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Farmers' Perception of Indigenous Forecast and Climate Information in West Africa: an Evidence-based Review

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Abstract

Using seasonal climate forecasts based on indigenous knowledge is common among West African farmers' strategies to make farming decisions and reduce climate risk on rainfed season productions. Farmers use endogenous climate forecasts to guide their decision-making in choosing farm plots, crop varieties, and sowing dates. The main categories of indicators of endogenous seasonal climate forecasts are environmental, biological, magic, and religious sources which are transmitted from one generation to another by oral tradition. This mode of transmission leads to biases in the endogenous climate forecasts. On the other hand, scientific climate information is also one way to mitigate the adverse effects of climate change on agricultural productivity. It focuses on starting and ending dates of the rainy season, length of the rainy season, number of rainy days, annual cumulative rainfall, and average and maximum duration of dry spells. However, scientific predictions often diverge from the observations during the rainy season due to biases and uncertainties in the simulations from these models. We conclude that farmers have few effective seasonal forecasting tools.

Keywords: farmers, rainy season, seasonal forecasts, West Africa

1. Introduction

West Africa is among the most vulnerable region to climate change and variability worldwide (Omondi et al., 2014; IPCC, 2014). There are four main climate zones in West Africa from North to South, defined by cumulative rainfalls, the length of the rainy season, and the vegetation: the Sahelian zone (250-500mm), the Sudano-Sahelian zone (500-900mm), the Sudanian zone (900-1100mm) and Guinean zone (>1100mm). West Africa has been experiencing an increase in climate variability since the end of the 1960s. The decline in average rainfall, before and after 1970, ranges from 15% to over 30% depending on the area (Paturel et al., 1997).

Climate change in West Africa directly affects more than 60% of the population's income and food security which mainly depend on rain-fed agriculture (FAO, 2011). Agriculture is considered to be the most weather dependent of all human activities (Hansen, 2002). To deal with these climate shifts, a set of strategies and means are gathered by the different stakeholders (Nkonya and Kato, 2011; Zorom et al., 2013; Zongo et al., 2015). The use of seasonal climate forecasts based on indigenous knowledge is noticeable among traditional strategies of West African farmers to reduce climate risk (impacts) on rainy season productions (Nyong et al., 2007). It helps farmers to guide their decision-making in choosing farm plots, crop varieties, sowing dates, crop rotation, and precautions to maintain crop production (Roudier et al., 2014). The main indicators of endogenous seasonal climate forecasts are environmental (moon, cloud, wind), biological (animals, plants), magic and religious (Chang et al., 2010).

Scientific climate information is also one possible way to mitigate the adverse effects of climate change and variability on agricultural productivity (Hansen, 2002; Sultan et al., 2010). It is developed by climate models and disseminated to farmers through media and farm advisory services (Klopper et al., 2006). The seasonal predictions focused on climatic parameters which are starting and ending dates of the rainy season, length of the rainy season, number of rainy days, annual cumulative rainfall, and average and maximum duration of dry spells (Goddard et al., 2010). The development of a pre-campaign climate forecast provides information on climate risk and can be used for the planning of agricultural activities at various levels. According to Ogallo et al. (2000) the results from the PRESAO (*Prévision Saisonnière en Afrique de l'Ouest*) models allow predicting total seasonal rainfalls from July to September. Regional forecasts are of moderate skill and have the potential to help taking resource management decisions. Over the past decades, World Meteorological Organization and other international organizations regional have played a major role in building capacity for climate prediction which helped catalyze the relationship between meteorologists, farmers, governments, Non-governmental organizations (NGOs), universities and research centers, and international climate institutions (Hansen et al., 2011).

In West Africa, scientists and farmers use different methods to forecast weather conditions and predict the likely behavior of climatduringin the planting season (Ofoegbu and New, 2022; Nyadzi et al., 2022). Scientists have, in the past few decades, developed different types of science-based knowledge, to better cope with climate variability (Traore et al., 2014; Rauch et al., 2019). However, farmers use climate forecasts based on their indigenous knowledge as guidance for agricultural activities to be undertaken (Zongo et al., 2015b; Ouedraogo et al., 2018; Nyadzi et al., 2021).

