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CLIMATE VARIABILITY AND INFORMATION TYPOLOGIES: UNDERSTANDING UPTAKE PREFERENCES AMONG SMALLHOLDER MAIZE FARMERS IN OYO STATE, NIGERIA

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ABSTRACT

Climate variability poses a serious stress on maize production. Yet, appropriate and timely climate information can assist in helping farmers to prepare, respond to climate-related risks as well as reduce negative impacts on production. Consequently, this study investigated climate variability and typologies of information smallholder maize farmers are inclined to uptake in Oyo State, Nigeria. A survey was used to elicit data from 107 farmers. Descriptive and inferential analyses of the elicited data showed that most respondents cultivated a farm size of 2.3±2.9 hectares, owned their crop farmland (71.0%), with 20.6±9.9 years of experience in maize farming. Climate variation was mostly felt in terms of erratic rainfall (2.7±0.5) and increased flooding/rainfall (2.6±0.6). Agro-input dealers (71.9%), farmers' organisations (69.1%) and extension services (61.7%) were key institutional elements enabling access to climate information. There was greater inclination to uptake agro-meteorological information ($\bar{X}$=1.38) relative to other CI types. Farm size, land ownership, onset of rainy season, relative humidity, temperature and wind/storms determined the decision to uptake all types of climate information. Making climate information available to smallholders through appropriate institutional elements would not only place them in a vantage position in determining the agricultural activities to undertake in preparation for and during a cropping season, but also the timing and scale of such activities.

Keywords: Climate variability, typologies of climate information, smallholders, inclination to uptake.

INTRODUCTION

Over time, there have been variations in global climate and such variations are anticipated to persist. Variations in climate are known to result from both biotic (e.g. human activities) and abiotic (e.g. solar radiation, volcanic eruptions) processes occurring in the environment. The impacts of climate variations are noticeable locally and internationally and span across various sectors of the economic. However, agricultural is most particularly vulnerable to climate variability, given its reliance on weather and climate. Yet, agriculture is a means of producing food needed for human livelihood thus constituting a crucial economic activity. In developing countries for instance, almost 50% of the active productive populace relies on agriculture for their living, making it the major livelihood globally for 70% of the poor (FAO, 2019).

Climate variability poses a serious stress on food production and availability. It is reckoned that between 20–80% of inter-yearly yield alteration is attributed to weather changes, and 5–10% of domestic farm production is lost yearly owing to weather variability (FAO, 2019). For instance in sub-Saharan Africa (SSA), the intensity and frequency of the impacts of climate change and variability are increasing as manifested in the occurrence extreme events. This affects over 40% of the 360 million individuals in SSA, thereby reinforcing poverty (Trisos *et al*., 2022). This stems largely from the fact that the greater part of agriculture in Africa is rain-fed, with every aspect of farming activities of smallholders being shaped by weather (i.e. from pre-planting to postharvest activities).

Smallholders in developing countries are strategic to food security, as they are responsible for cultivating the bulk of food. In Nigeria for instance, smallholders constitute over 80% of the total number of farmers (FAO, European Union and CIRAD, 2022), and account for around 90% of farm produce (Oyaniran, 2020). They cultivate arable crops including maize, being an essential cereal crop. Apart from presently being the most extensively cultivated crop globally (European Adaptation Strategy, 2019), maize has since 2013 ranked as the most important staple with a worldwide production of over 1 billion tonnes (10^{12} kg) (FAOSTAT, 2017). Of the roughly 200 million hectares of

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arable land in sub-Saharan Africa, almost 17% is occupied by maize (Ladele *et al*., 2016). Commonly in Nigeria, men (74.0%) and women (68.0%) cultivate maize (FAO, European Union and CIRAD, 2022). The total estimated land area allotted to maize in 2018 was 6,021.20 million hectares relative to 5773.62 million hectares in 2017, representing a 4.29% increase (NAERLS, FDAE and PPCD, 2018). These statistics give credence to the wide acceptability of the staple and its strategic importance as a food security crop.

Notwithstanding, maize production small is increasingly threatened by adverse climatic events. The crop is largely thought to be susceptible to heat stress, drought and irregular rainfall, all being climate risks (Hunter and Crespo, 2019). This makes its yield very sensitive to forces of climate irregularities (Tebaldi and Lobell, 2018). Iizumi *et al*. (2018) observed a 4.1% decline in the average yield of maize across the world within 1981-2010 due to climate change. Yield reduction would cause scarcity as well as an increase in the market price of the crop with consequent higher prices of livestock feed and meat. Smallholders therefore need of a system that can help them manage risks emanating from climate variability. Climate information can be a way out.

