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Farm management decision and response to climate variability and change in Côte d'Ivoire

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Abstract This paper investigates threats to farm management in the northern and central region of Côte d'Ivoire, with a particular focus on climate-related threats. To this end, farmers' perception and adaptation strategies for climate change have been analyzed. The data were collected from 205 respondents by means of the Focus Groups method, and they were evaluated using a framework analysis. The main reported threats related to the implementation of farming activities are the high cost of inputs and the lack of technical support, which are followed by diseases, insects, and climate variations (scarcity of rains, strong winds, and high temperature). We find that most farmers have a strong perception of changes in climatic conditions. Their perceived impacts on the local environment through evidences like the disappearance of certain farming practices, occurrence of new insects, and the disruption of key time reference periods. Farmers mainly attempt to adapt by adjusting their agricultural calendar, adopting new short-season varieties, and using mixed cropping. We find that the most influential factors for farmers' adaptation behavior is lack of contact with extension services and the scarcity of rainfall. Our suggestions for future agricultural policies for better adaptation to climate change are to take into account farmers' perception, to provide suitable climate forecast, and to improve local technical support.

Keywords Adaptation strategies · Agriculture · Climate change · Côte d'Ivoire · Perception · Smallholder farmers

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1 Introduction

Climate change (CC) according to the United Nations Intergovernmental Panel on Climate Change (IPCC), refers to any change in climate over time, whether due to natural variability or as a result of human activity. Climate variability refers to variations in the mean state and other statistical measures (such as standard deviations and statistics of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC 2007). Unless formal distinctions between CC and climate variability are drawn, CC itself becomes a difficult concept to define, because all natural "change" is merely a reflection of variability on some appropriate time scale (Washington et al. 2006). CC and climate variability are not conveniently separated processes, but are instead closely coupled in the complicated evolution of the climate system.

In West Africa, the impact of CC is expected to be very severe because it directly causes damage to domestic welfare, which depends mostly on the primary sector of the economy (Mendelsohn et al. 2000). During the last decades, CC has been very evident and has resulted in a southward shift of the climate zones, e.g., spread of the Sahara desert into the Sahelian zone (Wittig et al. 2007). A decline in annual rainfall has been observed since the end of the 1960s, with a decrease of 20–40 % noted between the periods 1931–1960 and 1968–1990 (Nicholson 2000; Chappell and Agnew 2004). As a prevision, it is foreseen that the crop yields will be adversely affected and the frequency of extreme weather events will increase (Collier et al. 2008). The projected reductions in yield could rise up to 50 % by 2020, and net crop revenues could fall down to 90 % by 2100, with small-scale farmers being the most affected (Boko et al. 2007).

Adaptation is defined as the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). Although CC is a difficult phenomenon to detect according to some authors (Blennow and Persson 2009; Elke 2010), farmers in Sub-Saharan Africa are well aware of CC (Benedicta et al. 2010). In particular, subsistence farmers are far more likely to notice changes in climate than other farmers because of their experience in farming (de Wit 2006). The fact that farmers are very good at detecting CC is a basic precondition for adaptation (Maddison 2006). Despite this fact, many African farmers have done almost nothing in response to CC (Ringler 2010). To overcome this gap in implementing adaptation strategies, it is essential to understand farmers' behavior in their decision-making with regard to climate risks, in order to establish efficient and acceptable adaptation strategies for CC.

Like most developing countries in Western Africa, Côte d'Ivoire is vulnerable to CC, specifically in the sectors of agriculture, coastal resources, water resources, and forestry (MEEF 2000; Ochou 2011). This vulnerability is exacerbated by widespread poverty, environmental degradation, natural resource mismanagement, and dependence on rain-fed agriculture (Dixon et al. 2003). The temperatures increased approximately by 1 °C between 1960 and 2000 (Kouakou et al. 2012), and annual rainfall decreased by an average of 0.5 % per year between 1965 and 1980 and by 4.6 % per year in the 1980s (MET 1994; Birgit and Bruzon 2006). The impacts of CC are gradual in the South of the country, but are already significant in the North (Gadegbeku 2009).

Based on this background, we aim to investigate how farmers in two regions of Côte d'Ivoire—Toumodi in the central part and Korhogo in the North—have perceived as well as reacted to these changes. More specifically, this paper intends to (i) identify farmers' decisions regarding farm management in general and more specifically regarding actions for adapting to CC; (ii) assess their perception of CC; and (iii) identify influencing factors for their adaptation behavior. This first study of its type in Côte d'Ivoire will provide useful insight into farmers' decision-making processes regarding adaptation to CC.

2 Study areas

The climate in Côte d'Ivoire is generally warm and humid and is overall transitional from equatorial to tropical (Fig. 1). Toumodi is located in the forest-savanna transition zone of central Côte d'Ivoire and has two rainy seasons; the average annual rainfall is 1,000–1,200 mm and the temperature ranges between 14 °C and 39 °C (MPARH 2003; Tié et al. 2010). The soil is characterized by sandy-humus and clayey horizons (Birgit and Bruzon 2006). The climate in Korhogo (North) is Sudano-Guinean with a single rainy season and annual rainfall between 1,100 and 1,600 mm. The temperature ranges between 10 °C and 42 °C (MPARH 2003). Generally, the soil in Korhogo is ferruginous with low humus content and average fertility (Zagbaï et al. 2006). The central and northern areas are different with regard to both their vegetation and socio-cultural characteristics. Therefore, the results of the study could help understand the importance of these socio-cultural factors in farmers' decision-making behavior regarding adaptation to CC.

