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Farmers' Perceptions about Climate Change and their Adaptation Strategies: a case Study in the Fakara Region of Niger

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Abstract

Information about farmers' perceptions of climate change and their adaptation strategies is needed for developing regional climate change adaptation plans for rural areas. This study was conducted in rural communities in the semi-arid Fakara region of Niger. The objectives were to identify the major effects of climate change and their impacts on the rural communities, adaptation strategies of the rural communities, and difficulties in using natural signs to predict the onset of the rainy season. Data were collected using participatory research tools. Farmers stated that the climate is becoming hotter and drier, and with more variability in rainfall. The major effects of climate change were drought, strong winds and floods. The major impacts were higher mortality of crop plants, insufficient pasture plants, increased parasites, eroded and crusted soils, destruction of habitat, and loss of livestock. Adaptation strategies were bio-physical (e.g., using early-maturing crop varieties, mulching, improving natural regeneration management), organizational, economic and cultural (e.g., organizing monitoring committees for natural resource management, working together to establish micro water catchments in crop fields, planting cash-crop species in the off-season).Farmers used to predict the onset of the rainy season based on tree phenology, bird behavior and other natural signs, but these indicators are no longer reliable. Despite difficult climatic conditions, farmers are trying to preserve their natural resources and adapt to climate change.

Keywords: Climate Change Adaptation, Environmental Risks, Indigenous Knowledge.

Introduction

Rural communities in semi-arid Niger are essentially in rhythm with the changing seasons. Their main activities are agriculture and animal husbandry, practices which are highly dependent on local natural resources. In the past, traditional practices of agriculture and animal husbandry preserved a balance between humans and the environment. The climate, however, has become hotter and drier, with more variability in rainfall (Buontempo, 2010). During the last 30 years, climate change and anthropogenic pressures exacerbated by high population growth have caused accelerated degradation of the environment (Vgen & Gumbricht, 2012), resulting in the local disappearance of many native tree and shrub species that rural communities use for essential products and environmental services (Larwanou, 2008). Climate change has also affected local knowledge systems: for example, in the past, farmers used natural phenomena such as vegetative and reproductive phenology of certain tree species to predict the onset of the rainy season, but these indicators are no longer reliable.

Faced with this situation and aware of the need to preserve natural resources, which are shared by all people and are the foundation of agricultural production, farmers and herders are developing local adaptation strategies to climate change (Boureima et al., 2012). Adapting to climate change includes all adjustments in behavior and activities that reduce the vulnerability of society to climate change (Smith et al., 1996; IPCC, 2001). Adaptation strategies of farmers and herders apply to all aspects of the rural sector and are based on a logic that seems obvious in the societies that produced them (Knowler & Bradshaw, 2007; Mertz et al., 2009; Huq et al., 2011).

This study deals with climate change as perceived by rural farming communities in the Fakara region of Niger. The objectives are to identify (1) the major effects of climate change and their impacts on the rural communities, (2) adaptation strategies of the rural communities; and (3) difficulties faced by rural communities in interpreting natural signs related to the onset of the rainy season. Adaptation strategies of rural communities, like those reported in this study, provide useful information for agricultural agencies responsible

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for developing climate change adaptation plans in semi-arid West Africa.

Materials and methods

Study area

The study was conducted in the Kampa Zarma and Bankadey villages located in the Fakara region of southwestern Niger (latitude and longitude of the two villages = 2.649 °N, 13.443 °E and 2.649 °N, 13. 530 °E, respectively). Fakara is a small region (6,000 km^2) with 47 villages, and is located between the Niger River valley in the west and the Dallol Bosso valley in the east. The climate is semi-arid with an average annual rainfall of 560 mm between 1905 and 1989, but only 495 mm between 1968 and 1989 (Le Barbé & Lebel, 1997; Hiernaux & Ayantunde, 2004). The rainy season lasts 4-5 months, with the heaviest rainfall in August. The monsoon system is very regular, but the spatial and temporal distribution of rainfall is unpredictable (Hiernaux & Ayantunde, 2004). The climate is also characterized by a long dry season with very low humidity (daily minimum <5%) (Hiernaux & Ayantunde, 2004). The average daily maximum and minimum temperatures recorded during the period 1960-1996 were 46 °C and 8 °C (DMN, 1997).