Climate information is a potent tool that can decrease any possible effects of climate risk on agriculture and help build farmers' resilience as well as their capacity to adapt (Ouedraogo *et al*., 2018). Climate information positions farmers in a vantage point to adequately prepare and respond to any potential climate-related risk that may occur in a cropping season. It is conceptualized into four types: agro-meteorological information; soil conservation information; crop information; and socioeconomic-related information. This is in line with the different categories of data essential for tailoring communication products for use in agro-meteorological services identified by FAO (2019). Agro-meteorological information relates to seasonal climatic forecasts on weather elements that have direct relevance on maize production. Soil conservation information entails information on how to sustainably manage the soil. Information on seeds, agronomic practices, crop protection and harvesting is classified as crop information, while information on how to reduce maize farmers' vulnerability as a result of changing socio-economic and natural conditions is known as socio-economic information.

In the reckoning of most farmers, climate variability has increased (FAO, 2019). Given that farming decisions made by smallholders is often premised on their local knowledge of the climatic condition in their agro-ecology, making science-based climate information available to them is crucial. It can greatly enhance them in making enlightened decisions in line with the management and planning of activities on the farm and off the farm alike. Research has focused on adaptation strategies of farmers to climate change effects, yet there is a paucity of studies relating to climate information types they are inclined to uptake. Therefore, the extent to which climate variability impacts the types of climate information smallholder maize farmers are inclined to uptake was investigated. Specifically, the south to:

1. Describe maize farmers' production characteristics;
2. Ascertain maize farmers' awareness of the extent of climate variation;
3. Identify the institutional elements enabling access to climate information;
4. Evaluate the types of climate information maize farmers are inclined to uptake.

MATERIALS AND METHODS

Methodology

This study was conducted in Oyo State, located in South-western Nigeria. Oyo State is prominent in maize production. Making use of a structured interview schedule, a sum of 107 respondents were randomly sampled. Data collected were on: production characteristics (i.e. farm size, farming experience, land ownership, membership of farmers' association); extent of climate variation (large extent=2, less extent=1, no extent=0); institutional elements enabling access to climate information (access=1, no access=0); and types of climate information (i.e. agro-meteorological information; soil conservation information; crop information; and socio-economic information)maize farmers were inclined to uptake inclined to uptake (more inclined=2; less inclined=1, not inclined=0). Analysis of data collected was done using percentages, mean scores, and standard deviation, while the hypothesis predicting the contribution of the independent variables on inclination to uptake climate information was tested using t-test from the linear regression. The model is defined below:

$Y = a + \beta_1 X_1 + \beta 2 X_2 + _{\ldots} + _{\beta n} X_n$

Y = Climate information; $X_1 \ldots X_n$ = independent variables; a = constant; $\beta_1 \ldots \beta_n$ = slope of line.

RESULTS AND DISCUSSION

Production characteristics of maize farmers

As presented in Table 1, Over three-quarters (77.6%) of them cultivated farmlands of less than 3 hectares (2.61±2.9), giving credence to the fact that they are smallholders. Compared to when there are more large scale farmers, this may negatively influence their decision to uptake climate information in an attempt to adjust to risks posed increasing climate variability. This is consequent on the fact that harvesting of information is inconsequential to smallholders whereas large farm holdings afford the opportunity to undertake diverse adaptation approaches (Thomas and Sanyaolu, 2017). Findings further revealed that the respondents were reasonably experienced in their enterprise as they possessed approximately 20 years

(20.62±9.95) experience in maize farming. As such they are expected to have a good understanding of the climate-related risks resulting from climate variability affecting their farm enterprise. Additionally, 71.0% owned their maize field. Typically, farmers who own their cultivated plots are likely to be more inclined to uptake climate smart practices (Kehinde *et al*., 2022).