3 Methodology

This study used a qualitative research method because the purpose is to develop an in-depth understanding of farmers' perception of and their adaptation behavior regarding adaptation to CC. The collected qualitative data allow us to identify in an exhaustive manner all factors influencing farmers' behavior.

3.1 Focus groups

Focus Groups is a method for collecting data through group interaction on a topic determined by the researcher (Morgan 1997). This method has been developed and applied since the 1990s (for more details see Krueger 1994; Templeton 1994; Morgan and Krueger 1998). One of the key advantages of Focus Groups is its flexibility and ability to reveal rich and sensitive information. One of the limitations of Focus Groups is that it can result in an undesirable bias: first, the moderator could exert too big an influence on the group; second, the phenomenon of dominance may occur (some participants may strongly influence the discussion). To avoid these biases, we developed precise guidelines and trained the moderator on how to deal with group interactions and dominant participants.

We have chosen this approach because it is ideal for exploring the complexity surrounding farmer's adaptation behavior regarding climate variability and change, and can generate large amounts of data in a relatively short time span; moreover, the findings may be used as preliminary data for quantitative procedures (Rabiee 2004).

The questions discussed were tailored around guidelines related to the following four topics: (i) Farmers' farm management and opportunities, including farmers' aims regarding farm management, the relevant threats, and implemented actions; (ii) Farmers' perception of CC through atmospheric characteristics, farming practices, and local environment; (iii) The way farmers deal with climate uncertainties, especially the sources and types of information they receive; (iv) Factors influencing farmers' behavior related to adaptation to CC. Therefore, their past experiences, knowledge, and expectation with regard to CC were

Fig. 1 Côte d'Ivoire study areas

discussed. Finally, the conflicts between crop and livestock farmers and their probable link with CC have also been discussed (e.g., damage to growing crops, destruction of harvest, and pressures on the fallow imposed by herds) (Hussein et al. 1999).

3.2 Sample selection and description

Sixteen Focus Groups investigations were carried out from June to August 2011 in Toumodi (8 in 9 villages) and Korhogo (8 in 4 villages), with a total of 205 respondents which represents 4 % and 0.8 % of all farming households in Toumodi and Korhogo, respectively. We followed the method of Krueger (1994) by continuing with the Focus Groups until a clear pattern emerged and subsequent groups produced only repetitious information (theoretical saturation). The resulting sample size is comparable to that of other studies which used the Focus Group approach (cp. e.g. Zaouche et al. 2011; Ishak and Bakar 2012). The information gathered in our Focus Groups was exhaustive, which was underlined by the finding that the last additional group discussion did not reveal any new item.

The ideal number of participants in a group ranges from six to ten (Zaouche et al. 2011). To build up our sample, we considered (i) the geographical location of the village, (ii) the type of farming activities, and (iii) the age of the farmer as the main selection criteria.

First, in Toumodi, the villages were randomly selected using a list of farmers obtained from the National Rural Development Support Agency (ANADER); villages in both in the forest and the savannah parts were selected, after ruling out those inaccessible by car. In Korhogo, the same process was used.

Secondly, participants in the Focus Groups were selected so that different farming activities were represented: we therefore selected crop farmers, livestock farmers, and those involved in diversified farming. Finally, elderly participants with maximum age about 80 years were selected because they had experienced a change in climatic elements over the past 30–40 years. This sampling approach allows researchers to compare the views of different types of farmers and to better understand the factors leading to the implementation of the strategies being practiced. The socio-cultural differences between the two areas were considered. In Korhogo (Muslim and conservative part of the country), women and men were separately interviewed, which was not the case in Toumodi.

The discussions were recorded and were conducted with the support of local extension agents and students who also translated the local languages *Baoulé*, *Sénoufo*, and *Dioula* to French. To avoid misinterpretation during the transcription, two agents worked together throughout all Focus Groups discussions. Furthermore, the geographical coordinates of villages, socio-demographic characteristics, and data related to the surface of farms, the type of crop grown, and the number of animals was collected.

The average age of the participants was 45 years, and the average household size was 10 people. The level of education in Korhogo is much lower than that in Toumodi. Moreover, the average number of years of experience in crop farming and livestock production was 22.32 years and 10.20 years respectively (Table 1). The Mann-Whitney *U* test (Field 2009) applied to the sample revealed significant differences between farmers with regard to crop farming experience, gender, education level, head of household status, and marital status.

3.3 Data analysis

The framework analysis as described by Ritchie and Spencer (1994) was used to analyze the 300 pages of transcribed notes. It involved five highly interconnected key stages: familiarization; identifying a thematic framework; indexing; charting; and mapping and interpretation. Familiarization can be achieved by listening to recorded discussions and notes and reading the transcript several times. This is followed by identification of a thematic framework by writing memos in the form of short phrases and ideas, and beginning to develop categories. Indexing involves sifting the data, highlighting and sorting out quotes, and making comparisons both within and between groups. Charting involves lifting the quotes from their original context

