decrease since 2005	Increasingly late seasons since 1991	Late end since 2007

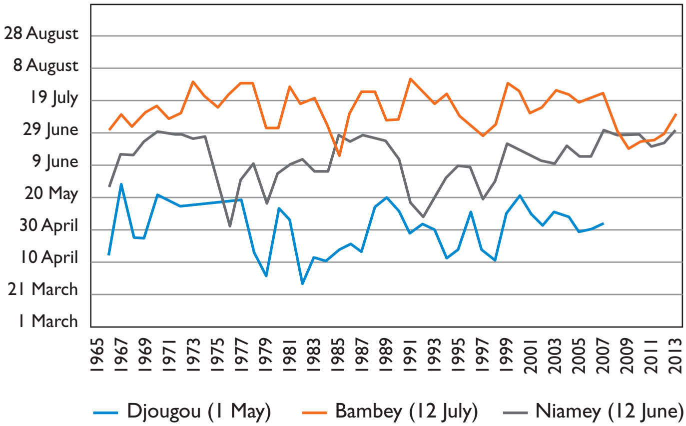

Figure 4.
Start of the rainy season in the three locations.
The figures are given as a 3-day sliding average.
The date in brackets is the average date of the onset of the monsoon during the period 1965-2013.

How do the populations perceive these changes?

Questioning the rural populations in the three countries about the recent trends in total rainfall (Fig. 5) reveals a good match between perceptions and rainfall observations, at least in Niger and Senegal where there have been substantial rainfall changes. In Niger, nearly 80% of the population surveyed said that they had perceived a decrease in rainfall in conformity with the deficit observed recently. In Bambey, the recent increase in rainfall had been perceived by more than 96% of the persons surveyed.

In Djougou, where the evolution of the climate is less marked and where rainfall has tended to remain stable in recent years, it is interesting to note that the opinions of the populations surveyed diverge, with nearly two-thirds of the persons surveyed considering that rainfall had decreased and nearly a third declaring the opposite. Only a very small proportion of the respondents at Djougou had perceived rainfall as being stable in recent years (2.4%). It is very probable that in the absence of a strongly marked trend as in Senegal and to a lesser degree in Niger, it is difficult to perceive stationary recent evolution, explaining the contradictory perceptions of residents of the Djougou area.

The populations surveyed in Senegal clearly perceived the transition observed between a dry period 20 years ago and the present wet period (Fig. 6). The drought – a major environmental problem for 65% of the population surveyed 20 years ago has now – has now become just a minor concern, with less than 3% considering it

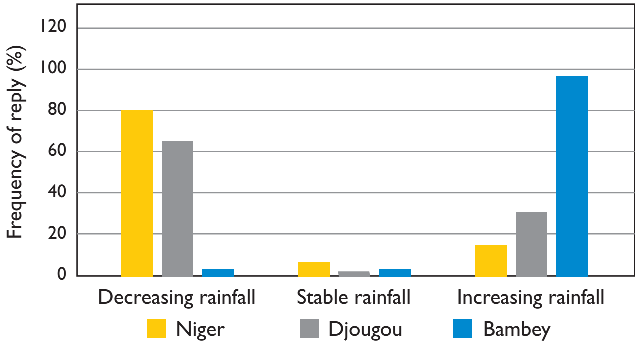

Figure 5.
Perception by rural populations of the recent evolution in cumulated rainfall. The results are shown as frequency of reply (%) for each of the three modes and for each of the three countries in which the surveys were conducted.

to be a problem affecting their area. The main concern today has become soil fertility, as highlighted by more than 70% of respondents. It is noted that the farmers in this part of Senegal are nearly three times as numerous to state that violent rainfall is currently a real environmental problem, in comparison with those who consider that this was already a major problem 20 years ago. The increased frequency of intense rainfall events is a phenomenon that has also been observed by climatologists.

