

Traditional capacity for weather prediction, variability and coping strategies in the front line states of Nigeria

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ABSTRACT

This paper is based on the results of a pilot project conducted to strengthen Nigerian Meteorological Agency's (NIMET) capacity to provide reliable planting date forecast in Nigeria. This aspect of the project aimed at understanding traditional knowledge base and farmers' prediction methods, community perceptions of impacts of rainfall variability, coping strategies and opportunities in Sokoto, Kano, Jigawa, Kaduna, Bauchi states of Nigeria. Based on prevalence of drought, a community was selected for survey in each of the five states. Semi-structured interview and focus group discussion were used to sources for information. The survey indicates that the farmers had good understanding of weather and climatic dynamics of their community. The farmers in the study locations characterize a year into five seasons based on the atmospheric temperature as felt by the body, changes in wind direction, farming activities, and the behavioral changes of some animal and birds and phenological changes in plant species. Rainfall variability in the community has altered the farming systems, either in terms of changes in cropping pattern, elimination/reduction in the level of producing some crops or introduction of new crop varieties that are drought resistant and early maturing, and diversification of source of livelihood (non-farm activities). Impacts of rainfall variability in the communities were asserted to include; poor yield, low prices of crop/livestock, low dowry for their daughters, high cost

of labor as a result of migration to urban centers, inadequate water for dry season farming, low income, low standard of living, and high level of poverty. Farmers recommended an integration of traditional proven methods of rainfall prediction with scientific methods to evolve reliable forecast that will reduce risks in their rainfed farming systems.

Keywords: Traditional Knowledge Base; Rainfall Prediction; Crop Production; Northern Nigeria

1. INTRODUCTION

Crop production in Nigeria is essentially rainfed. Agriculture is therefore heavily dependent on the seasonal characteristics of rainfall which has been shown to diminish in amount and duration as one move from the south to the northern part of the country. Current evidence clearly shows that rainfall variability is a real threat and that the need for action today cannot be ignored [1-3]. Agricultural development has been affected by natural climate variability and extreme climate events which have caused significant decline in productivity resulting in food insecurity and poverty among rural communities. Precipitation changes are currently insufficient for many crops that water scarcity increasingly constrains production [4]. Analyses conducted by the Nigerian Meteorological Agency (NIMET), have found that drought disasters are significantly more probable in recent times [5,6]. While droughts are frequent, the rate of growth in agriculture has been one of the slowest in terms of production and productivity [7,8]. The pressure also includes the intensified use of more fragile land resources, leading to accelerated degradation of the soil to desert-like conditions, thereby reducing sustainable agricultural production [9]. Today, Nigeria has less than 9%

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of the total cropped area under irrigation. Hence, the rural population is very vulnerable to rainfall fluctuations. Despite the economic hardship and the prolonged effects of drought and desertification, the people in the drought prone areas of northern Nigeria possess great reliance, patience, and adaptive capacity [10]. Environmental degradation caused by successive years of poor rainfall amount/distribution and recurrent droughts is exacerbated by combined effects of natural population growth and immigration from neighboring resource-poorer countries. In this study we focused on the vast traditional knowledge of the farmers on rainfall prediction and their understanding of its reliability through their observation, experience and practice in the field. Understanding them is not only necessary to communicate the scientific forecast, since it is learnt and identified by farmers within a cultural context and the knowledge base which follows specific language, belief and process. By perceiving such a knowledge base, it may facilitates social interaction and promote acceptance of scientific forecast among the farmers.

