We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,800
Open access books available

122,000
International authors and editors

135M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

CLARIVATE ANALYTICS
BOOK CITATION INDEX
INDEXED

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

GIS-Based Assessment of Smallholder Farmers' Perception of Climate Change Impacts and Their Adaptation Strategies for Maize Production in Anambra State, Nigeria

John Agbo Ogbodo, Samuel E. Anarah and
Sani Mashi Abubakar

Additional information is available at the end of the chapter

Abstract

The production of *Zea mays* (otherwise called maize or corn), which is an important staple food crop in Nigeria, is limited by the impacts of climate change; thus, posing food insecurity in the country. The primary purpose of this study is to assess the perception of smallholders' maize farmers on climate variability; and, their climate change adaptations practices in Anambra State, Nigeria. A multi-stage sampling technique and structure questionnaires were applied to this study. Collected data were analyzed using both descriptive/ inferential statistics, together with a simple technique of geographic information system (GIS). The results show that, approximately 57.2% of climate variability negatively impacts on maize production in the study area. Basically flooding ($\overline{x}$ = 2.02 $\pm$ 1.166), erratic rainfall ($\overline{x}$ = 2.02 $\pm$ 0.816), and decrease in crop yield by strange pests and diseases ($\overline{x}$ = 1.59 $\pm$ 0.896) affect maize production. The well-informed farmers practice some climate change adaptations techniques such as: planting of grasses to prevent erosion, and, use of improved maize seeds to withstand environmental stress. In conclusion, the lower the standard deviation values, the more knowledgeable the farmers were about issues of climate variability and on climate change adaptations practices; and, vice-versa.

Keywords: smallholder maize farmers, climate change perception, adaptation strategies, GIS, Nigeria

1. Background information

Zea mays, popularly known as maize or corn, and, sometimes called Indian corn or mealies [1]; is one of the important Nigeria's household grains that contributes to food security. Food security is of high importance on the Nigeria's national agenda, taken into account the increasing demand for food for its increasing population [1, 2]. The importance of corn in Nigeria can be underlined in two ways: (a) its economic value to the national treasury, and, (b) the large number of smallholder-farmers that cultivate the crop at subsistence level [3]. According to [2], Nigeria was the tenth largest producer of maize in the world, and the largest maize producer in Africa. It is estimated that 70% of farmers are smallholders, and this number accounts for 90% of the total farm outputs [4]. Maize crop started as a subsistence crop in Nigeria and has gradually risen to a commercial crop on which many agro-based industries depend on, as raw materials [3]. In 2016, maize production for Nigeria was 10.4 million tonnes. Though Nigeria maize production fluctuated substantially in recent years, its yield was projected to increase to a maximum of 10.4 million tonnes in 2016 [1].

As a Nigerian staple food, corn is being utilized in making household diets, for industrial processing as a raw material, and for animal feed formulation [5]. Processed maize product: *tuwo—masara (Hausa), fufu (Yoruba), nri-oka (Igbo), uwe-nyumbakpa (Igede) or semo (common English branded name)*, is one of the food products that can be obtained from maize utilization in Southeast, Nigeria [6]. It is essentially a food gel or dumpling which is stiff, has a yield value and can be molded into shapes. Other food products that are obtained from maize grain include the following Nigerian native names: ogi, eko or agidi, egbo, elekute, aadun, abari and guguru (i.e. popcorn) [7]. This important cereal crop is widely cultivated within the rainforest and the derived Savannah zones of Nigeria [4, 8]. Improved varieties have been developed for high yield production in the country [9]. About 60% of maize in Nigeria is from high rain-forest zones [10]; and many varieties of maize were developed and available for cultivation in Nigeria [11]. However, maize production is greatly limited by the impacts of climate change [12].

Climate change is the most serious contemporary environmental threat facing humankind [13–16]; because, many aspects of planet Earth are changing mainly due to anthropogenic (human-induced) activities. The foregoing scenario thereby raises climate change issues for sustainable maize production [2, 12, 17–19] in countries that are susceptible to climate change impacts. IPCC (Intergovernmental Panel on Climate Change) in 2007 defined climate change as: "a change in the state of the climate which can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It further refers to any change in climate over time, whether due to natural variability or as a result of human activity" [20]. In addition, IPCC expressed that, Africa seems to be the most vulnerable continent to future climate change impacts [21–23]. Justly, climate change is already a reality for millions of Africa's smallholder farmers, especially, maize producers [24, 25]. Despite that, maize plays fundamental roles to national food security in Africa [12]; its production is thus, highly dependent

on climatic variables [13, 14]. Therefore, concerns have been widely expressed, over the years by agronomists, research institutions, governmental agencies at both local and international fora, on the need to tackle the impacts of climate variability on maize yield [16, 26–28]. Climatic factors and are among environmental conditions that affect the productivity of many varieties of maize crops [29, 30]. Worse -still, many smallholder farmers are resource constrained, therefore, their demands for certain improved seeds vary as much as agro-climatic conditions do [24, 31, 32]. However, the formal seed sector has made some success in raising adoption of various improved maize varieties such as stress-tolerant varieties, early and extra-early varieties, or N_2-efficient varieties [29].

2. Related past research on climate variability and adaptation to climate change by smallholder maize farmers

This above expressed scenarios have motivated several past research works on climate variability on maize production over the past decade [12, 13, 33, 34]. Specifically, [33] identified climate variability as a global environmental challenge that is likely to have a serious effect on natural and human systems, economies and infrastructures. However, the nature of these biophysical effects and the human responses to these changes are complex and uncertain as the changes keep manifesting in different forms on a yearly basis. Climate change has already exhibited strong negative impacts on food security in many African countries such as: Eritrea [35]; Ethiopia [36]; Kenya [12, 37]; South Africa [38]; Nigeria [39]; etcetera.

Consequently, past studies have indicated substantial diversity in the awareness level of Nigerian maize farmers in regard to climate change adaption techniques [3, 10]. Adaptation to climate variability is defined as an adjustment in natural or human systems to actual or expected climatic stimuli or their effects, which moderates harm and exploit beneficial opportunities [40, 41]. Climate change adaptation depends on: demand for improved seeds for maize, category of techniques adopted to curtail climate variability, time of planting, among others [4]. Planting time is an essential component of maize crop management, especially in the South-eastern part of Nigeria [8]. Yields decline with lateness of planting after an optimum time, usually the start of the rains [17]. Response of maize varieties to climate variability is dependent upon planting time. Optimum planting in each of the major agro-ecological zones of Nigeria falls within the following ranges [42]: Forest zone—Mid April—second week in May; forest—Savannah transition—third week in April—third week in May; South Guinea Savannah comes up during the last week in April to the third week in May. These planting dates coincide with the period that flooding occurs with the riverine communities of the study area. Re-occurring flood is an impact of climate that strongly manifests in South-eastern Nigeria; thereby decreasing maize production in flood prone zones [43].