The rural populations surveyed in Niger and Senegal also display excellent perception of the changes in the seasonal features of the monsoon. The lateness of the rainy season was perceived by 72% of the rural people surveyed, while the increasing earliness of the 'winter' was observed by 67% of the persons surveyed in Senegal. Most of respondents (65%) placed this change in the onset of the monsoon from 2008 to 2010, effectively corresponding to a period in which particularly early rainy seasons were recorded (Fig. 4). An earlier end to the monsoon was perceived by 81% of the rural population surveyed in Niger whereas a later end was observed by 72% in Senegal. These two perceptions corroborate pluviometric observations (Table 1).

This fairly close agreement between meteorological observations and the perceptions by populations in Senegal and Niger with regard to several pluviometric indicators (the evolution of cumulated rainfall, the period of the start and end of the rainy season, the frequency of intense events, inter-annual variability, etc.) is particularly remarkable. As a general rule, the literature finds the opposite in the arid and semi-arid zones of Africa: populations—including farmers whose living conditions depend on rainfed crops—do not perceive climatic evolutions as detected by scientists. Although the respondent populations questioned mentioned the inter-annual irregularity of cumulated rainfall, they never mentioned the return of rainfall observed in recent years (Chapter 2; Akopnikpè *et al.*, 2010; Mertz *et al.*, 2009, 2012; Diessner, 2012). The main changes felt by the populations are a decrease in annual rainfall, a shortening of the rainy season (later start and earlier end), an increase in dry periods during the rainy season and the existence of periodic droughts in certain

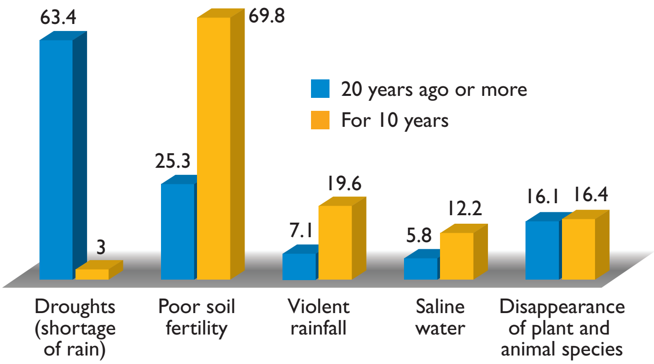

Figure 6.
The main environmental problems perceived by the populations survey in Senegal. Only those mentioned by more than 5% of the persons surveyed are indicated here.

years (AKOPNIKPÈ *et al*., 2010; ALLÉ *et al.*, 2013**;** MERTZ *et al*., 2012; NIELSEN et REENBERG, 2010; OUÉDRAOGO *et al*., 2010; TAMBO and ABDOULAYE, 2013; TSCHAKERT, 2007; WEST *et al*., 2008).

One of the main explanations for the difference between perceptions and observations is often the unsuitable spatial scales used for comparisons. Meteorological observations are often performed at a regional scale while the population always perceives climate at a local scale (HARTTER *et al*., 2012; WEST *et al*., 2008). However, precipitation can be subjected to strong local variations caused in particular by convection phenomena. On the other hand, perceptions are probably fashioned by exceptional climatic events and by the intensity of their impacts. Changes can thus be perceived in a much stronger manner—and even contrary to the overall trends actually observed (HARTTER *et al*., 2012; ORLOVE *et al*., 2010). Farmers' expectations with regard to climate can also influence their perceptions of climatic changes. MEZE-HAUSKEN (2004) suggests that the increasing rainwater requirement of Ethiopian farmers encourages them to interpret recent changes as a rainfall deficit, while observations show that precipitations are stable.

In Benin and Senegal, where the perception of temperatures was surveyed, it is seen that the populations questioned were less sensitive to the rise in nocturnal temperatures, even though this was shown in observations. An increase in temperatures in recent years was found by 69.6% of the persons surveyed in Senegal in comparison with only 60.6% in Benin. It was even observed that 16 and 20% persons surveyed in Senegal and Benin respectively perceived a fall in nocturnal temperatures. Similar results were obtained for the perception of day temperatures. This percentage of temperatures in apparent contradiction with observation can be explained among other things by the fact that temperature increases slowly and steadily, making warming difficult to perceive. Furthermore, temperature is not perceived as a vulnerability factor by populations who tend more to mention changes in rainfall (drought, late start and shortening of the rainy season, intense rainfall events) as causing more damages to crops and therefore having an impact on the daily life of populations.