2. MATERIALS AND METHODS

Five communities within 5 - 70 km from the nearby main town were purposively selected from each of the Agricultural Development Program (ADP) zones in each State based on reported high incidence of dry spell after the onset of rains. These sites are Gangara in Kaduna state (11°20'N, 07°23'E; 660 m above sea level) about 37 km north of Zaria on the Zaria-Funtua road; Shantake (12°10'N, 08°31'E; 469 m above sea level) in Makoda local government area of Kano state, Nigeria. The village is about 50 km north of Kano town along the Kano-Daura highway; Yan'dutse in Jigawa state (12°11'N, 9°15'E; 397 m above sea level) about 95 km northeast of Kano and 70 km north of Dutse (Jigawa State Capital) along Kano—Gujungu high way; Kasarawa (12°58'N, 05°12'E; 298 m above sea level) in Wamako local government area of Sokoto state, about 5 km south of Sokoto town and Dabarndak (09°34'N, 10°00'E; 641 m above sea level) in Dass local government area of Bauchi state, Nigeria. The selected sites in Kaduna and Bauchi state are in the northern Guinea Savanna zone while those of Kano, Jigawa and Sokoto states are in the Sudan savanna agroecological zone. The community survey involved the characterization of the community in terms of the traditional prediction of onset of rains/planting season, consequences of wrong predictions of onset of planting season and coping strategies/opportunities. A village was purposively selected in each state with the assistance of the Sasakawa Global 2000 an NGO, Extension staff of the Agricultural Development Project (ADP), and researcher from the University within the state. The survey used participatory methodology tool like semi-structured

interview with the community (25 - 60 in attendance) and focus group discussion for studying the traditional knowledge basis on weather and climate prediction. The ages of people that participated in the community group interview ranged from 25 - 75 years while the range for the focus group discussion was 45 - 75 years. Themes and probing checklists were prepared in advance and the participants were guided in the discussion. A series of Participatory Rural Appraisal (PRA) exercises such as livelihood analysis, seasonal calendar of activities and priority ranking were organized with the community and focus group of selected individuals who seems to be most knowledgeable about traditional methods for rainfall predictions. Focus group discussion (FGD) was used to clarify the needs, constraints and coping strategies on weather and climate of the community. Through a process of triangulation, the views expressed in the FGD, community discussion were consolidated and analyzed using descriptive statistics.

3. RESULTS AND DISCUSSION

3.1. Traditional Knowledge Basis and Farmers' Prediction Methods

The survey indicates that the farmers had good understanding of weather and climate of their community. They have developed a variety of traditional indicators for predicting weather situation to make farm management decisions and those relating to other means of livelihoods (**Table 1**). The local prediction skills have evolved through observations and experience and passed down the generations through oral tradition. The Islamic scholars (*Mallams*) in these communities also acts as local weather experts, and even those communities that have access to scientific weather forecast will rather act based on the information from local experts and they asserted that it works for them. The farmers in the study locations characterized a year into four/five seasons based on the atmospheric temperature as felt by the body, wind directional changes, farming activities, and the behavioral patterns of some animal and birds as well as the phenological changes associated with some plant/tree species. The four/five seasons are: *Damina*, (*rainy season*), *Kaka* (*harvesting season*), *Sanyi/hunturu* (*cold season*), *Rani* (*dry season*) and *Bazara* (*hot season*).

The people used several indicators to predict the onset of rainfall and planting season in the community. The traditional forecast knowledge has been adapted to local conditions and its requirement is dependent on physical observations like behavior of birds, flowering or flushing times of some trees species, prevailing wind directions and cloud patterns. Breman and Kessler [11] reported that climatic factors (rainfall distribution, air humidity, wind direction and temperature) and site conditions are

Table 1. Traditional knowledge base of farmer's decision processes during cropping season in the Northern Nigerian savanna.