The goal of the present study is to highlight and document farmers' perceptions of indigenous forecasts and climate information. We tried to answer different questions: (1) How do farmers understand and use indigenous forecasts and scientific climate information? (2) What information do farmers wish to have? (3) How to disseminate climate information to farmers? (4) How are decisions made to adapt to climate constraints? (5) How does scientific climate information influence the planning of agricultural activities by the farmers? Globally, two approach approaches are used to understand the perception of indigenous forecast and climate information: focus groups and/or household surveys (Carla Roncoli et al., 2008; Adaawen, 2021; Daron et al., 2021).

2. Farmers' Climate Perception

2.1 Cultural Understandings of Climate Change

In West Africa, agriculture remains the source of employment for more than 80% of the population however it is highly vulnerable to climate change, especially rainy change because the irrigated area is less than 5% (FAO and AfBD, 2015). Farmers' understanding of rainfall change is relative to rainfall duration, starting, ending, regularity, types of the rainy season, and precipitation (Limantol et al., 2016; Daron et al., 2021; Adaawen, 2021).

Farmers perceive that rainfall duration has decreased and become irregular (Nielsen and Reenberg, 2010; Adaawen, 2021). They substantively commented on the irregularity of rainfall and the perceived decline in the amount, and resulting agricultural efficacy, of the rains in Senegal (Dieye and Roy, 2012). These results corroborate those of Ouédraogo et al. (2010) and Zongo et al. (2015) who showed that farmers perceived an increase in a dry spell in the last two decades in Burkina Faso. Similar results are noted in several previous studies in other countries of West Africa (Fosu-Mensah et al., 2012; Limantol et al., 2016; Nyadzi et al., 2021).

According to Roncoli et al. (2001), farmers assess also the temporal dimension of rainfall through the occurrence of dry spells, duration, starting and ending of rainy.

Because of the importance of the duration of the rainy season for successful crop production under Sahelian conditions, farmers think about rainfalls as a process rather than a quantity (Roncoli, 2006). The rainfall during the rainy season, length of the rainy season, and rainfall intensity are shortened while the break between rainfalls in the rainy season and inundations are longer (Shackleton et al., 2015). However, farmers perceive rainfall to be less predictable today than four decades ago and to have a larger number of 'false starts' making it extremely difficult to know when to sow crops (Nielse and Reenberg, 2010). Moreover, farmers distinguish different types of rain depending on their impacts on crop production (Roncoli et al., 2002).

2.2 Local Forecasting Knowledge

Farmers forecasting knowledge is mainly based on their experiences (Ebhuoma et al., 2020; Nyadzi et al., 2021). They predict the beginning and the end of the rainy season or the nature of the coming season in terms of the total volume of water (Roncoli, 2006). These predictions are based on biophysical, religious, or magic signs. They include environmental observations, such as the behavior of some birds and insects, the phenology of some plant species, the direction of the wind, the moon and stars cycles, but also traditional divination and interpretation of Christian or Islamic Scriptures (Yaka et al., 2012). According to Hansen et al. (2011), farmers use different indicators based on their location and ethnicities. They rather consider signs and clues that arise at various times and from multiple settings, without striving to fit them into one coherent scenario (Roncoli et al., 2002). In farming, they combine their own experiences with agricultural extension advice. Farmers' knowledge of rainfall prediction includes common knowledge and specialized expertise (Dialla, 2005). The common knowledge is held by experienced farmers (most often the elderly) that make assumptions about the coming season by observing natural phenomena such as the period, intensity, and duration of cold or hot temperatures and winds (Ogallo et al., 2000).