During these surveys in Benin and Senegal, the persons questioned frequently mentioned strong winds that endangered crops. More than 80% had observed an increase in the frequency of high winds causing damage to crops. This is considered in both Niakhar and Djougou as the second most devastating environmental phenomenon for crops—after drought. However, analysis of average winds at the two locations does not seem to corroborate an increase in winds, even if the wind data at both of these stations suffer from many problems of quality (breaks in homogeneity, aberrant figures, missing figures) and are only daily averages and not maximum instantaneous readings. However, it should be noted that this perception of increased wind by rural populations is also reported by several authors in West Africa (OZER *et al.*, 2013; ALLÉ *et al.*, 2013**;** OUÉDRAOGO *et al.*, 2010) while all wind speed measurements tend to indicate the opposite. ALLÉ *et al.* (2013) suggest that the difference between perceptions and observations of wind speeds in southern Benin can be explained by a serious degradation of plant cover as a result of landholding pressure and the over-exploitation of natural resources, leading to changes in local wind patterns.

Does everybody perceive the climate in the same way?

Unlike town-dwellers in the North and the South who are generally disconnected from their natural environment, the people who work directly on the land using natural resources—especially in traditional societies—are still strongly linked to nature, because their means of subsistence depend on it (WOLF et MOSER, 2011). It can therefore be expected that the experience and knowledge of the environment and climate of rural people—and mainly crop and livestock farmers—are markedly different to those of town-dwellers. Likewise, perceptions of climate—when based on personal experience—are probably constructed using a certain number of factors such as access to meteorological information, the level of education, social networks, economic level, occupation, demographic variables (age and sex) and duration of residence.

Survey EMCV/A-2011 is an ideal framework for analysing these differences as it concerns an extremely varied population of 4,045 households distributed throughout Niger. It thus makes it possible to compare perceptions of climate collected in urban and rural areas, in semi-arid to arid regions and in sedentary and/or nomadic environments. χ^2 tests applied to perception data reveal significant differences according to the level of education, sex, nomadic or sedentary mode of life, rural or urban habitat, occupation and the rainfall at the place of residence. Nomads, men, rural people and uneducated persons living from activities that are strongly dependant on climate (crop farmers, livestock farmers) and in the driest zones have sharper perception of the recent worsening of rainfall in Niger. It can be explained easily by the fact that these population categories are dependent and vulnerable with regard to climatic variability and hence have a live memory of recent pluviometric events. In contrast, the age of the respondent does not seem to have affected replies. This can be explained by the fact that the questionnaire concerned the previous five years and not an earlier period.

Figure 7 illustrates this difference in perception of pluviometric variability in Niger by groups whose income is directly dependent on the climate (crop and livestock farmers) and those whose incomes are independent of the climate (civil servants, craftsmen, traders, self-employed workers, unemployed). It shows that climate-dependent populations have a much better perception of variations in the onset of the rains. Indeed, the high positive (negative) Pearson residuals for late (early) starts imply that the number of respondents mentioning a late start of the rains is very significantly higher (lower) than that expected by a random response. Perception is also good when persons are questioned about the start of the monsoon during the last five years or the start of the monsoon in 2011, which took place several months before the survey. This matching of perceptions and pluviometric observations contrasts strongly with those of populations whose incomes are independent of the climate. The replies in these surveys even sometimes mention a later start of the rains in contrast with observations that show that it is earlier.

Unlike Niger, the Senegalese survey was focused on a population that was fairly homogeneous as regards its characteristics and activities. All the persons questioned were crop/livestock farmers living in a rural area and all using the same millet and groundnut based farming system. However, as for the results for Niger, differences in perception can be seen between persons, regardless of their work as farmers and their place of residence.