Season	Period /Duration	Observation of weather elements/Human reactions	Behavior of animals and birds	Phenological changes in plants/Tree species	Activities/Remarks
BASARA (Hot season)	March-May (≈ 90 days)	<ul style="list-style-type: none"> High day time air temperatures. Perspiration on human body takes longer time to dry up (increased atmospheric humidity). Change in wind direction eastwards in late May indicative of possible rainstorm within 1 - 2 weeks of observation. A period of consistently high daily temperature for a minimum of 5 days indicates the commencement of rainy season. 	<ul style="list-style-type: none"> Appearance of wild duck-like birds ("Shamua") indicative of rainstorm within 2 weeks. If army worms (<i>Spodoptera exempta</i> or <i>S. littoralis</i>) are observed after planting, a period of dry spell is imminent. Appearance of Chameleon on cultivated field after rainfall commencement is indicative of a period of dry spell. 	<ul style="list-style-type: none"> Season starts when Locust bean tree (<i>Parkia biglobosa</i>) starts flowerings and ends when its fruits are ripe and ready for harvest. Complete defoliation of "Gawo" (<i>Fadherbia albida</i>) tree indicates the commencement of rainy season. Baobao (<i>Ceiba pentadra</i>) tree starts flowerings at the start of rainy season. Sprouting of <i>Dactyocetium aegyptium</i> ("Burgali") indicative of rainfall occurrence within 3 weeks of observation. 	<ul style="list-style-type: none"> Land clearing and preparation. Clearing of previous crop stover, shrubs and debris commences. Threshing of crops before planting. Transportation of manure and household refuse to the farm. Planting starts with the first heavy rainfall i.e. when ponding of water occur in furrows and depressions on the farm.
DAMINA (Rainy season)	May-October (≈ 180 days)	<ul style="list-style-type: none"> Wind direction changes from multi-directional and moves eastwards Reduction in day time air temperatures and increasing cloudiness 	<ul style="list-style-type: none"> Guinea fowl starts laying eggs at onset of rains and lay daily when rains are fully established Rains are well established when crickets dig holes and make loud chirping courtship calls. Termite's nuptial flights occur when rains are fully established. Appearance of locust is indicative of drought 	<ul style="list-style-type: none"> Flushing of tree species <i>Tamarandus indica</i> and Baobao indicate the full commencement of rainy season. 	<ul style="list-style-type: none"> Planting of crops, weeding and other agronomic practices
KAKA (Harvesting season)	October - January (≈ 120 days)	<ul style="list-style-type: none"> Cessation of rains Increase in day time temperatures and sunshine Reduced cloudiness 		<ul style="list-style-type: none"> Flushing of "Gawo" (<i>Fadherbia albida</i>) 	<ul style="list-style-type: none"> All rainfed crops are harvested Crop storage, processing and marketing prevails Land preparation for dry season (<i>Fadama</i>) and irrigation farming commences.
RANI (Cold /Dry season)	December - March (≈ 120 days)	<ul style="list-style-type: none"> Prevailing dusty cloud <i>harmattan</i> wind Low night and morning air temperatures <i>Harmattan</i> haze/dusts 			<ul style="list-style-type: none"> Raising of fruits and vegetable seedlings for dry season (<i>Fadama</i>) and irrigation farming. Trans-planting of seedlings and establishment of dry season crops.

the most important determinants of the presence of foliage and fruits on the woody plants of the West African semi-arid region.

The most popular and reliable method of predicting possibility of onset of rainfall within a week or two, ac-

ording to farmers is based on changes in wind direction from the west towards the east. If it rains before the wind changes direction, this rain is usually considered a false rain, and so farmers do not plant no matter the intensity of the rainstorm. The period when complete defoliation

of the “Gawo” (*Fadherbia albida*) tree occurs is rated next in term of reliability of prediction in the community. Lastly, they also use a method that depends on counting days from the last effective rains of the previous season. It assumes that, rain is bound to fall in the 7th month from the last effective rain of the previous year. However, if around that time rain falls without a change in wind direction, it is assumed to be a false rain. In addition to these local predictions knowledge base, the farmers in some states (Kano, Jigawa, and Kaduna) also have access to scientific forecast from their extension agents, radio and television, though they claim to depend more on their traditional forecast. Farmers use these predictions for land clearing and land preparation. Ridging starts after yet another heavy rain. Planting of drought resistant crops like millet, and sorghum also starts at this time. The documentation of farming systems with their complexities in relation to livelihood patterns have also been suggested to offer strategies for mitigation and adaptation to climate change [12]. Planting of other high value and drought sensitive crops (maize, soybean, groundnut and cassava) commences only when the rains are established (*i.e.* when rainfall is frequent and heavy enough to cause ponding on their fields). Farmer’s claim that their method for predicting the start of rain is correct in 8 years of the last 10 years. However, they have no methods to predict dry spell that may set in after the rains have commenced. The occurrences of long dry spells lasting 2 to 3 weeks, which have caused considerable hard-ships, have been noticed in three out of the last ten years.