Furthermore, some other previous long-term climate change studies have established a nexus between the effects of carbon dioxide concentrations in the atmosphere, and the mean global temperature [13, 44]. In addition, the studies by [43, 45] opined that, global warming has

influenced agricultural productivity negatively in parts of Sub-Saharan Africa, mostly in Nigeria, and had thus resulted in decline of food production. Numerous climate variability effects are outcomes of human activities bothering on industrialization, agricultural expansion, deforestation, bush burning, use of inorganic fertilizers, intensive livestock farming system and storage of wastes in landfills [46]. Landfill for example, releases lots of greenhouse gases to the environment thereby increasing the scourge of global- warming on humans and their crops [16]. Literature asserts that non-adaptation of climate smart strategies *vis-à-vis* lack of aware-ness creation about climate variability in communities, could aggravate a poor Nigerian economy at a percentage loss of between 2% and 11% GDP, by year 2020 [47]. The foregoing assertion could further worsen, to a record low of 12–50% by year 2050 [1, 48]. Such a negative trend can compromise the attainment of the purported Sustainable Development related Goals [27, 49] in Nigeria.

Nevertheless, the magnitude to which maize yield drastically reduced in last two consecutive years in Nigeria, creates the need for researchers to examine existing knowledge gaps on smallholder maize farmers' perception climate change variability in South-eastern Nigeria; as a remedy to forestalling future low maize productivity in the country.

3. Statement of the problem

Nigeria's ecological conditions and cultural diversities put the country at an advantage for production of a wide range of food products [25]. However, the Climate Change Vulnerability Index 2014 classified Nigeria's vulnerability as extreme and ranked the country as number six [6] most vulnerable country to climate change [39, 48]. This extreme vulnerability has negative implications for agricultural production and food security, especially in South-eastern Nigeria.

The awareness of farmers to adopting improved seed varieties as a panacea for climate change adaptation, has been relatively widely studied in Nigeria [3, 4, 9, 11, 13, 42, 50]. However, most previous climate change research measured the level of change in decades (long term) without considering the short term effects and adaptations [40]. The above illustrations also apply to Nigerian South-eastern states including Anambra State [6].

In a nutshell, smallholder maize farmers with a deep understanding of the specific environ-mental factors that determine or limit the growth of their crops, would have better capabilities to significantly increase their crop yields by making through rightful choices and using of novelty approaches of climate smart agriculture. Therefore, understudying the relative influ-ence of farmers' awareness toward curbing severe climate change impacts on their maize plant growth and yield, is very crucial.

The pervasive role of Geospatial technology in solving agricultural problems has widely been established. Therefore, Geographical Information System (GIS) is a type of Geospatial technology that provides the means to collect and use geographic data to assist in support of food production and food security. GIS is a system for capturing, storing, analyzing and managing data and associated attributes, which are spatially referenced to the Earth [51].

Therefore, the overall objective of this present study is to fill the knowledge gap between the perception of smallholders' maize farmers on climate variability and their use of climate change adaptation approaches in relation to GIS, toward contributing to sustainable food security in Anambra State, South-eastern Nigeria.

4. Research location

Located in South-eastern Nigeria, Anambra state lies between Latitude 6° 45′ and 5° 44′ N and Longitudes 6° 36′ and 7° 20°E [38]. The climate is humid with mean average rainfall of 2010 mm and average temperature of 87°C (**Figure 1**). It has a weak soil that is easily eroded [38]. The climate here is tropical. The average annual temperature is 27.0°C. The rainfall here averages 1828 mm. The driest month is December, with 7 mm of rain. Most precipitation falls in September, with an average of 306 mm (**Figure 2**).

The state is divided into four agro-ecological zones (AEZ): Aguata, Awka, Anambra and Onitsha. The sites for this present study are shown in **Figure 3**. There is a difference of 299 mm of precipitation between the driest and wettest months. The average temperatures vary during the year by 3.8°C. The state occupies a land area of approximately 4887 km^2 and a population of 4,182,032 people based on the 2006 census figures. According to the Nigeria's National Population Commission figures of 2006, the population distribution is 2,174,641 million males and 2,007,391 million females. Anambra state is bounded to the north by Kogi state, to the south by Imo and Abia state, to the east by Enugu state and to the west by Delta state.

In 2006, maize production index for Anambra state was put at 69,1000 metric tonnes [48]. However, the state has in recent years, been substantially experiencing fluctuations in maize production at a decline rate of 23.28%. The decrease in maize yield in this Southern Nigeria, can be attributed to: (a) climate change related flooding [9, 25]; that re-occurs almost every year; and (b) non-adaptation of climate-smart measures by smallholder maize farmers [52, 53]. However, climate change adaption measures for maize, which is one of the most important grain crops, is less studied in Anambra State [6]. Another knowledge gap scenario is that, there is a limited
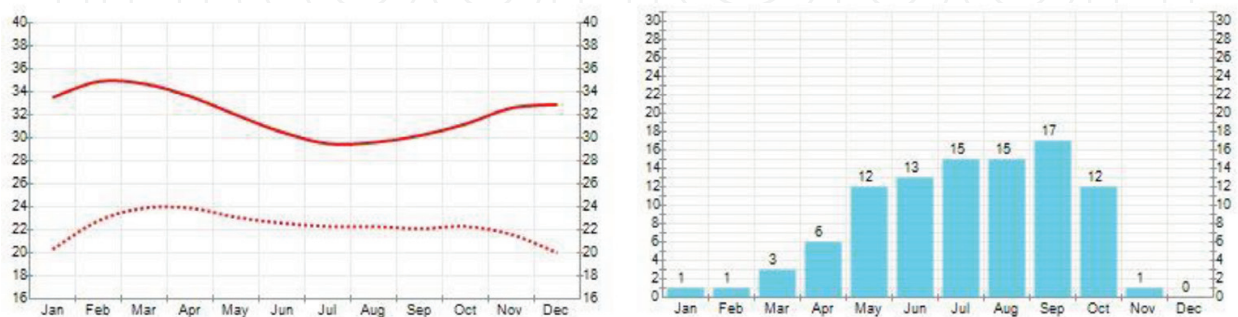