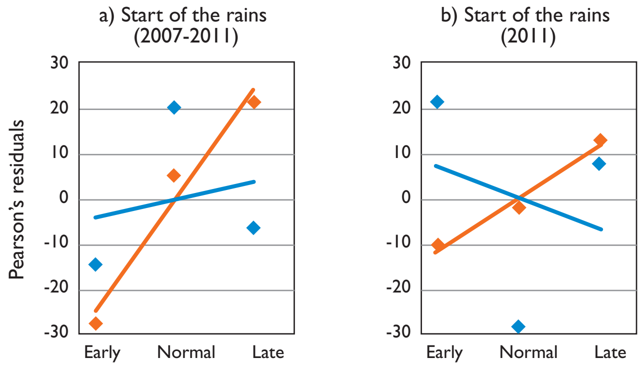

Figure 7.
The proportion of households that perceive a later start to the rains during the last five years (left) and during the last rainy season (2011). The ordinates represent Pearson's residual with, in red, the answers of persons questioned whose incomes depend directly on the climate and, in blue, those whose incomes do not depend on the climate.

A logistic model (Table 2) is used to see first of all that the perception by Senegalese farmers of climate and changes in climate matches scientific observations best when their occupations are mainly or solely in farming. Thus farmers with at least one non-agricultural occupation have less likelihood than the others of achieving good perception of recent climate change (OR = 0.77; p = 0.045).

However, in contrast with our hypothesis, having made several seasonal migrations during the last 10 years does not affect farmers' perception of the climate. This can be explained by the fact that seasonal migrants who possess land are always present in their village at the start of the farming season (before the first useful rain).

The other factor related to good perception of recent climatic evolution is regular listening to the radio weather forecasts. Farmers who do this are more likely to make an accurate detection of climate changes in conformity with observations by climatologists (OR = 1.61; p = 0.001). This of course shows the importance of access to

Table 2.
Analysis of the factors related to very good perception of recent (less than 10 years) climate changes by farmers in the Sine in Senegal.
Logistic regression for 1,017 farms (questionnaire survey, ESCAPE – 2013/2014).

	Complet model	
Number of observations (total ; yes ; no)	(1 017 ; 460 ; 557)	
Good perception of the climate	Odds Ratio	P>z
The person is a woman (or a man)	1.12	0.509
The person has never been to school (has been to school)	1.15	0.355
Age	0.99	0.690
Number of seasonal migrations in the las 10 years		
1	0.96	0.828
2 or 3 r	1.03	0.895
3 or more	0.61	0.302
Usually has a paid non-agricultural occupation (or not)	0.77	0.045
Caste		
Noble (or peasant)	0.87	0.403
Artisans ou griots (or peasant)	1.98	0.011
Member of a farming association (not a membern)	1.14	0.385
Use meteorologocal information in his/her work (does not)	1.61	0.001
Religion		
Mouride muslim (or Tidian muslim)	0.73	0.051
Christian (or Tidian muslim)	1.24	0.346
Poor(or not)	0.84	0.198
Constant	0.90	0.787
ROC curve	0.61	
Hosmer-Lemeshow test (prob. value)	0.59	

meteorological information for better perception of the climate. However, it also suggests that the perception and interpretation of the climate is a cumulative set of knowledge, beliefs and observations that evolves by adapting to new experience (BERKES *et al*., 2000). The integration of scientific and lay knowledge shows that the latter category can form a framework of reference within which farmers interpret and adopt scientific information such as weather forecasts.