Table 1 Characteristics of the farmer participants in the Focus Groups

	Variable	Korhogo	Toumodi
	Age (year)	45.85 (15.26)	46.98 (13.37)
	Household size	11.14 (7.12)	10.59 (5.85)
	Household head (%)	61.5**	81.2
	Male (%)	54***	85
Education level***	Illiterate (%)	83.7	39.6
	Primary school (%)	13.5	32.7
	Secondary school (%)	1.9	23.8
	University (%)	0	4
	Koranic school (%)	1	0
Marital status***	Single (%)	1.9	22.8
	Married (%)	90.4	74.3
	Widower/Widow (%)	7.7	2
	Divorced (%)	0	1
	Experience in crop farming (year)	22.32** (14.32)	15.26 (10.06)
	Experience in livestock practicing (year)	10.20*** (10.28)	7.2 (5.69)
	Surface of root, tuber & starchy (ha)	0.12*** (0.36)	1.55 (1.58)
	Surface of cereal (ha)	2.72*** (2.6)	0.16 (0.35)
	Surface of vegetable (ha)	0.13 (0.29)	0.19 (0.47)
	Surface of cash crops (ha)	4.87 (5.53)	3.25 (3.83)
	Number of ruminant and porcine	6.76*** (11.78)	2 (8.18)
	Number of poultry	5.08 (10.65)	5.55 (14.36)

Numbers in parentheses are standard deviations. *** and ** denote significance on the 1 % and 5 % level

and re-arranging them under the newly-developed thematic content. The coded data can be interpreted based on words, context, internal consistency, frequency, and extensiveness of comments (Krueger 1994). In qualitative analysis, coding the processes of identifying and connecting the passages of text and clarifying the concept or idea represented by the "node" is an important part of the analytic process.

A node (or item) is defined as a group of words, and sentences of the transcript, which are related to the same topic or subject. It could be sub-divided into small parts called sub-nodes which contain more focused information.

For this study, the frequencies of the number of quoted words or sentences are assigned to different nodes, which indicates its relative importance to other nodes. The score helps build up adequate and nuanced conclusions (Paillé 1996). As a requirement for reliability, an inter-coder was also used to establish dependability of the data analysis. The software N'vivo 9 was used to organize, code, and classify the transcript (www.qsrinternational.com/products_nvivo.aspx). The total number of nodes (equivalent to items) created for Toumodi and Korhogo was 108 and 106 respectively, grouped into 12 main nodes (Table 2), which covered 48 % and 46 % of the transcript respectively. The most represented nodes were "relevant threats in farm management," "adaptation strategies to CC," and "perception of CC." The similarity in both study areas reveals the common interests of farmers with regard to the most frequent items.

Table 2 Frequencies of most items quoted by farmers (% of words and sentences)

Item	Korhogo Frequency (%)	Toumodi Frequency (%)
Relevant threats	10.82	9.78
Adaptation strategies to CC	8.59	8.23
Perception of CC	7.75	8.76
Causes of CC	4.95	3.06
Impacts of CC	4.94	4.97
Suggestions for adaptation	3.26	1.93
Actions implemented against threats	2.93	1.95
Own objectives of farmers	2.34	3.14
Conflicts between crop & livestock farmers	1.31	2.27
Opportunities in farm management	0.77	0.53
Knowledge about weather & CC forecasting	0.50	1.34
Farmers' pessimistic expectations	0.12	0.43
Total	48.28	46.39
Standard deviation	3.48	3.30

The total does not equal 100 because all the 300 pages of transcript were not embedded into a node, notably the intervention of the moderator of the discussions

4 Results and discussion

4.1 Farmers' perception of relevant threats in farm management

The relevant threats of farmers have been grouped into seven categories (Table 3). The analysis of the Focus Groups showed that the threats related to the technical farming factors are the most relevant for farmers in both study areas. This category includes the following items stated by the farmers: high cost of inputs (pesticides, herbicides, and fertilizers), financial problems, rapid growth of weeds, non-effectiveness of certain treatments against insects and weeds, poor quality of seeds, lack and high cost of farming labor, coincidence of farming activities, wildfire, and large fields compared to the low availability of household labor. The major threats related to the technical farming factors differ across study regions. In Toumodi, the most important threats are insects and diseases, followed by climate (unpredictability of climate and scarcity of rains) and farming lands (lack of farming lands and poor soil fertility), and finally lack of technical support. In Korhogo, the major threats mentioned by farmers, in order of the biggest threat to the smallest, are market access and prices, insects and diseases, and climate and animal breeding. These differences are due to differences in farming systems (e.g., the use of different crops and the focus on livestock breeding in Korhogo) and location (Toumodi is closer to the main market in Abidjan).

4.2 Farmers' perception of climate change

In Korhogo, the following indicators are most frequently used by farmers to describe their perception of CC: changes and characteristics in rains patterns, changes in the local environment, and disappearance of some farming practices. Thus, indicators such as sunshine, wind characteristics, disturbance of farming seasons, and reference period are less