Figure 1. Average temperature per month (left) and average days with precipitation per month (right). Source: adopted from https://www.yr.no/place/Nigeria/Anambra/Anambra_State/statistics.html.
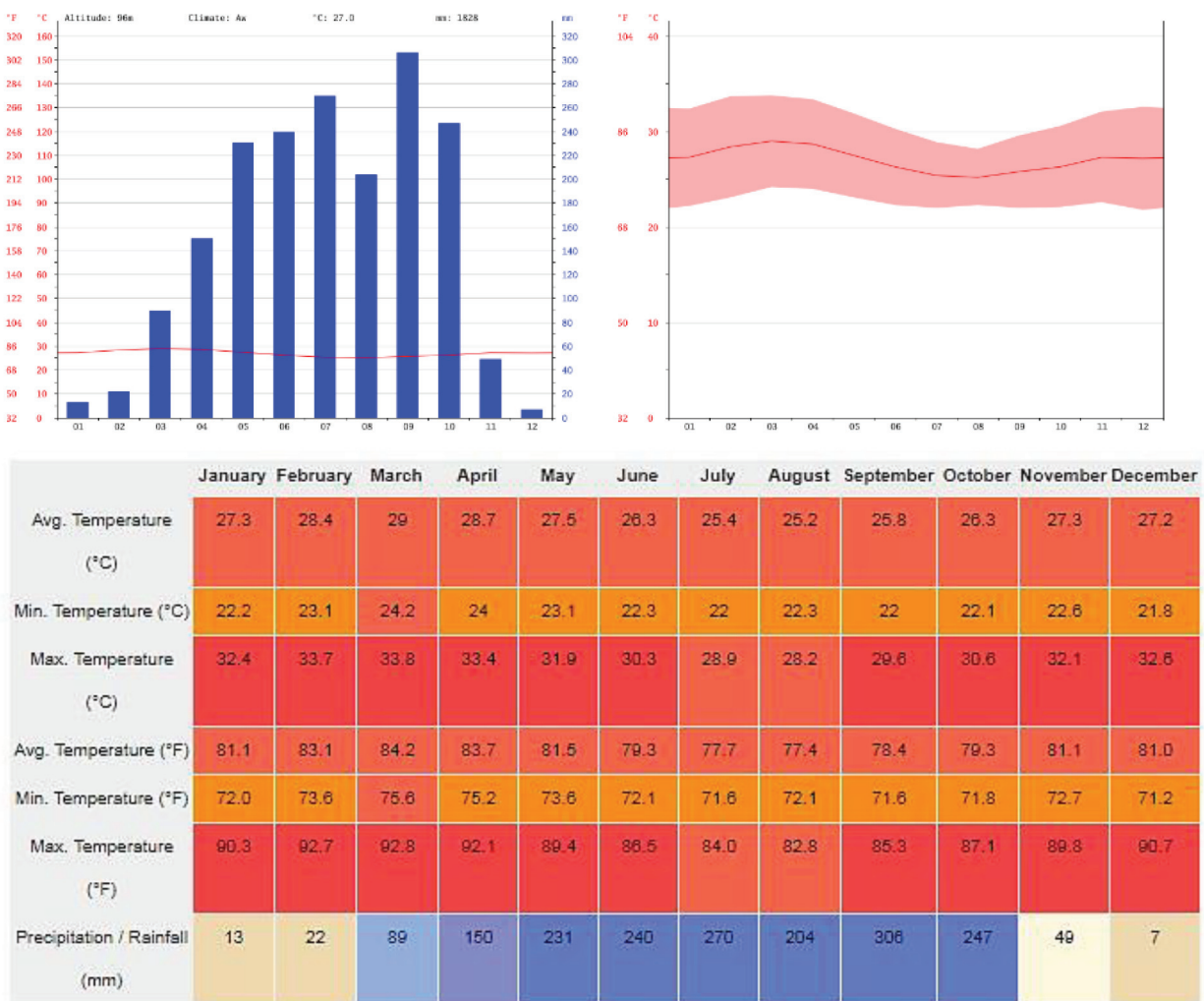
	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	27.3	28.4	29	28.7	27.5	26.3	25.4	25.2	25.8	26.3	27.3	27.2
Min. Temperature (°C)	22.2	23.1	24.2	24	23.1	22.3	22	22.3	22	22.1	22.6	21.8
Max. Temperature (°C)	32.4	33.7	33.8	33.4	31.9	30.3	28.9	28.2	29.6	30.6	32.1	32.6
Avg. Temperature (°F)	81.1	83.1	84.2	83.7	81.5	79.3	77.7	77.4	78.4	79.3	81.1	81.0
Min. Temperature (°F)	72.0	73.6	75.6	75.2	73.6	72.1	71.6	72.1	71.6	71.8	72.7	71.2
Max. Temperature (°F)	90.3	92.7	92.8	92.1	89.4	86.5	84.0	82.8	85.3	87.1	89.8	90.7
Precipitation / Rainfall (mm)	13	22	89	150	231	240	270	204	306	247	49	7

Figure 2. Climograph (left) and temperature graph (right and down) of Anambra state. Source https://en.climate-data.org/location/46675/#temperature-graph.

empirical evidence as to what extent climate variability is perceived by the smallholders maize farmers in Anambra state. These scenarios create the pertinent need to researching the assessment of smallholders maize farmers' perception on climate variability and its emerging consequences on their livelihoods in Anambra State of Nigeria.

5. Research methods

Survey design was adopted in carrying out the study. [54] describes survey research as the one in which a group of people or item is studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group. **Population of the study:** Anambra state is made up of 2270 smallholder maize farmers (Anambra State Agricultural

Figure 3. Map of Anambra state showing the four sampled study sites of Akwa North, Idemili, Orumba North and Oyi 1 local government areas (L.G.A.).

Development Programme, which formed the sample frame). The distribution is as follows; Anambra-520, Aguata-680, Awka-620, Onitsha-450. **Sampling Techniques and sample size:** A multi-stage sampling method was used in selecting the sample units for the study. Anambra state is made up of four agricultural zones, namely, Anambra, Aguata, Awka and Onitsha. One extension block was randomly selected from each of the four agricultural zones to avoid bias; Awka north, Orumba north, Oyi 1 and Idemili to give a total of four blocks. Secondly, two circles were randomly selected from each of the four blocks again to give equal coverage, the selected circles were Amansi and Awba ofe nmiri from Awka north, Ufuma and Ajali from Orumba north, Nteje and Umunya from Oyi 1 and Nkpor and Obosi from Idemili north, thereby giving a total of eight circles. In the fourth stage, two sub-circles were randomly selected from each of the circles, the selected sub-circles were Ore, Egbe agu, Umu eze and Enugu agu from Amansi and Awba ofe nmiri, Umu onyiba, Umu ogem, Umu abiama and Umu ereh from Ufuma and Ajali, Umuefi, Achalla, Umuebo and Amaezike from Nteje and Umunya, Akuzor, Nbuba, Ire and Umu ota from Nkpor and Obosi, thereby given a total of sixteen sub- circles. The last stage involved random selection of eight farmers contact from each sub-circles. In all, a total of 128 farmers (respondents) were chosen from a list comprising of 2270 small scale maize farmers provided by Anambra ADP which formed the sampling size.

Reliability of Instrument: Reliability of the questionnaire was tested using cromlech alpha method which is 0.82%.

5.1. Method of data collection

Primary data were collected with well validated open and close ended questionnaire by the researcher. Questionnaire construction was based on the objectives of this study.

5.2. GIS technique

The aim of the GIS technology applied in this present study is provide maps of climate variability, degree of climate change adaptation and level of acceptability among the samples sites. The input data were from outcome of the questionnaire approach and GPS coordinates.

5.3. Data analysis

Descriptive statistics such as mean, frequency distribution and percentage were made to visualize and analyze the distribution of field data using box plots. Ordinal regression model statistic was also applied to the study.