The quality of perception of the climate also has cultural and social aspects. The craftsmen and griot castes thus have better overall perception of the recent evolution of the climate than the Serer of the farming caste (OR = 1.98; p = 0.011). In our study, this group is represented mainly by griots, who conserve the collective and family memory. This means that they might be more sensitive to the changes that occur with the passage of time, and especially changes in climate. Conversely, it is observed that muslims who belong to the Miuride brotherhood perceive recent changes in climate less well (OR = 0.73; p = 0.051). The Mouride organisation features among other things economic and religious networks superimposed on a both national and transnational territory whose focus is the holy town of Touba (COPANS, 1980; BAVA, 2005). Mouridism thus involves great mobility among its members who often benefit, thanks to trade, from the difference in wealth between places. Even when they are farmers, Mourides thus have more inclination to travel and trade—both of which tend to cause a degree of disconnection with their natural and climatic origins. It is noted that the residents of the villages in the north of the observation zone where the Mouride influence is stronger (it is at the edge of the Diourbel region where Touba is sited) and extra-agricultural activities are more frequent have significantly poorer perception of climate than those of the villages in the south of the zone.

Overall, it is seen that individual perceptions of the climate are modelled by experience and beliefs and also according to the scientific knowledge that persons integrate. Furthermore, what is doubtless most important is the link between persons and nature, in particular through their occupations and lifestyle. This determines the accuracy of their perception of climate in comparison with scientific observations.

Conclusion

Good perception of the climate by African farmers is certainly an important issue in adaptation to climate change insofar as they are accustomed to managing their fields according to their perceptions and beliefs in terms of nature and climate. Accurate perception of the climate is hence necessary for assessing climatic risk and having the possibility of managing it well. This perception clearly does not automatically induce a rational action with regard to climate. Other risks or competing stresses may determine farmers' adaptation strategies (TSCHAKERT, 2007). However it is undoubtedly a necessary condition and one that meteorological information can help to reinforce.

In spite of natural climate variability and biases associated with memory, we have seen that the farmers in semi-arid zones in Africa have fairly clear and accurate awareness of recent climatic changes. However, it should be considered that this awareness is all the more clear-cut as climate change is taking place over a fairly short period of time and has considerable amplitude, as in central Senegal and certain parts of Niger. In contrast, it might be imagined that a more gradual change—such as a gradual increase in temperature for example—would be more difficult to detect and hence more difficult to face. The perception of climate change also depends on its impacts (positive or negative) on the way of life and standard of living of the persons who feel them. The violence of recent rainfall in Senegal caused phenomena (flooded houses, uprooted trees, etc.) that have probably marked the minds of farmers. Likewise, increased rainfall and the late end of the rainy season have changed the farming system, with the reintroduction of long cycle millet (see Chapter 18), contributing here again to better memorisation of changes in rainfall. In contrast, farmers pay less attention to climate warming, which has less impact on their work for the moment, but which for climatologists is nonetheless the most definite and the strongest signal.

In the light of all these remarks, we can affirm that perception by farmers is currently as much that of the impact as of the climate phenomenon that causes it, and that it's more the perception of uncertainty that that of the risk. We should therefore not be surprised to observe that farmers adapt to the change once it has happened, that is to say in reaction and not anticipation. Learning by observation alone is generally not enough to anticipate adaptation. For this, the signs of nature and the sky must be interpreted so that they might express a danger against which the populations will seek to protect themselves. These interpretations are in the course of construction today by both local beliefs and by the scientific knowledge to which African farmers have access.

References

Allé U. C., Vissoh P. V., Guibert H., Agbossou E. K., Afouda A. A., 2013
Relation entre perceptions paysannes de la variabilité climatique et observations climatiques au Sud-Bénin.
VertigO-la revue électronique en sciences de l'environnement, 13 (3).

Akponikpe P., Johnston P., Agbossou E. K., 2010
Farmers' perceptions of climate change and adaptation strategies in sub-Sahara West Africa.
2nd International Conference on Climate, Sustainability and Development in Arid Regions, Fortaleza-Ceara, Brazil.

Bava S., 2005
Variations autour de trois sites mourides dans la migration.
Autrepart, 36 (4) : 105-122.

Berkes F., Colding J., Folke C., 2000
Rediscovery of traditional ecological knowledge as adaptive management.
Ecological applications, 10 (5) : 1251-1262.

Berkes F., Kislalioglu Berkes M., 2008
Ecological complexity, fuzzy logic, and holism in indigenous knowledge. *Futures*, 41 : 6-12.