Table 3 Description of relevant threats in farm management

Domain	Relevant threats in farm management	Toumodi		Korhogo	
		Quotation	%	Quotation	%
Technical farming factors	High cost of pesticides, herbicides & fertilizers	10	4.17	48	15
	Financial problems	36	15	15	4.69
	Rapid growth of weeds	12	5	15	4.69
	Non effectiveness of pesticides and herbicides treatments	7	2.92	8	2.5
	Poor quality of seeds	6	2.5	7	2.19
	Lack & high cost of farming labor	12	5	0	0
	Coincidence of farming activities	7	2.92	0	0
	Wildfire, bushfire	3	1.25	1	0.31
	Too large fields	0	0	1	0.31
Insects & diseases	Insects and diseases	30	12.5	21	6.56
	Termites in the soil	4	1.67	2	0.63
	Animal diseases	4	1.67	29	9.06
Climate	Unpredictability of climate	5	2.08	0	0
	Scarcity of rains	19	7.92	23	7.19
	Wind	2	0.83	0	0
	Burning sun	2	0.83	0	0
	Scarcity of irrigation	3	1.25	9	2.81
	No dams and rivers	1	0.42	9	2.81
Farming lands	Lack & aging of arable land	0	0	15	4.69
	Problem of soil fertility	15	6.25	3	0.94
	Lack of forest	10	4.17	0	0
	Logging companies	2	0.83	0	0
Technical support	Lack of technical support	26	10.83	22	6.88
Market access & prices	Market access and low prices	15	6.25	56	17.5
Animal	Animal damages	3	1.25	21	6.56
	Theft of animals & accident with cars	4	1.67	3	0.94
	Lack of pasture	1	0.42	0	0
	No enclosure & hen house	1	0.42	12	3.75
	Total	240	100	320	100
	Standard deviation	9.35	3.90	14.45	4.52

Focus Groups

frequently mentioned. Furthermore, compared to the farmers in Korhogo, the farmers in Toumodi perceive more intensively the impact of the disruption of key time reference period and shift in rainy seasons (Fig. 2).

4.2.1 Rain patterns and characteristics

Farmers have observed a decrease in the frequency and amount of rain. In these areas, rainfalls usually occur at intervals of a few weeks even during the rainy season, and they are

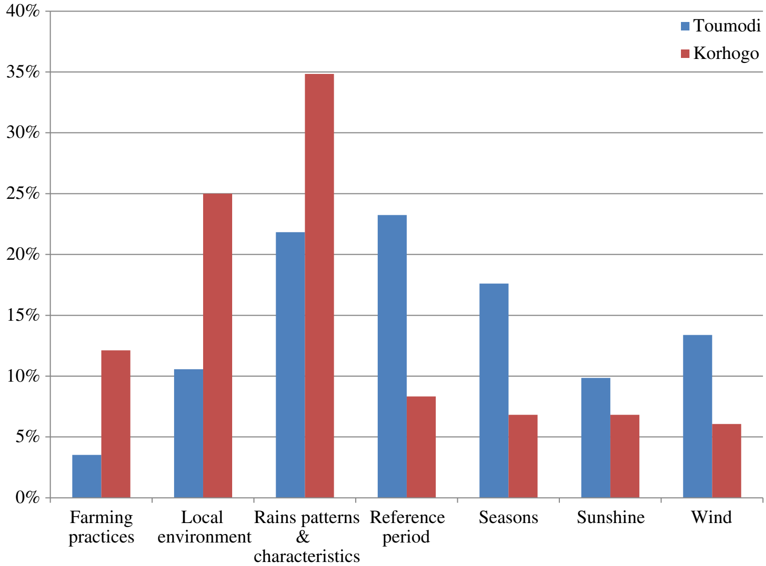

Fig. 2 Farmers' perception of changes in climate

accompanied by thunder and followed by violent winds. The intensity of rainfalls is low, and farmers even find hail after the rain. A change in the spatial distribution of rains has been observed. Also, the rainfalls are now more intense, which sometimes causes crop damage.

The changes observed in the local environment were also used by farmers to describe their perception of climate variability and change. For instance, water does not remain for a long time in shallow ponds during the dry periods anymore. Also, their forecast of rains based on the sunshine does not seem reliable; they used to consider the presence of a lot of stars in the sky at night to indicate upcoming rains, which is not a reliable indicator anymore. Therefore, farmers are not able to properly define the rainy periods. Moreover, current proliferation of unknown pests of crops and a change in fructification time have been noticed.

4.2.2 Seasons

It was observed that seasons have shifted and shortened. For instance, in Toumodi, the short dry season which started in August has shifted to July. In addition, farmers mentioned that the rainy seasons have become shorter over time. In the past, it would sometimes rain in the dry season, but this does not occur anymore. These assertions are confirmed by the findings of Goula et al. (2010), who reported that the duration of the growing season decreased by 30 days in the period 1951–2000. Along these lines, Ochou (2011) also attested to higher fluctuations in the end and start dates of the growing seasons.

Farmers explained changes in climate by modifications in their agricultural activities. The disruption of the agricultural calendar is proof of climate variability and change. Farmers mentioned that current onset and cessation times of the rains do not coincide with the times in their previous agricultural calendar. Consequently, they are confused about regularizing their cropping calendar and determining the most suitable crops to cultivate. The technique of crop succession and the semi-direct seeding of some crops such as cocoa (*Theobroma cacao*) are not suitable anymore to the new climatic conditions. Also, farming activities have become more sensitive to even little delays in their implementation.