5.4. Model specification

1. To get the mean score using three-point Likert scale

    High extent = 3, Moderate extent = 2, Low extent =1.

    Strongly aware = 3, Aware = 2, Not aware = 1.

    Mean score = $\frac{3+2+1}{3}$ = 2.0

2. Mean estimation

    Each of the total responses from all the respondents is calculated to get their individual mean response. The code of each of the responses is multiplied, and thereafter added to get the mean response thus:

    For high extent (3), assuming total response to be 90: (90/128)*3 = 2.109.

    For moderate extent (2), assuming total response to be 22: (22/128)*2 = 0.344.

    For low extent (1), assuming total response to be 16: (16/128)*1 = 0.125.

    Total mean score = 2.578 (thus, decision rule for this is high extent).

3. Equation for multiple linear regressions

$$Y_0 = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_p X_{pi} + e_i \tag{1}$$

Explicit.

where β_0 = the intercept, β_1 = slope (regression coefficient), Y_0 = dependent variable, e_i = standard error, X = independent variable, $p \geq 2$.

Where X_1 = age (years), X_2 = sex, X_3 = house hold size (No), X_4 = educational level (no of years), X_5 = farming years (No), X_6 = farming size (No), X_7 = labor source (Manday), X_8 = membership organization (No), X_9 = average income (₦), X_{10} = average yield (kg).

6. Findings and interpretations

6.1. Activities that contribute to climate variability

The various activities of the small scale maize farmers that contribute to climate variability are shown in **Table 1**.

Result in **Table 1**, reveals that the majority of the small scale maize farmers (88.28%) indicated that bush burning contribute to climate variability while (82.03%), (60.16%), (56.25%) and (50.78%) indicated that intensive agricultural land use, use of inorganic fertilizers, use of fossil fuels and deforestation as factors that contribute to climate variability. The implication of this finding is that many of the farming activities in the area contribute to climate change. This finding agrees with the study of Oladipo [41], who noted that most agricultural activities are the major factors of climate variability.

6.2. Level of awareness of climate variability

The result of mean responses of the level of awareness of climate variability by small scale maize farmers is shown in **Table 2**.

The result here, reveals that the smallholder maize farmers were significantly aware of the following climate variability in the study area: decreased rainfall days ($\overline{x}$ = 2.05; SD = 0.914), early onset of rainfall and early cessation ($\overline{x}$ = 2.08; SD = 0.929), late onset of rainfall and early cessation ($\overline{x}$ = 2.02; SD = 0.816), shorter than normal rainfall ($\overline{x}$ = 2.14; SD = 1.132), low

Farmers' activities	Frequency* (n = 128)	Percentage (%)
Burning of bush	113	88.28
Intensive agricultural land use	105	82.03
Use of inorganic fertilizers	77	60.16
Use of fossil fuels (fuel, kerosene, etc.)	72	56.25
Deforestation	65	50.78
Use of herbicides	54	42.19
Use of pesticides	55	42.97
Improper disposal of farm wastes	46	35.94

*Multiple response.
Source: Field survey, 2017.

Table 1. Percentage response of farmers according to the activities that contribute to climate variability.

S/N	Climate variability	$\overline{x}$	SD	Decision
1.	Decreased rainfall days	2.05	0.914	S
2.	Early onset of rainfall and early cessation	2.08	0.929	S
3.	Late onset of rainfall and early cessation	2.02	0.816	S
4.	Shorter than normal rainfall	2.14	1.132	S
5.	Low intensity rainfall	2.02	0.872	S
6.	Flash flooding	2.02	1.166	S
7.	Unusual patterns of precipitation	2.02	0.904	S
8.	High sunshine intensity	2.01	0.886	S
9.	Increase in earth surface temperature	1.50	0.627	NS
10.	Longer hours of sunshine	1.95	1.173	NS
11.	Short-lived Hamattan	1.48	0.869	NS
12.	Increase in crop yield	1.04	1.193	NS
13.	Decrease in crop yield	1.39	0.896	NS
14.	Loss in soil fertility	1.55	0.954	NS
15.	Increased erosion	1.50	0.854	NS
16.	Erratic/unusual rain	1.55	1.175	NS
17.	Early onset of rain and late cessation	1.03	1.131	NS
18.	Late onset of rain and late cessation	1.46	0.904	NS
19.	Delay in the onset of rainfall	1.56	1.194	NS
20.	Above normal rainfall	1.53	0.893	NS
21.	Below normal rainfall	1.40	0.964	NS
22.	Longer than normal rainfall	1.41	0.918	NS
23.	Longer period of dry spell	1.82	1.141	NS
24.	High intensity rainfall	1.52	0.947	NS
25.	Increase in rainfall	1.59	1.157	NS
26.	Erratic/torrential rainfall	1.48	0.930	NS
27.	Increase rainfall days	1.26	1.170	NS
28.	Rainstorms	1.62	0.896	NS
29.	Coastal flooding	1.48	0.957	NS
30.	Gustiness	1.09	1.191	NS
31.	Erosion/flooding	1.61	0.796	NS
32.	Rivers and stream overflowing their banks	1.41	0.910	NS
33.	Constant waves	1.98	1.153	NS
34.	Unusual flooding	1.53	1.170	NS
35.	Wet spells	1.24	0.867	NS
36.	Land slides	1.08	1.201	NS

S/N	Climate variability	$\overline{x}$	SD	Decision
37.	Increased in frequency of flooding	1.55	1.160	NS
38.	Low sunshine intensity	1.23	0.846	NS
39.	Early onset and early cessation of Hamattan	1.09	1.193	NS
40.	Late onset and late cessation of Hamattan	1.38	0.887	NS
41.	Early onset and late cessation of Hamattan	1.20	0.861	NS
42.	Late onset and early cessation of Hamattan	1.91	1.184	NS
43.	Typhoon wind	1.11	1.205	NS
44.	Erratic wind	1.69	1.092	NS
45.	High wind speed	1.88	1.136	NS
46.	Low wind speed	1.48	0.913	NS
47.	Frequency of cloudiness	1.05	1.179	NS
48.	Frequency of clement weather	1.03	1.048	NS
49.	Constant fog	1.08	1.188	NS
50.	Constant drought	1.01	1.187	NS
51.	Rising temperature	1.52	0.905	NS
52.	Presence of frost	1.14	1.202	NS
53.	Presence of hailstones	1.11	1.199	NS
54.	Constant waves	1.08	1.164	NS
55.	High humidity	1.39	0.889	NS
56.	Low humidity	1.73	1.008	NS
57.	Presence of unfamiliar diseases	1.95	1.149	NS
58.	Presence of unfamiliar pests	1.57	0.986	NS
59.	High incidence of pests	1.56	0.970	NS
60.	High incidence of diseases	1.41	0.910	NS

Source: Field Survey, 2017.
$\overline{x}$ = mean; SD = standard deviation; mean ≥ 2 = significant; mean ≤ 2 = not significant.