Boyard-Micheau J., Camberlin P., Philippon N., Moron V., 2013
Regional-scale rainy season onset detection: a new approach based on multivariate analysis. *Journal of Climate*, 26 : 8916-8928.

Copans J., 1980
Les marabouts de l'arachide. La confrérie mouride et les paysans du Sénégal. Paris, Le Sycomore (2e édit. 1988, Paris, L'Harmattan).

Delaunay V., Douillot L., Diallo A., Dione D., Trape J., Medianikov O., Raoult D., Sokhna C., 2013
Profile: The Niakhar Health and Demographic Surveillance System. *International Journal of Epidemiology,* 42 (4) : 1002-1011.

Diessner C., 2012
It will rain if god wills it: local perceptions of climate change in the Futa Tooro of northern Senegal. Doctoral dissertation, University of Missouri, Columbia).

Fontaine B., Janicot S., Monerie P.-A., 2013
Recent changes in air temperature, heat waves occurrences and atmospheric circulation in Northern Africa. *J. Geophys. Res. Atmos.*, 118 : 8536-8552, doi:10.1002/jgrd.50667

Gbetibouo A. G., 2009
Understanding farmers' perceptions and adaptations to climate change and variability. The Case of the Limpopo Basin, South Africa. IFPRI Discussion Paper 00849. February 2009.

Grothmann T., Patt A., 2005
Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environmental Change*, Part A 15, 199-213.

Hansen J., Marx S., Weber E. U., 2004
The Role of climate perceptions, expectations, and forecasts in farmer decision making: the Argentine Pampas and South Florida. IRI Technical Report 04-01. International Research Institute for Climate Prediction, Palisades, NY.

Hartter J., Stampone M. D., Ryan S. J., Kirner K., Chapman C. A., Goldman A. 2012
Patterns and perceptions of climate change in a biodiversity conservation hotspot. *PloS one*, 7 (2) : e32408.

Ingram K. T., Roncoli M. C., Kirshen P. H., 2002
Opportunities and constraints for farmers of west Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. *Agricultural Systems*, 74 : 331-349.

Judex M., Thamm H.-P., Menz G., 2008
« Dynamiques d'utilisation des terres dans le centre du Bénin ». *In* Judex M., Röhrig J., Shulz O., Thamm H.-P (éd .) : *IMPETUS Atlas du Benin. Résultats de Recherche 2000-2007,* 3e édition, Département de géographie, université de Bonn, Allemagne.

Klopper E., Vogel C.H., Landman W.A., 2006
Seasonal climate forecasts – Potential agricultural-risk management tools? *Climatic Change*, 76 : 73-90

Lebel T., Ali A., 2009
Recent trends in the Central and Western Sahel rainfall regime (1990-2007). *Journal of Hydrology*, 375 (1-2) : 52-64.

Leclerc C., Mwongera C., Camberlin P., Boyard-Micheau J., 2013
Indigenous past climate knowledge as cultural built-in object and its accuracy. *Ecology and Society*, 18 (4) : 22.

Lericollais A., 1999
Paysans sereer: dynamiques agraires et mobilités au Sénégal. Paris, Orstom Éditions, coll. À travers champs.

Liebmann B., Marengo J. A., 2001
Interannual variability of the rainy season and rainfall in the Brazilian Amazon basin. *Journal of Climate,* 14 : 4308-4318.

Marteau R, Sultan B., Alhassane A., Baron C., Traoré S. B., 2011
The onset of the rainy season and farmers' sowing strategy for pearl millet cultivation in Southwest Niger. *Agricultural and Forest Meteorology*, 151 (10) : 1356-1369.

Mertz O., Mbow C., Reenberg A., Diouf A., 2009
Farmers' perception of climate change and agricultural adaptation strategies in rural Sahel.
Environmental Management, 43 : 804-816.

Mertz O., D'haen S., Maiga A., Moussa I. B., Barbier B., Diouf A., 2012
Climate Variability and Environmental Stress in the Sudan-Sahel Zone of West Africa.
Ambio, 41 (4) : 380-392.