Certain specific months and dates are considered as key reference indicators of climate over the years. As soon as a change occurs in these time points, farmers associate it as evidence of changes in climate. In Korhogo, August was formerly perceived as a rainy month, with rainfall levels of up to 400 mm (Beaudou and Sayol 1980). Farmers mentioned that this is no longer the case: i.e., August is currently not perceived as a rainy month. This perception of farmers is confirmed by data from the database of the National Meteorological Office of Côte d'Ivoire (SODEXAM), which show a decrease of 228 m in August rainfall levels in the period 1971–2002. Furthermore, rainfalls now occur in August instead of July

Table 4 Description of farmers' perception of climate change through non-climatic indicators in Toumodi

Level	Sub-level	Description
Agriculture	Farming seasons	In the past, the rainy season was the longest. The difference between the two was small, as it rained sometimes in the dry season. The short dry season, which is a period of wind, occurred in August but has shifted to July.
	Farming practices	In the past, farmers practiced the semi-direct seeding of cocoa, but nowadays they make seedbeds.
		Crop succession was possible, as rains before the harvest of yam (*Dioscorea alata*) allowed farmers to sow maize in the hillocks of yam.
		Nowadays, any little delay in the implementation of farming activities leads to significant loss in harvest.
		The wild animals destroy much more crop.
Environment	Local environment	In the past, it was possible to pick up some small pieces of ice when it rained, but it does not happen anymore. The weather is colder in the rainy season than before.
		Fruit maturation has changed as evidenced in the case of some fruits, which are mature on one side and still green on the other. Other fruits contain a lot of chenille. There is also green moss on the leaves of mango trees, which did not occur so much before.
		The small rivers and dams have dried up and no longer flow during the dry season.
		Unknown insects are found in the farms.
Time reference	Reference period	There was no rain even in June, which is in the rainy season. This year (2011) there was no rain in July either.
		In July, it used to rain a lot, precisely on July 14th; now it does not rain.
		It used to rain in April, even until July, but now everything has changed.
		In the past, the early yams were harvested in July.
		In the past, February was the beginning of the growing season.
		In 2006, it did not rain much. However, in 2009, it was worse.
		In 1985, there was a major wildfire. In 1990, bush fires destroyed everything.

Focus Groups

Table 5 Description of farmers' perception of climate change through non-climatic indicators in Korhogo

Level	Sub-level	Description
Agriculture	Farming seasons	The farming seasons were longer before, and there were two- or three-month intervals between two rainy seasons
		In the past, the first rains were strong and followed by the sun. They were called "Gbinwoza" or "Zewoza" which means "rain of February" in *Sénoufo*, the local language of Korhogo.
		January and February were characterized by hot winds that predict the coming rains; however, now the rain begins in May and ends in September.
	Farming practices	There is a disturbance in the agricultural calendar. The former planting dates are not anymore suitable to the new climatic conditions. Indeed, it does not rain enough during the sowing time; for instance, it often happens that the rain stops when the rice is sown.
		The lack of rain makes the space used for growing remain dry for a long period.
		The long-season (6 months) crops of yam (*Dioscorea spp*.) and rice (*Oryza sativa*) cannot be grown anymore because of lack of rain.
		Before, there were already new yams in August.
		In the past, the first rains started in March and April; the fields were already cleaned, and the hillocks of yams were built up so that the yams were already mature by August. Nowadays, the yams are progressively abandoned because it does not suit the new climate.
		The technique of crop succession is not feasible anymore. In the past, farmers could grow groundnuts followed by cotton; after the harvest of the groundnut, the furrows were used for the sowing of cotton.
		The rice could be grown twice a year, the "SATMACI" variety during the dry season and another variety in the rainy season. But now, only one harvest a year (during rainy season) can be done if the rain does not stop.
Environment	Local environment	Before, it rained enough and all the ponds and streams were filled. One could even see fishes. Moreover, water remained in shallow wells in dry periods. Nowadays, it completely disappears during the dry season.
		If it rains today, the soil dries up faster
		In the past, farmers harvested the rice and brought it to the village while it still rained, but now it stops before the harvest period.
		In the past, old men forecasted well the rain based on the intensity of sunshine and the stars in the sky. Now, the sun is not anymore an indicator of rains but rather the announcement of a freshness period.
Time reference	Reference period	It rained a lot in August and all the roads were flooded at that time; but today, August is dry
		In the past, the groundnut in some villages and the new yams were already mature in August.
		The maturation time of the Shea nuts coincided with the rainfall, which does not happen anymore.

Focus Group

in Toumodi. The rainy season was earlier well defined, and marked by the fruits of the Shea butter tree beginning to mature.

4.2.3 Wind and sunshine

The intensity of the sun and the power of winds have changed. Before, the winds were less intense, but now, strong winds which precede the rains chase out the stormy clouds. The lack of data on changes in wind speeds from SODEXAM does not help to confirm farmer's assertion. However, similar increasing winds had caused more pronounced movement of sand and destroying crops in Burkina Faso, a neighbor country of Côte d'Ivoire (Nielsen and Reenberg 2010). Sunshine is stronger nowadays than it was two decades before. For instance, from 1971 to 2000, the temperature in Korhogo has increased by an average of 0.8 °C every year (database from SODEXAM). Moreover, the direction of wind has changed according to some farmers. Further details of farmers' perception of CC are presented in Tables 4 and 5.