Table 2. Mean responses of the level of awareness of climate variability by small scale maize farmers.

intensity rainfall ($\overline{x}$ = 2.02; SD = 0.872), flash flooding ($\overline{x}$ = 2.02; SD = 1.166), unusual patterns of precipitation ($\overline{x}$ = 2.02; SD = 0.904) and high sunshine intensity ($\overline{x}$ = 2.0; SD = 0.886). The farmers indicated that they were aware of the following climate variability: erratic/unusual rainfall with ($\overline{x}$ = 1.55; SD = 0.914), longer period of dry spell ($\overline{x}$ = 1.82; SD = 1.132), unusual flooding ($\overline{x}$ = 1.53; SD = 0.904), longer hour of sunshine ($\overline{x}$ = 1.95; SD = 1.173), decrease in crop yield ($\overline{x}$ = 1.59; SD = 0.896), loss in soil fertility ($\overline{x}$ = 1.55; SD = 0.954), increased erosion ($\overline{x}$ = 1.50; SD = 0.854) and rainstorms ($\overline{x}$ = 1.62; SD = 0.896). They also indicated awareness of erosion/flooding ($\overline{x}$ = 1.61; SD = 0.796), presence of unfamiliar diseases ($\overline{x}$ = 1.95; SD = 1.149), presence of unfamiliar pest ($\overline{x}$ = 1.57; SD = 0.986), high incidence of pests ($\overline{x}$ = 1.56; SD = 0.970).

However, they were not aware of the following climate variability: short-lived Hamattan ($\overline{x}$ = 1.48; SD = 0.869), presence of frost ($\overline{x}$ = 1.14; SD = 1.202), low wind speed ($\overline{x}$ = 1.48; SD = 0.913). The standard deviations show the means variability. By implication, the lower the standard deviation the more the respondents are aware of the climate variability; the higher the standard deviation the lesser the respondents are aware of climate variability. These findings were in line with the result from trend analysis on such climate change variables conducted by the studies of Nwaiwu [55], which show that climate change effect is disastrous to agricultural production and requires mitigation. Also, it supports the findings of FAO [17] that there has been spatial increase in climatic variables from 1905 to 2010, and this is expected to continue over time.

6.3. Effects of climate variability on maize production

The ordinal regression on the effects of climate variability on maize production in Anambra State is shown in **Table 3**.

The R-square value of 0.572 explains about 57.2% of the level of climate variability affecting maize production in the study area. The chi-square value of 78.688 with the p-value less than 0.05 shows that the model prediction is good. Maize production is affected by increased rainfall (0.003), decreased rainfall days (0.004), increased rainfall days (0.002), erratic/unusual rainfall (0.002), increased earth surface temperature (0.042), decreased crop yield (0.004), loss in soil fertility (0.001), early rainfall and cessation (0.004), late rainfall and early cassation (0.000), erosion/flooding (0.002) and presence of unfamiliar diseases because they have significant coefficients (p < 0.05). This means maize production is affected by climate variability in Anambra State. This research finding justifies why, between 2015 and 2017, there was some worrying fluctuations regarding corn production as against its supply and demand trend in Nigeria (**Table 4**). Consequently, it is hereby expected that the Anambra state maize production index could further be constrained mainly by lack of climate smart improve measures that can contribute to reversing the current national export capacities at an average of minus-forty-percent (−40%) for Nigeria (**Table 4**) as against import of the maize commodity. Worse-still, the lack of government financial support to smallholder maize farmers and insecurity resulting from incessant herdsmen killings of farmers are expected to reduce maize production in the study area.

A high percentage of smallholder maize farmers in Anambra State do recycle their own maize seed from crops from their harvest and only a fraction of farmers purchase these seeds from other sources.

Detail results of the mean responses of the level of use of indigenous and improved adaptation strategies by small scale maize farmers in Anambra State are shown in **Tables 5** and **6**.

Table 5 shows that, planting of cover crops ($\overline{x}$ = 2.96; SD = 1.30) is largely adopted by the farmers to mitigate climate change impacts. Also, mixed farming ($\overline{x}$ = 2.59; SD = 1.25), change in tillage methods ($\overline{x}$ = 2.62; SD = 1.25), diversification from non-farming to farming activities ($\overline{x}$ = 2.70; SD = 1.31), use of organic/farmyard/mulch material ($\overline{x}$ = 2.80; SD = 1.19) were used by maize farmers as indigenous adaptation strategies. On the other hand, mixed

Climate variability	Coefficient	Standard error	Wald	df	Sig.	Cox & Snell (R^2)	Chi-square (goodness-of-fit)
Increased rainfall	0.044	0.369	0.014	1	**0.003**	0.572	78.688*
Erratic/unusual rain	1.017	0.411	0.002	1	**0.002**		
Delay rainfall onset	0.476	0.492	0.938	1	0.333		
Longer dry season period	0.041	0.45	0.008	1	0.928		
Increased rainfall days	0.184	0.424	0.188	1	**0.002**		
Decreased rainfall days	0.038	0.422	0.008	1	**0.004**		
Unusual flooding	0.338	0.445	0.575	1	0.448		
Increased flooding freq	0.829	0.441	3.542	1	0.060		
Increased earth surface temp	1.429	0.703	4.130	1	**0.042**		
Longer sunshine hours	0.463	0.486	0.906	1	0.341		
Short-lived Harmattan	0.403	0.585	0.474	1	0.491		
Increased crop yield	0.397	0.609	0.425	1	0.514		
Decreased crop yield	1.105	0.388	8.105	1	**0.004**		
Loss of soil fertility	1.166	0.482	0.118	1	**0.001**		
Increased erosion	0.263	0.443	0.352	1	0.553		
Early rainfall and early cessation	1.108	0.424	0.065	1	**0.004**		
Early rainfall and late cessation	0.105	0.409	0.066	1	0.798		
Late rainfall and late cessation	0.493	0.537	0.846	1	0.358		
Late rainfall and early cessation	1.225	0.453	0.248	1	**0.000**		
Above normal rainfall	0.157	0.476	0.109	1	0.741		
Below normal rainfall	0.332	0.509	0.425	1	0.514		
Longer than normal rainfall	0.149	0.428	0.121	1	0.728		
Shorter than norm rain	0.186	0.581	0.102	1	0.749		
High rainfall intensity	0.5	0.427	1.368	1	0.242		
How rainfall intensity	0.007	0.360	0.000	1	0.985		
Erratic/torrential rain	0.533	0.490	1.181	1	0.277		
Flash flooding	0.636	0.501	1.612	1	0.204		
Rainstorms	0.323	0.569	0.322	1	0.57		
Coastal flooding	0.534	0.476	1.257	1	0.262		
Gustiness	−0.250	0.434	0.333	1	0.564		
Erosion/flooding	2.230	4.017	0.308	1	**0.002**		
Rivers/streams Overflow their banks	0.381	0.600	0.402	1	0.526		
Constant waves	0.240	0.390	0.378	1	0.538		
Unusual precipitate pattern	0.322	0.453	0.504	1	0.478		
Wet spells	0.146	0.440	0.11	1	0.741		