The annual vegetation and wildlife cycles are also used as an indicator to predict the imminent approaching season. For example, when sibga (Lannea microcarpa) begins to give fruit, farmers in Burkina Faso know they must be ready to sow (Dialla, 2005). For the savanna populations in the North Ivory Coast, the rainy season comes with the beginning of the large tree refoliation during the dry season: the Baobab tree (*Adansonia digita*) and especially the kapok tree (*Ceiba pentandra*) (Brou and Chaléard, 2007). Conversely, the dry season begins with the gradual loss of the leaves of these trees. Similarly, for the Krou in the South-West of Ivory Coast and forest populations, the dry season is announced in November by the defoliation of some trees, the disappearance of the snails, and the arrival of wild cotton. It is during this period that wild grapes are ripping, while the swallows make their resurgence. These signs are like those suggested by the populations of the East and South-West of the Ivory Coast living in a forest environment. The resurgence of hibernation of the snail, and the arrival or departure of migratory birds is a sign of season change. According to Dialla (2005) women in Burkina Faso also observe the behavior of insects in trash points. If a black insect of the Orthoptera specie, fills its nests that are dug into a pile of garbage with soil (thus symbolizing a full-grain store), women will expect a good farming season. Another indicator to predict rainfall divisions of the year is the observation of the movement of a particular star that is in the East during the dry season and reaches the West during the rainy season (Brou and Chaléard, 2007). The farmers in Burkina Faso are also able to interpret the movements of the constellation and the phases of the moon.

The specialized knowledge of rain prediction is held by cultural and ritual specialists from their knowledge of predictions from divination, visions, or dreams (Roncoli et al., 2002). Unlike the observation of natural phenomena which can be reached by most farmers, divination and other magic practices can only be accomplished by a few villagers. According to Dialla (2005), the "traditional land manager" of the Mossi villages, called tengsoaba, performs the sacrifices to intercede between the living and ancestral spirits affecting the rain. The predictions are made from the behavior of sacrificed animals (usually a chicken): the time they take before falling, the direction in which they fall, the position of the body when they fall, and the place where the blood spreads. Tengsoaba and other traditional specialists can also receive predictions of rainfalls from the ancestors or gods in dreams or visions.

2.3 Farmers' Expectations

In West Africa, farmers must make important choices. The experience of devastating fluctuations in climate that have occurred in the Sahel over the last 30 years has reduced farmers' confidence in their predictions and increased their demand for scientific forecasts (Ingram et al., 2002). However, there is a considerable gap between the information needed by small-scale farmers and that provided by the meteorological station (Blench, 1999). According to Yaka et al. (2012), while farmers perceive rainfall as an unfolding process, scientists think about it as a measurable amount. However, climate forecasts continue to be formulated in terms of quantity rather than temporal parameters, as currently available tools and models cannot reliably predict the duration and distribution of rainfalls. Furthermore, using a mental model approach (Morgan et al., 2002; Hansen et al., 2004) compared how farmers and climate scientists conceptualize climate variation and its determinants. The analysis indicates that the farmers think in terms of shorter time frames and localized scales, while the scientists have a more long-term global perspective. Thus, farmers' seasonal information expectations differ from forecasts given by scientists.

Depending on farmers and their environment, the expectations from forecast information vary (Ouedraogo et al., 2018; Adaawen, 2021; Ofoegbu and New, 2022). However, according to Blench (1999), low-income farmers of South Africa are mainly interested in the following characteristics of precipitation: total rainfall, patchiness of rainfall, its intensity, and starting date. Long dry spells and rainfalls above certain intensity are also very important according to farmers since they might have devastating impacts on yields. In addition to climate predictions, farmers seem to be interested in discussing management strategies to help them enhance the utility of the information.

3. Methods of Perception Assessment

3.1 Forecast Dissemination

Different factors need to be considered when disseminating forecasts. The first point is to assess the accuracy of the climate information as well as the reliability of its source and depending on that, discuss with institutions and local communities the scope of climate forecasts (Sultan et al., 2013). If climate information remains too experimental, a small exploitable sample will be chosen. According to Meza et al. (2008), very few studies have quantified the economic value of climate information in West African agriculture.

Secondly, it is important to choose in which zones, by whom and how often will the information be disseminated. Giving the information in different agro-ecological zones may allow comparing different agricultural strategies to climate hazards. In this case, concerned populations must be comparable: similar livelihood systems, reflecting conditions prevalent in each zone but differed somehow in terms of topography, hydrology, and infrastructure (daily market access, immigration, leadership patterns, political unity, etc.) (Roncoli et al., 2008).