Extent of maize farmers' awareness of climate variation

Awareness of climate variation is essential in influencing the measures farmers will deploy against climate variability in order to increase and sustain food production. With respect to the extent of variation of specific climatic parameters, Table 2 reveals that erratic rainfall ($\bar{X}$=2.72), heavy rainfall resulting in flooding ($\bar{X}$=2.60), variations in the intensity of sunshine ($\bar{X}$=2.57), and rainfall seasonality ($\bar{X}$=2.52) were the most varied climate parameters in the study area. Given that these findings revolve around rainfall as well as temperature, it implies that rainfall plus temperature are the major climatic parameters affecting agriculture in the area. This is even as climate drivers pertinent to food security comprise both rainfall and temperature-related metrics (IPCC, 2019). Water availability and temperature thus have the greatest influence on crop production (FAO, 2019). They are quite essential because crops show stimuli to rainfall and temperature on a daily basis. For instance, maize can be cultivated twice in a cropping season in the study area i.e. early and late cultivation. However, erratic or irregular rainfall pattern makes the cultivation of early maize a gamble, as most farmers are increasingly hanging their hope on the late maize cultivation option when the rainy season fully sets in. Aside from crop failure and reduction in yield, heavy rainfall and flooding can cause farm land erosion and dislodgment of farming communities. Additionally, the level of temperature determines soil water infiltration, evapotranspiration, runoff and deep percolation. Tailoring climate information around rainfall and temperature-related metrics can arouse smallholders' inclination to incorporate such in their decision-making.

Institutional elements enabling access to climate information

Availability to institutions that facilitate access to climate information can inform smallholders' decision to seek and incorporate such in their local settings. Table 3 shows that agro-input dealers (71.9%), membership of farmers' organisations (69.1%) and agricultural extension services (61.7%) were the key institutional elements facilitating smallholders' access to climate information. Being a body of agricultural service providers who are very close to smallholders, it makes it logical why agro-input dealers constitute an important means of accessing climate information. Their closeness to smallholders positions them in a vantage position to recommend appropriate maize varieties that can thrive under specific agro-ecological conditions e.g. early maturing and high yielding varieties which are tolerant to low rainfall and increased drought. Equally, smallholders often associate with farmers' groups as such groups are essential means of getting across agricultural technologies. Research has shown that membership of such groups enhances farmers' access to climate information (Chandra, 2017). Furthermore, farmers who have access to extension services are deemed to possess a higher chance of accessing climate information. This is even as extension officers operating in rural settings offer assistance in the spread of climate information to farmers after its generation by climate service agencies (FAO, 2019). Therefore, extension can be used to correct any erroneous opinions smallholders may have about climate variability and change.

Typologies of climate information maize farmers are inclined to uptake

Results in Table 4 show that dry spell/drought prediction ($\bar{X}$=1.72) and onset of rainy/cropping season ($\bar{X}$=1.70) as the agro-meteorological information maize farmers were more inclined to uptake. These highlight a keen interest in information about rainfall. Within a cropping season there may be occurrence of periods of little or no rainfall (i.e. rainfall cessation) that can negatively affect maize crops. Also, the onset of rainy season is a priority need to farmers because when farmers are uncertain of the arrival (early or late) and stability of rains, they may not be able to ascertain the appropriate time to sow their seeds. Changing the time of land preparation activities ($\bar{X}$=1.42) was the most important soil conservation information to the farmers. This is understandable considering that climate change can adjust the agricultural calendar or timing of performing agricultural activities, which could elongate the cropping season. This would prompt farmers to begin land preparation activities in time should the onset of rainy season happens earlier (Yegbemey *et al*., 2014). When this occurs, it can avail farmers the opportunity to adequately cultivate early maize and late maize, highlighting a positive impact.

Regarding crop information, the smallholders were more disposed to planting early maturing varieties ($\bar{X}$=1.52), along with changing of planting date ($\bar{X}$=1.51). Crop information can guide farmers on maize varieties that are appropriate for specific agro-ecologies, in line with the climate outlook for a particular cropping season. This can help to avoid waste of resources (e.g. inputs and finances). Readiness of the respondents to change maize planting explains why they were equally willing to alter land preparation activities as earlier observed. Sowing date is quite important because it determines whether a farmer will cultivate early or late maize, or both, in a particular cropping season.