Climate variability	Coefficient	Standard error	Wald	df	Sig.	Cox & Snell (R²)	Chi-square (goodness-of-fit)
Landslides	0.283	0.358	0.624	1	0.43		
High sun intensity	0.205	0.443	0.214	1	0.644		
Low sun intensity	0.352	0.386	0.832	1	0.362		
Early onset of Harmattan and early cessation	0.393	0.481	0.667	1	0.414		
Late onset of Harmattan late and cessation	0.253	0.460	0.303	1	0.582		
Early onset of Harmattan and late cessation	0.095	0.375	0.065	1	0.799		
Late onset of Harmattan and early cessation	0.114	0.395	0.084	1	0.772		
Typhoon wind	0.275	0.472	0.339	1	0.561		
Erratic wind	0.371	0.345	1.156	1	0.282		
High wind speed	0.208	0.374	0.310	1	0.578		
Low wind speed	0.391	0.509	0.590	1	0.442		
Freq cloudiness	0.451	0.399	1.278	1	0.258		
Freq clement weather	0.379	0.503	0.566	1	0.452		
Constant fog	0.445	0.601	0.549	1	0.459		
Constant drought	0.012	0.372	0.001	1	0.975		
Rising temp	0.345	0.454	0.577	1	0.447		
Presence of frost	0.495	0.557	0.790	1	0.374		
Presence of hailstones	0.022	0.398	0.003	1	0.956		
Constant waves	0.010	0.392	0.001	1	0.979		
High humidity	0.121	0.552	0.048	1	0.827		
Low humidity	0.316	0.561	0.317	1	0.573		
Presence of unfamiliar diseases	1.145	0.525	0.076	1	**0.021**		
Presence of unfamiliar pests	0.294	0.368	0.639	1	0.424		
High incidence of pests	0.197	0.46	0.184	1	0.668		
High incidence of diseases	0.013	0.433	0.001	1	0.976		

Source: Field survey, 2017.

Table 3. Ordinal regression of the climate variability affecting maize production.

cropping ($\overline{x}$ = 2.05; SD = 1.30) and changing planting dates ($\overline{x}$ = 2.06; SD = 1.15) were moderately used by maize farmers as indigenous adaptation strategies while change in fallow period ($\overline{x}$ = 1.60; SD = 1.23) was used to a low extent by small scale maize farmers in Anambra State. This finding is in agreement with Okali [56], who found that the use of mulching materials (**Figure 4**) could prevent excessive soil moisture loss, and improve soil

Corn market begin year in Nigeria	2015/2016		2016/2017		2017/2018		Percentage (%) difference
	Oct 2015		Oct 2016		Oct 2017		2016–2017
	USDA	Other source	USDA	Other source	USDA	Other source	Other source, only
Harvested area	3800	3800	4000	4000	0	3800	5.13
Beginning stocks	361	361	161	161	0	161	0.00
Production	7000	7000	7200	7200	0	6900	4.26
MY imports	300	300	300	300	0	200	40.00
TY imports	300	300	300	300	0	200	40.00
TY imports (USA)	98	0	0	0	0	0	0.00
Total supply	7661	7661	7661	7661	0	7261	5.37
MY Exports	200	200	200	200	0	300	−40.00
TY Exports	200	200	200	200	0	300	−40.00
Feed and Residual	1800	1800	1800	1800	0	1800	0
FSI consumption	5500	5500	5500	5500	0	5000	9.52
Total demand	7300	7300	7300	7300	0	6800	7.09
Ending stocks	161	161	161	161	0	161	0
1000 (Ha), 1000 (MT)							

Source: Adapted from [53].

Table 4. Observable trend on corn production, supply and demand in Nigeria, 2015–2017.

S/N	Items	$\overline{x}$	SD	Decision
1.	Mixed cropping	2.05	1.297	S
2.	Mixed farming	2.59	1.245	S
3.	Changing planting dates	2.06	1.155	S
4.	Changing tillage methods	2.62	1.255	S
5.	Diversification from farming to non-farming activities	2.70	1.312	S
6.	Planting of cover crops	2.96	1.376	S
7.	Use fertilizers (organic/farmyard/mulch materials)	2.79	1.186	S
8.	Change in fallow period	1.60	1.231	NS

Source: Field survey, 2017.
$\overline{x}$ = mean; SD = standard deviation; mean ≥ 2 = significant; mean ≤ 2 = not significant.

Table 5. Mean responses of level of indigenous adaptation strategies used by small scale maize farmers.

S/N	Items	$\overline{x}$	SD	Decision
1.	Improved crop variety	2.93	1.112	S
2.	Climate predictions	1.56	1.048	NS
3.	Precision agriculture	1.50	1.089	NS
4.	Drought resistant varieties	2.53	1.065	S
5.	Drought tolerant varieties	2.60	1.056	S
6.	Resistant to temperature stresses varieties	2.16	1.114	S
7.	High yield water sensitive varieties	2.06	1.978	S
8.	Mixed crop-livestock farming system	2.14	1.070	S
9.	Crop diversification	2.14	1.055	S
10.	Changing harvesting date	2.03	1.059	S
11.	Rain making	2.06	1.121	S

Source: Field Survey, 2017.
$\overline{x}$ = mean; SD = standard deviation; mean ≥ 2 = significant; mean ≤ 2 = not significant.

Table 6. Mean responses of the level of improved adaptation strategies used by small scale maize farmers.

Figure 4. Cross section of mulched maize farms available in the study area (photo credit: Mr. Samuel Anarah).

aeration and moisture holding capacity of the soil. Types of grasses usually used for mulching purposes in the study area include: spear grass (*Heteropogon contortus*), and guinea grass (*Panicum maximum*). [57] observed that growing of varieties of crops on the same plot of land is an appropriate adaptation strategy for farmers because it helps to avoid complete crop failure as different crops may be affected differently by climate variability and may also require different soil nutrients.

Figure 5. The type of vertiva grass (red circled) that is planted for controlling erosion on farm farms in Anambra State.

Consequently, some smallholder maize farmers plant vetiver grass (*Chrysopogon zizanioides)* in (**Figure 5**) to control erosion menace on their maize farms.

Table 6 reveals that to a low extent precision agriculture ($\overline{x}$ = 1.50; SD = 1.11), climate predictions ($\overline{x}$ = 1.56; SD = 1.05), were used by maize farmers as improved adaptation strategies. Improved crop variety ($\overline{x}$ = 2.93; SD = 1.11), drought resistant varieties ($\overline{x}$ = 2.53; SD = 1.07) and drought tolerant varieties ($\overline{x}$ = 2.60; SD = 1.06), were used by maize farmers in high extent as improved adaptation strategies while resistant to temperature stresses varieties ($\overline{x}$ = 2.16; SD = 1.11), high yield water sensitive varieties ($\overline{x}$ = 2.06; SD = 1.10), mixed-crop-livestock farming system ($\overline{x}$ =2.14; SD =1.07), crop diversification ($\overline{x}$ = 2.14; SD =1.06), changing in harvesting date ($\overline{x}$=2.03; SD =1.06) and rain making ($\overline{x}$ = 2.06; SD =1.12) were moderately used by maize farmers as improved adaptation strategies to climate variability. This finding concurs with the work of [57], who concluded that farmers can adapt to climate changes through improved adaptation strategies relevant to them.