Data collection and analysis

Data were collected in three distinct but complementary phases in November 2016, using participatory research tools. These included discussions in village meetings, discussions in focus groups, and focused interviews. The village meetings brought together all social strata in the villages. Each meeting lasted approximately 45 minutes and was attended by 60 men and 67 women in Kampa Zarma, and 52 men and 60 women in Bankadey. Relevant and reliable information was collected from the villagers and used to prepare for the discussions in focus groups. Two discussion sessions in focus groups were held in each village: one focus group of older men and women, and another focus group of younger men and women. There were six men and six women in each focus group. The focus groups allowed older men and women to comment on the observed changes related to climate in their village landscape during the last thirty years, and younger men and women to explain how they face the adverse climate in order to preserve their livelihoods. In each village, individual interviews were conducted with 10 men and 10 women identified in the focus groups. Detailed information about adaptation strategies was obtained in these interviews. The interviews were recorded electronically and transcribed. The information was organized into categories that included all the ideas about different aspects of climate change.

Results

Major effects and impacts of climate change

The major effects of climate change in Kampa Zarma and Bankadey were drought, strong winds and floods, listed in order of severity. These effects have impacts on the available resources from which the communities derive their livelihoods. The impacts were greatest on natural resources (crop fields, ponds, water points, herbaceous and woody pastures), financial resources (livestock, market access) and to a lesser extent physical resources (granaries, houses, farm equipment). Farmers listed many impacts but, for further analysis, we retained what they considered to be the main impacts (Table 1). The main impacts related to production of food crops, pasture plants and domestic animals.

Adaptation strategies of rural communities

Farmers cannot tackle climate change directly, but they can mitigate the short- and medium-term impacts on their livelihoods. Farmers' adaptation strategies are listed in Table 2, and described in more detail in Table 3. The adaptation strategies are endogenous or introduced. Most are bio-physical strategies (e.g., using early-maturing crop varieties, mulching, improving natural regeneration management, etc.). Some are organizational, economic or cultural strategies (e.g., organizing monitoring committees for natural resource management, working together as a community to establish zaï pits in the crop fields, and planting cash-crop species in the off-season).

Difficulties in using natural signs to predict the onset of the rainy season

Farmers' perceptions are rooted in traditional knowledge, which is the cumulative body of knowledge, know-how and practices maintained and developed by people whose history is intertwined with the natural environment. The interpretation of natural phenomena, which is part of the traditional knowledge, has been affected by climate change. In the past, farmers üsed certain natural signs to predict when the rains would start, but now those signs are no longer reliable. For example, a 75-year-old farmer from Bankadey said: "We elders today are disoriented because the same causes do not produce the same effects. Now, when we see a sign or phenomenon we cannot say exactly when the rains will start". Another older farmer in Kampa Zarma said: "Now farming is like the lottery. We can no longer effectively predict what will happen by simple observations of environmental signs."

Table 4 lists some of the natural signs that farmers traditionally used to predict the onset of the rainy season in a relatively short time (30 days), but which today are not reliable because of climate change. These signs are based on phenology of vegetative buds and fruits of trees, the response of certain birds to a change in temperature associated with a change in wind direction, and a change in bird's plumage.

Table 1
Major effects and observed impacts of climate change perceived by rural communities in the Fakara region of Niger

Major effects	Observed impacts
Drought (prolonged lack of rain during the rainy season)	• Loss of seeds and need to resow seeds • Insufficient pasture due to the disappearance of woody and herbaceous vegetation • Parasite infestations on crop plants and pasture plants
Strong winds	• Young plants buried by sand • Soil erosion and crusted soils • Destruction of habitats and grain stores
Floods	• Loss of large number of livestock • Leaching, creation of gulleys and erosion of crop fields

Table 2
Current adaptation strategies of rural communities to mitigate observed impacts of climate change in the Fakara region of Niger

Observed impacts of climate change	Current adaptation strategies
Loss of seeds and need to resow seeds	• Use improved early-maturing varieties • Use other crop plants, such as cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*), sorrel (*Rumex acetosa*) and sesame (*Sesamum indicum*) • Produce certain crop plants in the dry season
Insufficient pasture due to the disappearance of woody and herbaceous vegetation	• Improved land clearing and natural regeneration management (NRM) • Monitoring committees for NRM • Plant fodder tree species
Parasite infestations on crop plants and pasture plants	• Fumigation
Young plants buried by sand	• Crop fields are partially cleared until weeding • Improved land clearing and natural regeneration management (NRM)
Soil erosion and crusted soils	• Mulch crop fields or cover soil with branches and crop residues (millet stems, etc.) • Work together to establish zaï pits in crop fields (small water catchment pits)
Destruction of habitats and grain stores	• Dead and live fencing
Loss of large number of livestock	• Move livestock to higher ground in the plateaus
Leaching, creation of gulleys and erosion of crop fields	• Use organic matter • Use small quantities of mineral fertilizer • Mulch crop fields or cover soil with branches and crop residues