To the smallholders, foremost socio-economic information was diversification of livelihood activities ($\bar{X}$=1.66), which can be on-farm (crop cultivation, livestock rearing, fish farming, etc.) or off-farm (processing of farm produce, produce marketing, etc.). As well as address climate risks, livelihood diversification ensures economic and subsistence security for smallholder farmers (Chandra, 2017). Additionally, improvement of household food safety skills ($\bar{X}$=1.64) was also deemed highly important. Timely warning on upcoming risk events in the growing season can assist farmers to apply basic food safety, storage and marketing principles. This accounts for why early warning systems towards risk management constitute the most apparent and efficient inputs made in the advancement of climate variability and change adaptation (FAO, 2019).

Overall, though the respondents were inclined to uptake all types of climate information as seen from the grand mean scores, yet they displayed greater inclination to uptake agro-meteorological information ($\bar{X}$=1.38). Willingness to incorporate agro-meteorological information relative to others is adducible to the fact that agro-meteorological information finds significance in the design of seasonal calendars or informs the agricultural activities to be done prior to and/or during a growing season (e.g. timing of land preparation, seed variety selection, sowing date, maintenance of field crops, crop harvesting and management of household or farm budget). Another study Chandra (2017) observed that through agro-meteorological information, smallholders' were able to successfully coincide with early or late onset of rains by simulating the sowing period thus avoiding disasters.

Table 1. Maize farmers' production characteristics.

Variable	Category	Percentage	Mean
Farm size (ha)	≤ 3	77.6	2.3±2.5
	4-6	15.9	
	7-9	2.8	
	≥ 10	3.7	
Farm experience (years)	≤ 10	18.7	20.6±9.9
	11-15	16.8	
	16-20	18.7	
	21-25	17.8	
	>25	28.0	
Land ownership	Yes	71..0	
	No	29.0	
Membership of farmers group	Yes	65.0	
	No	35.0	

Table 2. Extent of climate variation.

To what extent do you think there has been:	Mean	SD
Number of hot days (temperature) over the past years	2.52	0.59
High wind/storms over the past years	2.14	0.47
Intensity of sunshine over the past years	2.57	0.55
Occurrence of dry spells/droughts over the past years	2.12	0.84
Number of humid days over the past years	1.67	0.76
Increased rainfall and flooding over the past years	2.60	0.64
Erratic rainfall in the past years	2.72	0.53
Onset of rainfall in the past years	2.46	0.72
Rainfall cessation over the past years	2.21	0.62
Rainfall seasonality over the past years	2.52	0.69

Table 3. Institutional elements enabling access to climate information.

Institutional elements	Accessibility
Agricultural extension services	61.7
Researcher institutes	43.0
Agro-input dealers	71.9
Workshops/seminars	39.3
Membership of farmer groups	69.1

Table 4. Typologies of climate information maize farmers are inclined to uptake.

Climate information	Mean	SD
Agro-meteorological information		
Onset of rainy/cropping season	1.70	0.48
Cessation of raining/growing season	1.44	0.57
Length of growing season	1.49	0.54
Dry spell/ drought prediction	1.72	0.53
Soil temperature	1.47	0.64
Soil moisture content	1.39	0.58
Sunshine intensity	1.41	0.77
Relative humidity level	1.16	0.73
Wind speed/strength and direction	1.41	0.70
Potential flood prediction	1.44	0.60
Daily weather forecast	0.89	0.75
Early warning messages and preparedness attempt	0.99	0.94
Grand mean	**1.38**	
Soil conservation information		
Changing the time of land preparation activities	1.42	0.57
Making ridges across slopes	0.88	0.88
Planting of economic trees	0.97	0.94
Practice of cover cropping	1.36	0.54
Mulching of maize seed beds	1.10	0.76
Use of organic manure	0.93	0.88
Use of irrigation	0.75	0.81
Grand mean	**1.06**	
Crop information		
Intercropping maize with legumes	1.08	0.85
Drought and pest/disease tolerant maize varieties	1.18	0.73
Change of planting date of maize	1.51	0.57
Planting early maturing maize varieties	1.52	0.67
Practice of crop rotation	1.42	0.65
Information on growing stages of maize	1.05	0.82
Grand mean	**1.29**	
Socio-economic information		
Diversification of livelihood activities	1.66	0.51
Acquisition of budgeting skills	0.81	0.82
Use of energy efficient products (e.g. cooking stoves)	1.26	0.58
Improvement of household food safety skills	1.64	0.62
Shifting from maize production to maize marketing	1.01	0.88
Evaluating the characteristics of new maize varieties	1.22	0.72
Migrating out of climate risky areas to maize production	1.42	0.55
Grand mean	**1.29**	

Table 5. Explanatory variables of typologies of climate information smallholder maize farmers are inclined to uptake.