Sources of information	Frequency* (n = 128)	Percentage (%)
Fellow farmers	99	77.34
Radio set	67	52.34
Extension agents	79	61.72
Television set (NiMET)	62	48.44
Internet/social media	26	20.31

Source: Field Survey, 2017. NiMET = Nigerian Metrological Agency weather forecast.

Table 7. Percentage response of sources of information on climate variability by maize farmers in Anambra State.

Socioeconomic variables	Coefficient	Standard error	Sig.	R^2	p-Value
Age	0.278	0.126	**0.028**	0.176	0.048
Sex	−0.226	0.242	0.351		
Marital status	0.154	0.170	0.363		
Household size	0.370	0.152	**0.015**		
Education level	0.199	0.154	0.195		
Farming years	0.428	0.183	**0.019**		
Farm size	0.624	0.123	**0.046**		
Labor source	0.021	0.163	**0.037**		
Membership organization	0.330	0.239	0.167		
Average income	0.334	0.226	0.164		
Average yield	0.233	0.233	0.143		

Table 8. Multiple linear regressions of the socio-economic characteristics and production level of small scale maize farmers.

6.4. Sources of information on climate variability

The percentage response of sources of information among small scale farmers on climate variability in Anambra State is shown in **Table 6**.

Result from **Table 7** reveals that majority (77.34%) of the maize farmers source their information from fellow farmers, (61.72%) from extension agents, few (52.34%) from radio set, very few (48.44%) source from television set while (20.31%) source their information from the internet/social media. The implication is that farmers that belong to agricultural groups are more likely to have access to farm information on climate variability adaptation strategies than those who do not belong to any. This finding is similar to that of [36, 57] whose studies showed that adequate information flow channel and extension contact with registered farmers have a positive relationship with the adoption of agricultural strategies since extension agents transfer modern agricultural technologies to farmers to help counteract the negative impact of climate change.

Table 8 shows multiple linear regressions of the socio-economic characteristics of small scale maize farmers and their production level. The R-square value of 0.176 indicates that the socio-economic variables explained 17.6% variability of maize production. Of all the socio-economic variables, age (0.028), household size (0.015), farming years (0.019), farm size (0.046) and labor source (0.037) have significant coefficients ($p < 0.05$). The coefficient value of 0.278 for age indicates that a unit increase in age increases level of maize production by 0.278 kg. The coefficient value of 0.370 for household size indicates that increase in household size increases level of maize production by 0.370 kg; that of farming years which is 0.428 indicates that increase in farming experience increases level of maize production by 0.428 kg; that of farm size which is 0.624 indicates that increase in farm size increases level of maize production by 0.624 kg while that of labor source which is 0.021 indicates that increase in labor source increases the level of maize production by 0.021 kg. The p-value at 0.048, indicate that there is a significant relationship between socio-economic characteristics and production level by the small scale maize farmers in the study area. This further means that as the age, household size, farming years, farm size and labor source of small scale maize farmers in Anambra State increase, their propensity to produce maize also increases. This finding is in agreement with the study of [41] who noted that household size and farm size increases farmers' food production.

7. Conclusion

Better understanding and perception of climate variability and adaptions to climate change impacts in Anambra State, Nigeria, is crucial for increasing farmers adoption of improved maize seed varieties and practicing of climate-smart maize production. The ultimate objective of this study was to assess the smallholder maize farmers' perception on climate variability and their use of climate change adaptation approaches in Anambra state.

The results of this study show that, approximately 57.2% of climate variability negatively impacts on maize production in the study area. Basically flooding ($\overline{x} = 2.02 \pm 1.166$), erratic rainfall ($\overline{x} = 2.02 \pm 0.816$), and decrease in crop yield by strange pests and diseases ($\overline{x} = 1.59 \pm 0.896$) were identified as climate change effects on maize production. The smallholder maize farmers are significantly aware of the consequences of climate variability on their maize farms, reason for some of them, practicing climate change adaptations. 88.28% of the smallholder maize farmers perceived bush burning as a major contributor to climate variability in the study area. Whereas, other identified climate change drivers include: intensive agricultural land use (82.03%), use of inorganic fertilizers (60.16%), use of fossil fuels (56.25%) and deforestation (50.78%). Finally, from the statistical analysis in this study, we conclude that, the lower the standard deviation values, the more knowledgeable the farmers are about climate variability and on practice of climate change adaptations; and, vice-versa.

Therefore, an integrated efforts to mobilize funding resource for further research on climate change mitigation and adaptions in the forest zone of Nigeria and for practical works at the local level, are hereby recommended.

Author details

John Agbo Ogbodo[1,2]*, Samuel E. Anarah[3] and Sani Mashi Abubakar[4]

*Address all correspondence to: jaogbodo@yahoo.com

1 Department of Forestry and Wildlife, Faculty of Agriculture, Nnamdi Azikiwe University Awka, Anambra State, Nigeria

2 Sustainable TransEnvironment International Foundation—STEi Foundation www. steifoundation.org, Nigeria

3 Department of Agricultural Economics and Extension, Faculty of Agriculture, Nnamdi Azikiwe University Awka, Anambra State, Nigeria

4 Nigerian Meteorological Agency (NiMET), Bill Clinton Drive, Nnamdi Azikiwe International Airport, Abuja, Nigeria

References

[1] Knoema. Nigeria-Maize Production Quantity. 2018. Available from: https://knoema.com/atlas/Nigeria/topics/Agriculture/Crops-Production-Quantity-tonnes/Maize-production [Accessed: May 3, 2018]

[2] IPCC-Inter-governmental Panel on Climate Change. Contribution of Working Group II to the Fourth Assessment Report of the IPCC Summary for Policy Makers. Geneva, Switzerland: Cambridge University Press; 2007. pp. 1-3

[3] Iken JE, Amusa NA. Maize Research and Production in Nigeria. Ibadan, Nigeria: Institute of Agricultural Research and Training (IAR & T), Obafemi Awolowo University; 2014. pp. 302-307

[4] Manyong VM, Kling J, Makinde K, Ajala S, Aenkir A. Impact of IITA-Improved Germplasm on Maize Production in West and Central Africa. Ibadan, Nigeria: International Institute of Tropical Agriculture (IITA); 2000

[5] Kent NL, Evers AD. Technology of Cereals: An Introduction for Students of Food Science and Agriculture. Oxford: Elsevier; 1994

[6] Bolade MK, Adeyemi IA, Ogunsua AO. Studies on the traditional methods of production of maize tuwo (a Nigerian non-fermented maize dumpling). African Journal of Food, Agriculture, Nutrition and Development. 2009;**9**(7):24. ISSN: 1684-5374