Table 6 Description of relevant actions implemented by farmers to deal with their threats in farm management

Level	Action implemented	Toumodi		Korhogo	
		Quotation	%	Quotation	%
Farming activities implementation	Association of crops	2	5.26	0	0
	Use of new varieties	1	2.63	0	0
	Re sowing & re planting	5	13.16	3	5.45
	Cleaning by hand	3	7.89	10	18.18
	Farming activities quickly completed	1	2.63	1	1.82
	Sanitary treatment of farms and livestock	11	28.95	16	29.09
	Animals in pens	3	7.89	0	0
	Firewalls	3	7.89	0	0
	Group of mutual aid	2	5.26	1	1.82
Funding of farming activities	Borrow money to buy inputs	0	0	1	1.82
	Funding certain product by selling others	3	7.89	4	7.27
	Pre-financing of farming activities	1	2.63	2	3.64
	Produce charcoal to buy inputs	0	0	4	7.27
	Sell fertilizer to solve household problem	0	0	1	1.82
Nature of farming lands	Find new farming lands	0	0	1	1.82
	Soil fertilization	0	0	2	3.64
	Reducing farm size	1	2.63	0	0
Sale of products	Creation of cooperative for better market access	0	0	6	10.91
	Sell before harvest	1	2.63	0	0
No actions	No solutions	1	2.63	3	5.45
	Total	38	100	55	100
	Standard deviation	2.55	6.72	4.00	7.27

Focus Groups

4.3 Action implemented against threats in farm management

Five different levels of intervention were identified (including the option of "no action") (Table 6): Implementation of farming activities, Funding of farming activities, Sale of products, and Nature of farming lands. However, no measures for fighting against bushfires and straying of animals were mentioned in Korhogo; the farmers deal with the problem of funding agricultural activities by producing charcoal. This short-term solution is a real problem, as deforestation in this area has increased in 2002 after the departure of water and forest protection agents due to the civil war (Pswarayi et al. 2010).

Poor soils in Korhogo have resulted in the search for more suitable land for agriculture. Otherwise, fertilizers, pesticides, and herbicides are applied if farmers have adequate financial means; in addition, farmers are more likely to organize themselves into cooperatives and informal groups to facilitate the sale of their products.

4.4 Interrelationship between non-climatic threats in farm management and arising actions implemented by farmers

In Toumodi, as in Korhogo, farmers implemented more measures for farming activities (borrowing money to buy inputs, re-sowing, replanting, etc.), while threats related to damage by livestock were inadequately addressed (Fig. 3). Therefore, farmers' range of possibilities with regard to technical farming activities is more important, while the lack of technical support is not addressed at all because it is outside the farmers' field of action. Also, the centrality of "no solutions" in Fig. 2 reveals the low adaptive capacity of farmers in dealing with non-climatic threats.

4.5 Adaptation strategies for climate change

The variety of rice (*Oryza sativa*) called 'SATMACI' was grown twice a year in Korhogo, but now, due to climate variability and change, only one harvest is possible

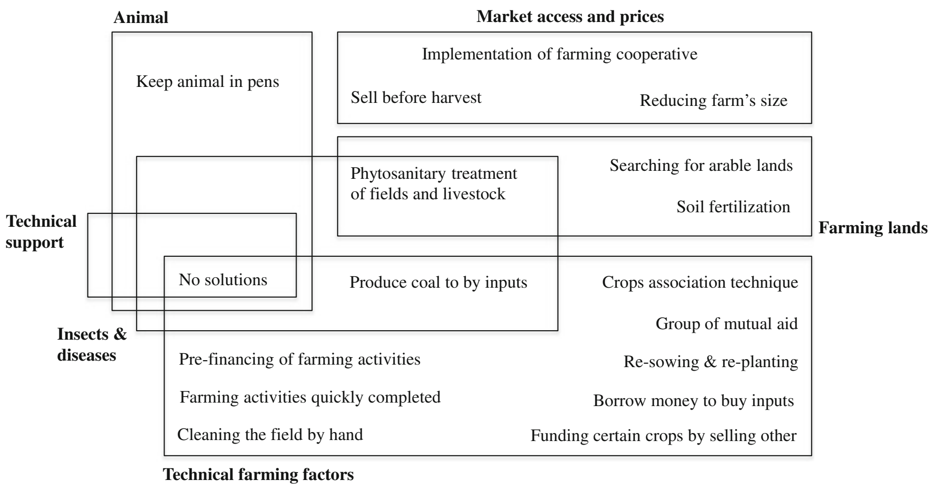

Fig. 3 Interrelationships between implemented actions and corresponding non-climatic threats in both study areas

Table 7 Description of adaptation strategies for climate change in Korhogo and Toumodi

Adaptation strategies	Korhogo	Toumodi
Adoption of new varieties	Use of a short-cycle (3 months) white variety of groundnut and rice. The yellow maize (*Zea mays*) was used to replace the white maize	The cocoa with a 3- to 4-year vegetative cycle has been replaced with the 14- to 18–month variety.
		The variety of yam (*Discorea spp*) called "Brazil," which was introduced by the extension services, is still used by farmers.
Crop association or mixing cropping	Rice-maize, maize-sorghum (*Sorghum*), millet (*Panicum milia ceum*)-rice, cotton-sorghum, groundnut-maize-sorghum, groundnut-millet-rice	Cocoa-banana (*Musa spp*) and then maize, cocoa-yam-banana, cocoa-yam-cassava (*Manihot esculenta*)-banana
		New varieties of yams are mixed with the traditional varieties on the same field.
Agricultural calendar adjustment	Cotton is cultivated before February. Rice is sown in June instead of April.	Yams are cultivated 1 month earlier.
	Green beans (*Phaseolus vulgaris*) and sorghum are planted in August instead of July; the white groundnut is planted in May or April instead of March.	
Change in the method of planting	Draft oxen are used to make large hillocks and large farms.	Large holes are made for the seedbeds to facilitate water retention.
	Re-sowing is undertaken after the lack of rain, or if the sun has burnt out the germinated nuts.	The technique of re-sowing is also implemented after poor germination of crops.
	Much higher amount of rice seeds are used during sowing.	A safe distance is kept between plants to prevent the wind from uprooting banana trees.
	Small hillocks of yams are made to improve rainwater infiltration in the hillocks, and trees are grown in the field.	
Crop watering	Deep wells are built to provide water.	The seedbeds are watered using the pumps in the village.
	River water is increasingly used to water crops.	
Livestock watering	The bovines (*Bos taurus indicus*) receive drinking water 3 times a day instead of once because of the lack of grass.	
Livestock enclosure	Instead of barbed iron which is recommended, certain stockbreeders use wood to build their enclosure.	
Animal treatments	More sanitary treatments for animals done when the financial means allow it.	
Dietary change	Yam, cassava, and millet are consumed less, and more maize is eaten.	Cassava is becoming the more basic crop because it is more suitable to the new climatic conditions.