Onset of rains may triggers planting of drought tolerant crops such as millet (*Pennisetum glaucum* L.R. Br.) and sorghum (*Sorghum bicolor*). But farmers tarry to plant input intensive and drought sensitive food and cash crops. They wait for rains to establish and use following indicators to determine establishment of rain and onset of planting:

- It rains frequently with heavy thunder and lightning; the soil remains soft and moist for an extended period
- After sunset, reddish horizon reflects in the east, this usually comes along with rain.
- Termite’s nuptial flight only occurs when the rains are fully established.
- *Kulba* (snake-like lizard) makes a lot of noise when rains are fully established.
- Cricket (*Acheta domesticus*) makes loud chirping courtship calls (noise) and dig holes.
- Appearance of a species of reptile which when mature looks like a lizard.
- Appearance of algae growth on walls of residential buildings.
- African Guinea fowl (*Numida meleagris galeata*) lays egg every day.

- Continuous croaking of toads (*Bufo regularis*) inside wells or under trees.

Once rains are established, planting may commence if the soil is moist (determined by using a local hoe called *sungumi* to dig the soil and determine the depth of moist soil) or after a heavy rainstorm. Farming communities surveyed agreed that their traditional forecasting methods often work for predicting the onset of rainfall and planting season but rarely for the distribution of rainfall within the year. The farmers’ prediction skills have also improved over the years as people are actually trained in this act by traditional religious teachers within and outside the communities. In Kaduna state for instance, farmers look out for chameleon (*Chamaeleo chamaeleon*) on the field after the first heavy rain. If chameleons are observed, it is believed that it will take sometime before the next rain, in which case they have to wait for another heavy rain before planting. It was emphasized in Bauchi state that appearance of small army worms-*Spodoptera exempta* or *S. littoralis* (moth larvae) after early season rains indicates a possibility of dry spell. In south-eastern Kenya, the main indicators for farmers to start land preparation and planting were reported to include budding of certain trees, high temperature and relative humidity, animal behaviors, wind direction and the smell of rain [13]. These also form part of the important traditional knowledge systems on how farmers might respond to climate change. Some farmers also acknowledged having access to scientific weather forecast from radio, television and extension agents and these are used to supplement their own traditional forecasting methods. Some stations even tell them when to start preparing their farmland. The information is used in complementing the traditional prediction methods. However, if the scientific weather forecast contradicts their own prediction, they take decision based on their own forecast.

3.2. Community Perceptions on Impacts of Rainfall Variability

Year-to-year rainfall variability *is* perceived as a major constraint to increased agricultural production. Farmers recalled that the seasons have become less predictable than in the past. Droughts are frequent –about 3 in every 10 years. Rainfall variability in the community has altered the farming systems, either in terms of changes in cropping pattern, elimination/reduction in the level of producing some crops or introduction of new crop varieties that are drought resistant and early maturing. Nyong *et al.* [14] also suggested the concept of integrating adaptation into mitigation strategies of climate change effects with adequate knowledge of the indigenous knowledge base. Relay cropping was a common practice in the community over ten years ago but this has been eliminated as a result of low distribution of rainfall and effort

made to reduce competition for limited water resource and increase productivity of crop. For instance, the farmers used to cultivate millet and harvest before planting cowpea. Some farmers even use the proceeds from millet to farm cowpea. Now all these crops are intercropped on the same plot. *Maiwa* millet was a common crop in the community in the past but this has also been eliminated from their farming system due to the low yield of the available cultivars and early cessation of rains. Groundnut production has been reduced drastically in the community due pest and diseases problems, which was also attributed to poor distribution of rainfall in farmers' understanding. Early maturing and high yielding sorghum variety (*yar Zaria*) is now the most commonly used sorghum variety in the community due to reduction in rainfall amount. The following were identified as consequences of delayed onset of rain and incorrectly predicted planting decision