Meze-Hausken E., 2004
Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia.
Climate Research, 27 : 19-31.

Nielsen JØ, Reenberg A., 2010
Temporality and the problem with singling out climate as a current driver of change in a small West African village.
Journal of Arid Environments, 74 : 464-474.

Orlove B., Roncoli C., Kabugo M., Majugu A., 2010
Indigenous climate knowledge in southern Uganda: the multiple components of a dynamic regional system.
Climatic Change, 100 (2) : 243-265.

Osbahr H., Dorward P., Stern R., Cooper S., 2011
Supporting Agricultural Innovation in Uganda to respond to climate Risk: Linking Climate Change and Variability with Farmer Perceptions.
Experimental Agriculture, 25 : 293-316.

Ouédraogo M., Dembéié Y., Somé L., 2010
Perceptions et stratégies d'adaptation aux changements des précipitations : cas des paysans du Burkina Faso.
Sécheresse, 21 (2) : 87-96.

Ozer P., Hountondji Y.-C., Ahomadegbé M. A., Djaby B., Thiry A., De Longueville F., 2013
« Évolution climatique, perception et adaptation des communautés rurales du plateau d'Abomey (Bénin) ».
In : *Actes du XXVI*e *colloque de l'Association Internationale de Climatologie*,
AIC, Cotonou, Bénin : 440-445.

Pélissier P., 1966
Les paysans du Sénégal.
Saint-Yrieux, Imprimerie Fabrègue.

Reckien D., Wildenberg M., Bachhofer M., 2012
Subjective realities of climate change: how mental maps of impacts deliver socially sensible adaptation options.
Sustainable Science, 8 (2) : 159-172.

Slegers M. F. W., 2008
"If only it could rain": Farmers' perceptions of rainfall and drought in semi-arid central Tanzania.
Journal of Arid Environments, 72 : 2106-2123.

Simelton E., Quinn C. H., Batisani N., Dougill A. J., Dyer J. C., Fraser E. D. G., Mkwambisi D., Sallu S., Stringer L. C., 2013
Is rainfall really changing? Farmers' perceptions, meteorological data, and policy implications.
Climate and Development, 5 (2) : 123-138.

Sultan B., Baron C., Dingkuhn M., Saar B., Janicot S., 2005
Agricultural impacts of large-scale variability of the West African monsoon.
Agricultural and Forest Meteorology, 128 (1-2) : 93-110.

Tambo J. A., Abdoulaye T., 2013
Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna.
Regional Environmental Change, 13 (2) : 375-388.

Tschakert P., 2007
Views from the vulnerable: understanding climatic and other stressors in the Sahel.
Global Environmental Change, 17 : 381-396.

Tubiana L., Gemenne F., Magnan A., 2010
Anticiper pour s'adapter : Le nouvel enjeu du changement climatique.
Pearson Education France, 204 p.

Weber E. U., 2010
What shapes perceptions of climate change? Wiley Interdisciplinary Reviews:
Climate Change, 1 (3) : 332-342.

West C. T., Roncoli C., Ouattara F., 2008
Local perceptions and regional climate trends on the Central Plateau of Burkina Faso.
Land Degradation & Development, 19 : 289-304.

Wolf J., Moser S. C., 2011
Individual understandings, perceptions, and engagement with climate change: insights from in depth studies across the world.
Wiley Interdisciplinary Reviews: *Climate Change*, 2 (4) : 547-569.

Kosmowski F., Lalou Richard, Sultan Benjamin, Ndiaye O., Muller B., Galle Sylvie, Seguis Luc.

Contrasting perceptions with climate change : scientific observations in three West African contexts.

In : Sultan Benjamin (ed.), Lalou Richard (ed.), Amadou Sanni M. (ed.), Oumarou A. (ed.), Soumaré M.A. (ed.).

Rural societies in the face of climatic and environmental changes in West Africa.

Marseille : IRD, 2017, p. 87-107. (Synthèses). ISBN 978-2-7099-2424-5