Table 7 (continued)

Adaptation strategies	Korhogo	Toumodi
Worship of spirits	In the past, when it did not rain, the farmers worshipped the spirits.	
	To prevent logging of trees, the chief of the village of Kouniguékaha has put up a fetish object to frighten people	

Focus Groups

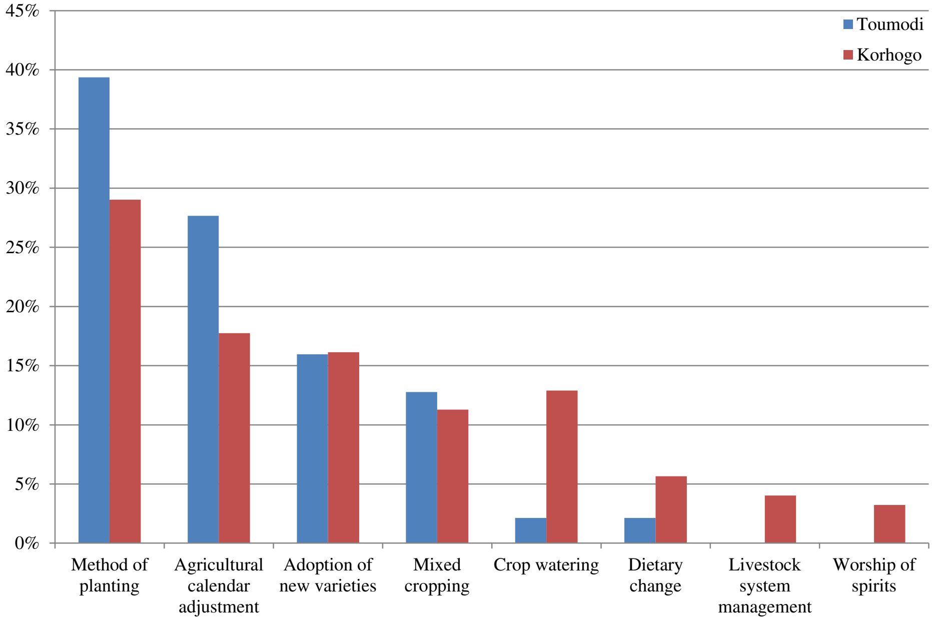

Fig. 4 Importance of adaptation strategies to climate change in Toumodi and Korhogo

per year. Moreover, in Korhogo, the cultivation of groundnuts (*Arachis hypogaea*) was followed by white cotton (*Gossypium hirsutum*). After harvesting the groundnuts, farmers used the old furrows for the sowing of cotton; but inadequate rains have prevented similar practice in recent times and the farmers needed to adapt. The adaptation strategies in both areas included other practices such as change in diet and worship of spirits (see Table 7).

The adaptation levels found using Focus Groups appear to be rather similar in Toumodi and Korhogo (Fig. 4). The most developed strategies concern the different methods of planting. This is followed in order by agricultural calendar adjustment, adoption of new varieties, and implementing mixed cropping. However, at the level of "water shortage solving," farmers in Korhogo have implemented more strategies than farmers in Toumodi, which shows the extent of water shortage problems in this zone. For certain adaptation levels such as "livestock system management," farmers in Toumodi appear to have adapted no strategies.

4.6 Identification of factors influencing farmers' adaptation behavior

Different influential factors were identified (Table 8). They were grouped into two levels: internal factors related to farmers and exogenous ones. Internal factors are, for instance, gender, farming experience, household size, and wealth. Exogenous factors found to be influential are, for instance, lack of contact with extension services, length of rainy seasons, and the availability of drought-resistant crop varieties. This distinction between factors has been made to help future agricultural policies to focus on identified factors to ensure implementation of climate adaptation measures.