Table 3
Description of farmers' current adaptation strategies to climate change in the Fakara region of Niger

Current adaptation strategies	Description
1. Use improved early-maturing varieties	Due to climate change, the rainy seasons are not like they were in the past. To reduce risk, farmers are using small amounts of improved early-maturing varieties of pearl millet (*Pennisetum glaucum*), sorghum (mainly *Sorghumbicolor*) and cowpea. However, local varieties are still used and jealously conserved.
2. Use other crop plants, such as cowpea, groundnut, sorrel and sesame	If the rainy season is delayed or if there are dry spells of 3-4 weeks after planting millet, then farmers abandon the millet and plant

	crops such as cowpea, groundnut, sorrel or sesame.
3. Womens' groups produce certain crop plants during the dry season	Due to the uncertainty of rainfall, crop production during the dry season has grown in importance in the Fakara, mainly in villages that have water resources, as is the case in Bankadey. The main crops are lettuce, tomato, cabbage and potatoes.
4. Improved land clearing and natural regeneration management (NRM))	NRM is a traditional technique that involves selecting seedlings in the fields while preparing the fields for planting. Species are chosen based on their importance and farmers' preferences. This technique is carried out from February to May.
5. Monitoring committees for NRM	The monitoring committee is composed of two men and two women from the village. The committee is responsible for controlling and preserving the forest resources of the village.
6. Plant fodder tree species	Several useful fodder tree species have disappeared in and around the villages of Kampa Zarma and Bankadey. Farmers try to reintroduce some species in their crop fields. The most planted species are local and improved varieties of *Ziziphus mauritiana*, *Balanites aegyptiaca*, *Piliostigma reticulatum* and *Bauhinia rufescens*.
6. Fumigation	Treatment of crops in case of parasitic attack is done by fumigation. Harmful insects are caught and burned in the fields in order to smoke out other harmful insects.
7. Crop fields are partially cleared until weeding	To protect seedlings against strong winds, farmers gradually clear the fields. In some parts of sown fields, they leave shrub stems to protect the seedlings: they reduce the shrub stems only when the seedlings are vigorous.
8. Mulch crop fields or cover soil with branches and crop residues (millet stems, etc.)	Mulching involves covering the crop fields, especially the degraded parts, with stems of millet or sorghum, branches and other crop residue after harvests. To do this, the farmers must determine the direction of water flow and the direction of prevailing winds, and cover the field with a layer of dead plant material oriented in the direction of the prevailing wind and the flow of rainwater. This traditional technique performed after the harvest has several advantages: it is simple and manageable by farmers; the material used to cover the soil is readily available; the investment costs are low; and it gives value to agricultural by-products.
9. Work together to establish zaï pits in crop fields	This cultivation technique is used to collect rainwater and loosen crusted and compacted soils. It involves digging holes in staggered rows that are perpendicular to the flow of rain water. The holes have the following dimensions: diameter = 20-30 cm; depth = 20-25 cm; distance between holes = 60-80 cm. The excavated soil is placed downslope of the holes so that it receives water coming from upslope. This technique should be carried out preferably after the harvest when the soil is still moist and easy to dig. Using compost is desirable because decomposing manure can burn seedlings. This technique has the advantage of being simple and it has low investment costs.
10. Dead and live fencing	Farmers use dead and live fences to protect habitat and graineries against high winds. These protective fences are made with millet and sorghum stems, and branches from native tree and shrub species.
11. Move livestock to higher ground in the plateaus	To prevent major losses of animals in case of flooding, shelters are built on upland plateaus.
12. Use organic matter	This technique involves applying manure on eroded areas and barren fields. This traditional strategy of rebuilding soil fertility is prevalent in villages. Manure is always placed on the soil surface, rather than being buried in the soil. The manure of small animals is more popular than that of large animals. Two periods of manure application are observed. The manure produced during the dry season is left in piles in the field, and is applied only shortly before

	the first rains to limit losses caused by wind erosion. The second application period is during crop harvest. The ground was still moist, which facilitates decomposition and mineralization of the manure.
13. Use small quantities of mineral fertilizer	Farmers use mineral fertilizer in small quantities (microdose) when the crops are in the fields. The most used mineral fertilizer is NPK (15-15-15).