- The farmers affirmed that in a bad year, replanting occurred as many as four times a year. In which case, farmer's who have already applied fertilizer may replant without another application if he cannot afford it. Apart from the additional cost of inorganic fertilizer, there may also be the need to source for seed and pay for labor (if using hired labor) leading to additional cost of production.
- Low yield: In case of delay in rainfall, the yield loss may not be appreciable if the rain resume early enough. However, if the length of growing season reduces drastically as result of the delay, it could cause a yield loss of up to 50%. In case of drought, the yield loss could be as high as 90%.
- Low rainfall could dry up sources of water for domestic use and for livestock. This also affects the health status of the people in the community as they revert on any source (clean or unclean) of water for domestic use. Common ailments resulting from inadequate water supply due to low rainfall are malaria, guinea worm, typhoid, and cholera.
- Delay in rainfall affect dry season farming, particularly where the people depends on residual soil water stored from the previous season rains.
- Severe drought in the community may also cause temporary migration to other communities or urban centre to farm or trade. It was reported that some of these migrants are the carriers of viruses causing ailments like HIV into the communities.
- Inadequate rainfall or water required for crop growth usually lead to poor quality of grains leading to poor milling and low prices and consequently low income and standard of living:
- Low rainfall affects growth of animals due to inadequate feed and water. This ultimately reduces their stock (sale of the animals at very low prices or move-

ment of animals out of the community in search of feed and water).

- Dowry for daughters ready for marriage is low due to low prices of poor quality crops and livestock and consequent low income.

3.3. Farmers Coping Strategies/Opportunities

The indigenous knowledge base in some part of West Africa with the use of biological and social data have also helped in the adoption of mitigation strategies and conservation of biodiversity that may have resulted from climate change [15]. Adaptive responses to delay or shortening of the rainy season in the communities surveyed include;

- Evolving contingency cropping systems—when rains are delayed, they use early maturing crop varieties or change the crops grown—instead of millet, use early maturing dwarf sorghum variety (*Mace da kunya in Sokoto*) once it germinates and starts growing, it can withstand drought till harvest time.
- Rainfall variability in the communities has also altered the farming systems, either in terms of changes in cropping pattern, elimination/reduction in the level of production of some crops or introduction of new crop varieties that are drought resistant and early maturing.
- Relay cropping was a common practice in the communities about ten years ago but this has been eliminated as a result of low distribution of rainfall. For instance, the farmers used to cultivate millet and harvest before planting cowpea (*Vigna unguiculata*). Some farmers even use the proceeds from millet to invest in cowpea production. With reduction in the amount of rain, all these crops are now intercropped on the same plot.
- The level of sugarcane production has decreased as a result of reduction in the quantity of water for irrigation. They now cultivate more vegetables like pepper, onion, tomato which does not require as much water as sugarcane.
- Migration of pastoralists and their animals out of the community in search of feed and water. In case of drought, arable farmers also move to areas where there are no problems with rainfall for rainfed farming and return after the season.
- Diversification of income—trading, artisans, digging tube wells for money, packing sand and selling etc.

4. CONCLUSION

This paper has attempted to assess farmers' knowledge and skills on rainfall prediction, variability and coping strategies. It is evident from the findings of the survey

that farmers have evolved several indicators for predicting onset of rains and planting season. However, the people were of the opinion that the level of accuracy is lower now than before with the erratic nature of weather in the present days. This is a clear evidence of the reality of global climate change phenomenon in the survey area. In case of wrong prediction or poor rainfall, farmers were forced to adapt various coping strategies to sustain their livelihood. Even where the communities have access to scientific weather forecast, some farmers still adhered to forecast of local experts in making farm management decision. Farmers therefore recommended an integration of traditional proven methods of rainfall prediction with scientific methods to evolve reliable forecast that will reduce risks in their rain fed farming systems.

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