Table 8 Internal and external factors influencing farmers' behavior with regard to adaptation to climate change

Type	Factor	Level
Internal factors	Gender	Farmer
	Experience in farming activities	
	Household size	
	Financial goals	
	Financial means	
	Failure to understand? rainfall forecasts	
	Aims to adopt the best varieties	
	Objective of early harvest	
	Type of crop in association	
	Ensure a safety production of at least one crop in association	
	Harnessed culture	
	Perceived benefits of the new technique	
	Religion	
Exogenous factors	Lack of contact with extension services	Institutional
	Existence of village pump	
	Price of certain products such as cotton	
	Scarcity of rains	Climate
	Length of the rainy season	
	Beginning of the first rains	
	Stop of rains after sowing	
	High winds	
	Sunshine	
	Availability of farming lands	Lands and soil
	Soil fertility	
	Presence of trees on the field	
	High price of fertilizer, seeds, farming labor	Inputs
	Adaptation of the variety to any type of soil	New varieties
	Drought resistant variety	
	Short-season variety	
	Good production's quality of the variety	
	Good adequacy of corn, rice, cassava	Farm
	Poor harvest	
	Disease of draft oxen	
	Gradual disappearance of yam and millet	
	Crop water requirement	Environmental
	Availability of wood to build up animal fence	
	Lack of pasture	
	Draining of the wells	
	Existence of nearby rivers or dams	

Focus Groups

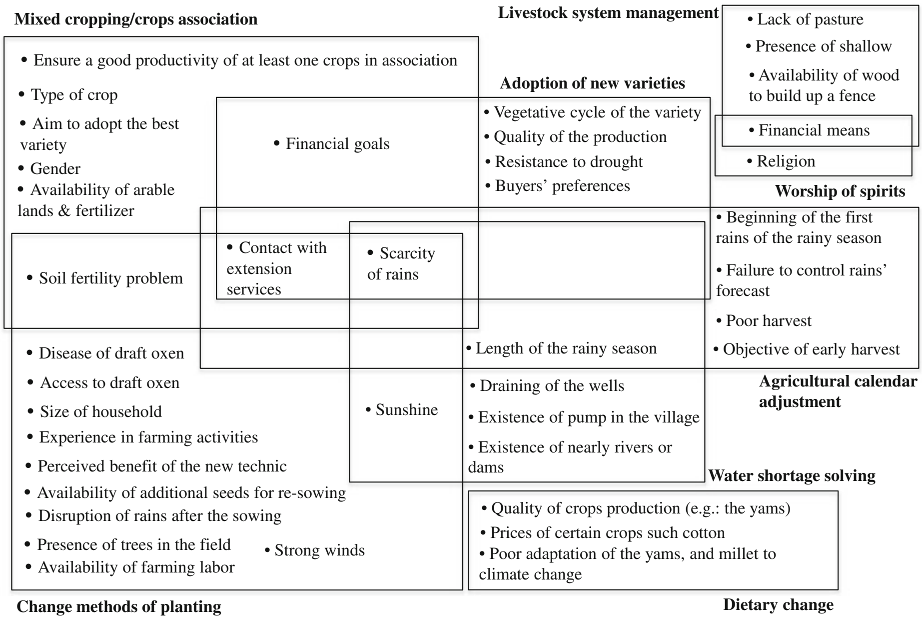

Fig. 5 Interrelationships between influencing factors and adaptation strategies to climate change

4.7 Interrelationship between influencing factors and adaptation strategies

The interrelationships between identified factors and different adaptation strategies are shown in Fig. 5. Different factors affecting farmers' behavior are identified and then linked to a specific adaptation measure. Therefore, some factors influence different levels of adaptation at the same time, which reflect their relative importance. Scarcity of rains and the lack of contact with extension services are the factors which influence the most adaptation strategies, followed by sunshine and financial goals. The probable interaction between different levels of adaptation cannot be excluded, but in Fig. 5, only the interrelationships between factors and adaptation levels have been highlighted. Furthermore, change in the method of planting and mixed cropping/crop associations are the adaptation strategies related with the largest number of factors.

5 Conclusion

CC emerged as a significant constraint for poor smallholder farmers in terms of satisfying their food needs; the present study therefore has gathered in-depth information to better understand farmers' adaptation behavior. This research thus forms the basis and contextual background for subsequent quantitative analyses on the adaptation behavior of farmers in Côte d'Ivoire. Therefore, the identified local strategies need to be enhanced by researchers. We suggest that future agricultural policies take into account farmers' perception, to provide suitable climate forecast and to improve local technical support for better adaptation to climate change, and to ensure successful knowledge transfer in the local framework.

Our analysis reveals that smallholder farmers in Toumodi and Korhogo (Côte d'Ivoire) perceive, in addition to problems related to insects and diseases, market access, prices, and changes in climatic conditions to be relevant constraints for their farming activities. To address these threats, four different levels of intervention were identified: Farming activities implementation, Funding of farming activities, Sale of products, and Nature of farming lands. Adaptation measures related to the first category were the most implemented and comprise, for instance, crop associations and re-sowing and replanting. The study also revealed the low adaptive capacity of farmers to deal with non-climatic threats because of a lack of technical support, which falls outside of their decision-making ability. Farmers strongly perceive CC through characteristics and changes in rain patterns, changes in the local environment, and the disappearance of certain farming practices. Farmers in Toumodi perceive more the impacts of CC through the disruption of key time reference period and shift in rainy seasons, than farmers in Korhogo. To adapt, they mostly change the methods of planting, adjust the agricultural calendar, adopt new varieties, and employ mixed cropping. This adaptation behavior is influenced by the factors "contact with extension services" and "scarcity of rains." Furthermore, farmers in both study areas asserted that they have no effective solutions to adopt when facing poor seed quality, strong sunshine, and new weed varieties.

Furthermore, based on our results, we suggest that for better adaptation to climate change in Côte d'Ivoire, future agricultural policies should take into account farmers' perception, to provide suitable climate forecast and to improve local technical support. Local organizations and non-governmental organization (NGOs) need to work together on government extension services and also try to involve a greater number of farmers in the services and ensure proper transfer of adaptation measures.

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