Model	Unstandardised coefficients		Standardised coefficients	T	Sig.
Constant	34.343	9.109		3.770	0.001
Production characteristics					
Farm size	0.942	0.301	0.298	3.129	0.003***
Farming experience	-0.131	0.074	-0.132	-1.773	0.085
Land ownership	1.304	0.445	.247	2.930	0.006***
Climate parameters					
Hot days (temperature)	-5.591	2.590	-0.323	-2.159	0.038**

Wind/storms	-5.175	2.287	-0.212	-2.262	0.030**
Intensity of sunshine	1.468	1.694	0.077	0.866	0.392
Dry spells/droughts	-0.703	1.096	-0.054	-0.641	0.526
Humid days	6.844	1.329	0.588	5.150	0.000***
Increased rainfall and flooding	-1.704	1.724	-0.099	-0.989	0.329
Erratic rainfall	2.527	1.747	0.117	1.446	0.157
Onset of rainfall	3.235	1.485	0.221	2.179	0.036**
Cessation of rainfall	2.271	1.562	0.129	1.454	0.155
Seasonality of rainfall	-0.850	1.543	-0.054	-0.551	0.585
Model summary	$R=0.927$, $R^2=0.859$, Adjusted $R^2=0.809$				

*, ** and *** depict statistical significance at 10% ($0.05<P< 0.10$), 5% ($0.01<P< 0.05$) and 1% ($P<0.01$), respectively.

Explanatory factors of typologies of climate information smallholder maize farmers are inclined to uptake

Key factors influencing maize farmers' inclination to uptake climate information are given in Table 5. The regression model was observed to be highly significant at $p<0.01$, indicating the goodness of fit of the model. The inclination to uptake climate information was explained by about 86.0% of the explanatory factors utilised in the model. Farm size, land ownership, number of hot days (temperature), wind/storms, number of humid days (relative humidity) and onset of rainy season were the key factors influencing the types of climate information the respondents were inclined to incorporate in their decision making as strategies for coping with climate variability. Farm size was significantly positively correlated to smallholders' inclination to uptake climate information at 1%. This finding infers that the scale of enterprise of maize farmers can influence whether it is worthwhile to uptake climate information, given that its deployment may not be cost effective in small farm holdings. This gives consideration to the fact that adaptation cost is associated with climate change risks (Adeagbo *et al*., 2021).

This takes into account of the fact that the decision to adapt to climate risks is not without a minimum or fixed cost element (Madison, 2007). Similarly, land ownership was positively correlated with inclination to uptake climate information at 1%. Smallholders who own their maize field will have a higher sense of security than those who do not own their farmlands. This is premised on the fact that ownership of farmlands can encourage them to adopt land conservation practices such as planting of economic trees that can serve as windbreaks or protect the soil.

Onset of rainy season and relative humidity had significantly positive correlations with the decision to uptake climate information at 5% and 1%, respectively. These are among the main climatic elements affecting the planning of farm operations. The management decisions of farmers for instance are usually premised on the date when the onset of the rainy season is observed, considering that cropping seasons that have early onset of rains have a longer duration, with higher water volumes (FAO, 2019). The extent or rate at which crops consume water is dependent on factors like temperature as well as wind speed. As such temperature and wind/storms, both significantly correlated at 5%, constituted key factors for the respondents' decision to uptake climate information to cope with climate variability. For instance, wind speed can determine the time when agro-chemicals such as pesticides and fungicide can be sprayed (Venkatasubramanian *et al*., 2014).

CONCLUSION AND RECOMMENDATION

Increasing climate variability is prompting smallholder farmers to explore means of reducing the exposure of their enterprises to climatic risks. Among other types of climate information, smallholders were more inclined to incorporate agro-meteorological information (particularly information about rainfall) in their decision making as a response to climate variability. Farm size, land ownership, onset of rainy season, relative humidity, temperature and wind/storms determined the decision to uptake all types of climate information as a mechanism for managing climate variability. Consequently, making climate information available to smallholders through appropriate institutional elements would not only place them in a vantage position in determining the agricultural activities to undertake in preparation for and during a cropping season, but also the timing and scale of such activities. This can greatly reduce the exposure of their enterprises to the risks emanating from climate variability.

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