Finally, the way climate information will be disseminated is crucial. Indeed, communication sharing is affected by salient social boundaries (West, Roncoli, and Ouattara. 2008). Nowadays, different means of communication are available, and a lot of studies have tried to assess which one is the best among local radio in local languages, participatory workshops, village or district meetings, text messages, flyers, etc. Indeed, confusing, or inaccurate wording can seriously undermine the farmers' ability to do this, leading to over-or under-reactions. The RANET project, for example, which employs durable satellite-based radios to broadcast forecasts and other relevant information to rural African communities, unfortunately, has had difficulty taking hold in villages without the existence of someone to deliver the message interactively with the farmers (Chavas, 2008). Furthermore, according to Yaka et al. (2012), producers who did not attend workshops received the forecasts mainly through radio (37%), village meetings (22%), and word of mouth (22%). However, a lot of villagers did not receive any information (34%). To respond to the concerns of radio use, several projects, including the CFAR project in Burkina Faso (Tarhule and Lamb, 2003; Roncoli et al., 2008), the Climate Prediction and Agriculture (CLIMAG) program, and extension efforts of "Société Burkinabe de Fibres et Textiles (SOFITEX)" (Tarhule, 2005), have taken a village-level focus to forecasting dissemination, with "key" farmers with much interaction to explain forecasts. These farmers then act as intermediaries to spread the forecast to other farmers in their villages (Kirshen et al., 2003). Until literacy levels significantly get improved, the print media, including newspapers and published pamphlets, will continue to play negligible roles (Tarhule and Lamb, 2003).

Workshop presentations can allow clarifying limitations of the forecasts, in terms of their time frame, spatial scale, and parameters. For example, the percentage of villagers retaining some aspects of the forecast limitations is more than half when attending the workshop than when not (about 10%) (Hansen et al., 2011). However, one of the major issues with all current methods of forecast information dissemination to farmers is the complexity and the cost-prohibitive nature of proper evaluation. The remaining viable options are community meetings, extension agents, intra-village personal contact, and inter-village personal contact. Community meetings and intra- and inter-village personal contacts are intermediary conduits that spread information horizontally but do not reliably move information vertically downwards from the top. In such ways, these forms of communication can increase the number of farmers with access to information but cannot perpetuate the flow itself. Therefore, according to Chavas (2008), while these mechanisms are purely supplemental (although potentially highly beneficial), the creation of an external consultant as an access point to information is a necessary condition for useful forecast information dissemination.

Other studies show the potentiality of NGOs and local civil society organizations for disseminating climate information in very isolated rural areas (Tarhule and Lamb, 2003). However, according to Chavas (2008), the rapid proliferation of mobile phone use among rural farmers to access information has the potential to revolutionize forecast dissemination by eliminating geographic barriers, thus significantly reducing costs while maintaining critical two-way interaction. Furthermore, dissemination via mobile phones would represent the first demand-based system of forecast dissemination, thereby internalizing evaluation of both the means of dissemination and the skills of the consultants themselves. Given the substantial logistical and economic barriers to the evaluation of extension agents and their services, mobile phones may provide a cheap, efficient, and adaptable means of forecast dissemination to rural farmers (Traore et al., 2015).

3.2 Accessing Forecasts

Communication pathways mark salient social boundaries and reflect or reinforce power imbalances among social groups. According to (Roncoli et al., 2008) gender, ethnicity, and politics profoundly shape the way forecast information is shared and accessed. The random selection of participants would be culturally inappropriate and socially awkward and would be certainly rejected. Instead, several eligibility criteria can be proposed by the communities and by the researchers and discussed until consensus is achieved. Sometimes criteria might favor socially prominent individuals (being able to relay the information to their communities, being responsible for production decisions, and being able to express one's views and understand a basic presentation...). It is possible to introduce as a criterion that each village will be represented by at least four participants from minority groups and two women. However, this requirement could entail complex negotiations since ethnicity is a sensitive issue and cannot always be openly discussed (Patt and Gwata, 2002). In the South-West and Central Plateau of Burkina Faso, for example, Fulani ethnic group herdsmen and Mossi ethnic were not invited to the workshops of the CFAR project and subsequent community meetings because they are not counted as village residents, although they have inhabited the area for decades (Roncoli et al., 2008). Once climate information dissemination is achieved, the study of the impact of climate information can be conducted.