Table 4
Some natural signs that rural communities used in the past and now use to predict the onset of the rainy season in the Fakara region of Niger

Natural signs	In the past	Now
Initiation of vegetative bud growth on *Adansonia digitata* trees	At the onset of the first buds, farmers expected that the rainy season would start in 30 days.	Even after 45 days, the rainy season has not effectively started.
Fruits of *Sclerocarya birrea* trees are ripe and ready to harvest	Farmers started to sow millet and sorghum seeds in the fields when the *S. birrea* fruits were ripe. Children helped sow the seeds and also collected ripe fruits that had fallen to the ground.	The sowing season starts after the children have finished the collection of *S. birrea* fruits.
Wind blowing from west to east	When the wind started blowing from west to east, farmers expected the first rains in 15 days.	The rains start 30 days or more after the wind starts blowing from west to east.
The capture in large numbers by the village children of a small fat bird commonly called "Bangaliti" that lives in hollow trees	These birds do not tolerate high temperatures and the wind from west to east is warm, so the birds seek shelter in the village huts where they are easily captured by children. When the birds were caught in large numbers, farmers expected the rains to start in 15 days.	One month after the children have caught large numbers of the birds, the rainy season still has not effectively started.
The appearance of a feather on each wing of a small bird commonly called "Gartché"	With the appearance of these feathers on the wings of the bird, giving it the appearance of a tillage tool (Koumbou) used for weeding in Zarma ethnic communities, farmers expected the rains to start in 15 days.	The rainy season may start as much as 45 days after the feathers appear on these birds.

Discussion

Farmers in Kampa Zarma and Bankadey in the Fakara region of Niger perceive that climate change is a reality. Very few farmers in Niger use the results of climate research and have access to seasonal forecasts (Tarhule & Lamb, 2003), so their perceptions about climate change are based mainly on personal observations and the analysis and interpretation of environmental phenomena. Most interviewed farmers in this study stated that the rainy season has changed over the last thirty years. They agreed that now the rainy season is shorter and hotter, and rainfall is more variable, which is consistent with recorded changes (Buontempo, 2010). They did not, however, understand the phenomenon of global warming resulting from the production of greenhouse gasses.

Farmers in this study stated that the major effects of climate change were drought, strong winds and floods. Studies in other regions in Africa [Limpopo Province of South Africa (Thomas et al., 2007), eastern Saloum region of Senegal (Mertz et al., 2009), northern Benin (Guilbert et al., 2010)] also show that farmers recognize that the climate is changing. This is to be expected because climate change directly affects their livelihoods. Although farmers are aware of the problem, perceptions about the effects and their impacts differ due to cultural, social and environmental factors (Wolf & Moser, 2011).

Climate change has not only increased the vulnerability of rural communities in this study, but has also weakened their ability to predict the onset of the rainy season based on natural signs. When natural signs are no longer reliable predictors of seasonal changes, planning agricultural activities is more difficult. Understanding the problem and analyzing different options for adaptation are essential therefore in order to

reduce vulnerability (Tschakert, 2007). Adaptation strategies integrate technological and social innovations that necessitate strengthening the adaptive capacity of local communities. For example, natural regeneration management by farmers in Niger has increased woody vegetation cover during a period of increasing aridity and human population growth (Ozer et al., 2010). Farmers in Niger have also adapted by using improved seed of crops for production during the dry season in areas where water is available for irrigation. In addition, they have created new organizational structures as part of their adaptation strategies: these include monitoring committees for natural regeneration management and management committees for the production of crops during the dry season. These organizational structures, which are composed of men and women, were created to ensure sustainability of the practices, to facilitate learning and knowledge exchange within the rural communities, and to strengthen the community's sense of ownership of the adaptation strategies.

Farmers in other parts of semi-arid West Africa are also developing and implementing climate change adaptation plans. For example, farmers in northern Nigeria have demonstrated resilience by actually increasing agricultural production through various technical innovations (Adger et al., 2003), and farmers in Senegal are adapting in part by using a broader range of cash crops such as cowpea, sesame and watermellon (*Citrullus lanatus*) (Mertz et al., 2009).

Climate change is global and directly or indirectly affects everyone, but concerns about the impacts of climate change differ. In this study, the major concern of farmers was the impacts of climate change on their livelihoods, which are highly dependent on rain-fed agriculture. Studies in other continents have shown that concerns about climate change include not only environmental and livelihood issues, but also issues related to global inequalities, fairness and health (Wolf & Moser, 2011).

In conclusion, despite the difficult climatic conditions, farmers in the Fakara region of Niger are trying to preserve their natural resources. Men and women from all social classes have developed climate change adaptation strategies based on their experience and knowledge. These strategies could be used in development initiatives in Niger. Similar studies in other parts of semi-arid West Africa are needed in order to recommend regional strategies.

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