3.3 Assessing Farmers' Responses to the Seasonal Forecast

Being able to assess climatic information impacts on farmers' strategies, different means can be used: ethnographic or participatory workshops, semi-structured interviews, and structured questionnaires (Amegnaglo et al., 2022). Depending on the conditions and objectives of the study (extent of the study, analysis...), one or various techniques can be chosen (Ofoegbu and New, 2022).

Semi-structured interviews improve the contextualized quality of the data than structured interviews. Individual and collective adaptations are shaped by common ideas about what is believable, desirable, feasible, and acceptable (Nazarea-Sandoval,1995). Therefore, the potential contributions of anthropologists to climate research are the description and social practice, which cannot be easily captured by methods of other disciplines, such as structured surveys and quantitative parameters. Ethnographic fieldwork, based on extended periods of residence and research at a community level, is a way to gain insights into the relationship between climate and culture (Roncoli et al., 2008). The terms 'ethnographic' and 'participatory' are used loosely to refer to methods that entail some degree of farmer involvement and mutual interaction between farmers and scientists (Roncoli, 2006). Participatory research differs from ethnography in that the former seeks to change rather than to study social behavior. As an illustration, participatory workshops had been carried out in Senegal to assess climate forecast impacts on cropping activities and yields (Roudier et al., 2012). Workshops were conducted four times in two contrasted villages with sixteen participants per village. For each year, farmers first described their farming activities without forecasts. After receiving seasonal and ten days forecasts and they described the same activities again considering the information. According to this study, it might be useful to have fewer participants in the workshops to have more details during the discussion (Ziervogel et al., 2005). Thus, emphasis on local context and dynamics enriches the analysis, but the particularistic focus, informal methods, and non-random samples that characterize the participatory and ethnographic approaches limit their replication or the generalization of results. Furthermore, village-wide meetings and group works are likely to privilege normative explanations and produce the appearance of consensus, obfuscating difference, and dissent.

For each one of the chosen approaches, it is necessary to come back to the field and talk to farmers. It might seem that all the approaches have pros and cons. A combination of all of them could enable us to get the best results. When assessing the impacts of participatory workshops, it will be necessary to interview farmers having either participated or not in those workshops. The outline of interviews conducted by the CFAR contained the following information: whether respondents had received any forecast information (either at the workshop or by other means), if they had, what they understood, how and with whom they shared the forecasts, whether and how they used them in making production decisions, how they felt about their experience (Roncoli et al., 2008). According to Roudier et al. (2014), the introduction of seasonal forecasts induced changes in farmers' practices in almost 75% of the cases in Senegal. But farmers' responses were categorized as either implying pure intensification of cropping systems (21% of cases), non-intensified strategies (31%), or a mix of both (24%).

A methodological limitation for assessing farmers' response to forecasts appears when the interviewing team is composed of the same researchers and facilitators who conducted the workshop and worked on the project. Indeed, this might bias farmers toward providing positive assessments of the forecasts. Another limitation is the reliance of the study on a convenience sample, which limits the extent to which findings can be generalized. The composite nature of the overall dataset, including multiple zones and villages, with different socioeconomic characteristics, livelihood systems, and ethnic compositions, may also confound some analyses. However, the small sample sizes for each village make it difficult to assess the effects of heterogeneity through multi-level modeling.

4. Assessing Climate Information Impacts on Farmers' Agricultural Strategies

4.1 Making Sense of Forecasts

Farmers have attitudes towards forecasts based on their understandings and beliefs (Roncoli, 2006). Therefore, farmers' forecast interpretation is a crucial step. Indeed, cultural notions of what is true and trustworthy are crucial in assessing credibility and accuracy both in farming communities as well as scientific circles. The uncertainty of climate predictions means that their dissemination and interpretation are shaped not only by cultural contexts but also by power struggles involving different intermediaries and stakeholders (Salack et al., 2011).

Furthermore, the comprehension of the probabilistic nature of information might have an important impact on the next harvest. Many climate application studies have highlighted the risks of a deterministic interpretation of climate forecasts, and many experimental approaches have been directed at explaining their probabilistic nature (Ziervogel et al., 2005). According to Yaka et al. (2012), the majority of villagers who did not attend workshops understood probability as a possibility or a chance and commonly included expressions of faith, while nearly all of the workshop participants had any understanding of the probabilistic aspect of the forecast and their limitations.

Also during CFAR project workshops in Burkina Faso, it seems that farmers' comprehension of the probabilistic nature of the forecast seemed to be easily understood through comparison to local indicators (Roncoli et al., 2008). In both groups, some farmers interpreted probability in terms of spatial variability (e.g., "the forecasts said that it will rain, but it did not say where"). Others had a more sophisticated understanding that, while multiple scenarios were possible, some were more likely than others (e.g., "the chance of rain is stronger than the chance of drought" or "the good is higher than the bad"). Overall, the large majority of farmers retained something about the nature of the season (e.g. "it will rain"; "it will be a good season"), in most cases as a prediction for a favorable season (Yaka et al., 2012). Therefore, interactive experiments show that farmers' ability to understand scientific forecasts can improve, particularly by integrating such forecasts with farmers' own knowledge and experience. They recognize that seasonal forecasts have contributed to their decisions making on planning and implementation of agricultural activities. Seasonal forecasts facilitate the choice of crop rotation, crop varieties, and soil type (Klopper et al., 2006).

4.2 Responding to Forecasts

Forecasts help farmers be prepared, make decisions, adjust strategies, and prevent losses (Roudier et al., 2012). However, demonstrating a direct linkage between climate forecasts and changes in management practices remains a challenge, as production decisions by African farmers are shaped by many environmental, agronomic, and economic factors beyond climate information (Patt et al., 2005; Ziervogel et al., 2010). It might seem that these decisions are made up of small, sequential adaptations to shifting conditions rather than a single deliberation (Batterbury and Forsyth, 1999; Mortimore and Adams, 2001).

In affecting management decisions, forecasts interact with farmers' observations, experiences, and predictions. In some cases, farmers' interpretations can predict good rains, but when the onset of the rainy season is delayed, they might doubt their predictions and shift to shorter-duration crops. Several surveys have studied the impact of forecasts on farmers' practices (Bro et al., 2005; Ouédraogo et al. 2010; Roudier 2012).

The main agricultural adaptations found in several studies are location and size of planted areas, crop and variety selection, land management-labor allocation, higher input application, and use of soil and water conservation techniques (Kirshen et al., 2003; Blench, 1999). Although, most livestock management decisions tend to follow rather than anticipate rainfalls, and animals can move to where water and pastures are available. The main livestock adaptations are the alteration of husbandry practices, vet treatments, transhumance decisions, and feeding regimes (Yaka et al., 2012).

However, it is sensible to assume that the climate forecasts are not but one among many factors that shape farmers' decisions. Choices of what, when, and where to plant are closely related, so it is sometimes difficult to separate forecast responses into discrete options (Hansen et al., 2011). However, it seems that farmers who attend participatory workshops employ a wider repertoire of responses than farmers who do not. Workshop-participants were especially more likely to report three or four strategies, outcomes that were possibly influenced by discussions of technical information during the workshop, while non-participants mainly had one forecast response.

5. Conclusion

Many communities have been relying for centuries on the local forecasts to plan their farming activities with success. Changes in rainfall patterns, have resulted in greater uncertainties and may be vulnerable, to the extent that many farmers in West Africa are keen to receive information that can be added to their knowledge and help them orient their risk management strategies. Despite the progress achieved on forecasts so far and the increased accessibility to them, most West African countries have not taken advantage of such information to reduce the negative effects of climate variability. This problem is mainly due to the difficulty for vulnerable groups and the organizations responsible for the management of the climate information transfer, to access forecasts and farmers' ability to exploit them properly. In sum, the farmers have few effective seasonal forecasting tools, and their concerns are to find innovative strategies for the planning of agricultural activities.

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