[7] Okoruwa AE. Utilization and Processing of Maize. IITA Research Guide No. 35. Ibadan: IITA; 1997

[8] Obi IU. Maize: Its Agronomy, Diseases, Pests and Food Values. Enugu: Optimal Computer Solutions Limited; 1991. 208 p

[9] Daniel IO, Adetumbi JA. Maize seed supply systems and implications for seed sector development in Southwestern Nigeria. Journal of Sustainable Agriculture. 2006;**28**(2): 25-40

[10] IITA. International Institute for Tropical Agriculture. Growing in Nigeria. Commercial Crop Production Guide Series. Information and Communication Support for Agricultural Growth in Nigeria. Moor Plantation, Ibadan: USAID; 2012. pp. 1-8

[11] Lawal BO, Saka JO, Oyegbami A, Akintayo IO. Adoption and performance assessment of improved maize varieties among smallholder farmers in Southwest Nigeria. Journal of Agricultural & Food Information. 2005;**6**(1):35-47

[12] Shuaibu SM, Ogbodo JA, Wasige EJ, Sani Mashi A. Assessing the impact of agricultural drought on maize prices in Kenya with the approach of the SPOT-VEGETATION NDVI remote sensing. Future of Food: Journal on Food, Agriculture and Society. 2016; **4**(3):8-18

[13] Apata TG, Samuel KD, Adeola AO. Analysis of climate change perception and adaptation among arable food cassava-based crop farmers in South Western Nigeria. Contributed Paper prepared for presentation at the International Association of Agricultural Economists' Conference, Beijing, China, August 16-22, 2009. p. 209

[14] Brussel SEC. Adapting to climate changes: The challenge for European agriculture and rural areas. Commission of the European Communities. Commission Working Staff Working Document Accompanying the White Paper No. 147 Building Nigeria's Response to Climate Change. 2009. pp. 3-5

[15] Mejia D. Maize: Postharvest operations. In: Mejia D, Parrucci E, editors. Postharvest Compendium. Rome: FAO; 2006. Available from:: http://www.fao.org/inpho/ [Accessed: Dec 10, 2005]

[16] World Health Organization (WHO). World Health Report 2002: Reducing Risks, Promoting Healthy Life. Geneva: WHO; 2002. pp. 7-9

[17] FAOSTAT. Food and Agricultural Organisation of the United Nation. FAOSTAT. 2015. Available from: http://faostat fao.org/site/567/default.aspx [Accessed: Aug 20, 2015]

[18] Hassan R, Nhemachena C. Determinants of African farmers' strategies for adapting to climate changes: Multinomial choice analysis. African Journal of Agricultural and Resource Economics. 2008;**2**(1):85-104

[19] Khanal RC. Climate change and organic agriculture. The Journal of Agriculture and Environment. 2009;**10**:100-110

[20] IPCC—Intergovernmental Panel on Climate Change. Climate change 2007: Synthesis report. Intergovernmental Panel on Climate Change. 2007:23-73

[21] Onumadu FN. Approval of environmental benefits of adaptation of agro forestry practices by small-scale farmers in Katsina State of Nigeria. Journal of food and Fibre Production. 2009;**2**(1):423-428

[22] Boko M, Niang I, Nyong A, Vogel C, Githeko A. Africa, climate change 2007: Impacts, adaptation and vulnerability. In: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press; 2007. pp. 433-467

[23] Case M. Climate Change Impacts on East Africa: A Review of the Scientific Literature. Switzerland: WWF–World Wide Fund For Nature, Gland; 2006. p. 12

[24] Stinge LC, Stave J, Chan KS, Ciannelli L, Pretorelli N, Glantz M, et al. The effect of climate variation on agro-pastoral production in Africa. Proceedings of the National Academy of Sciences of the United States of America. 2006;**103**:3049-3053

[25] Ogbodo JA, Tembe ET, Peter JG. Assessing the Issues and Prospects of Sustainable Forestry in Nigeria. 2017. Available from: https://www.researchgate.net/publication/314239 587_Assessing_the_issues_and_prospects_of_sustainable_forestry_in_Nigeria

[26] Ogbo AI, Onyedinma AC. Climate change adaptation in Nigeria: Problems and prospects Sacha. Journal of Environmental Studies. 2012;**2**(1):130-145

[27] Ohajianya DO, Echetama JA, Offodile PO, Osuagwu CO, Henri-Ukoha A, Okereke E, et al. Allocative efficiency among maize farmers in Imo state Nigeria. Report and Opinion. 2010;**2**(12):139-147

[28] World Bank. Agriculture for development policy brief: Adaptation and mitigation of climate change in agriculture. World Development Report. The International Bank for Reconstruction and Development/The World Bank 2008. 2008. pp. 3-5

[29] Olakojo SA, Akinlosotu TA. Comparative study of storage methods of maize grains in southwestern Nigeria. African Journal of Biotechnology. 2004;**3**(7):362-365

[30] Oyekale AS. Climatic variability and its impacts on agricultural income and households' welfare in southern and northern Nigeria. Electronic Journal of Environmental, Agricultural and Food Chemistry. 2009;**8**(1):13-34

[31] Coumou D, Robinson A, Rahmstorf S. Global increase in record-breaking monthlymean temperatures. Climatic Change. 2013;**118**(3–4):771-782

[32] Skinner M, Smith WB, Holly Dolan A, Bradshaw B, Bryant CR. Adaptation Options to Climate Change in Canadian Agriculture: An Inventory and Typology Report. Guelph, Ontario: Department of Geography, University of Guelph; 2001. pp. 1-3

[33] Knowler D, Bradshaw B. Farmers adoption of conservation agriculture: A review and synthesis of recent research. Food Policy. 2007;**32**(1):212-228

[34] Ohajianya DO, Osuji MN. Climate change, adaptation measures and the determinants among food crops farmers in South East Nigeria. In: Paper presented at the 86th Average Conference of the Agricultural Economics Society Warwick University, April 16–18, 2012. pp. 34-37

[35] Araya B, Adjaye JA. Adoption for farm level soil conservation practices in Eritrea. Indian Journal of Agricultural Economics. 2001;**56**:239-252

[36] Deressa TT, Hassan RM, Ringler C, Alemu T, Yesuf M. Analysis of the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile basin of Ethiopia. IFPRI Research Brief 15–9. Washington, D.C. USA: IFPRI; 2008

[37] Ayuya OA, Lagat JK, Mironga JM. Factors influencing potential acceptance and adoption of clean development mechanism projects: Case of carbon trade tree project among small scale farmers in Njoro District, Kenya. Resource Journal Environmental Earth Science. 2011;**3**(3):275-285

[38] Gbetibouo GA. Understanding farmers' perceptions and adaptations to climate change and variability: The case of the Limpopo Basin, South Africa. IFPRI Discussion Paper No. 00849 [cited May 3] 2009. pp. 23-27

[39] Nzeh EC, Eboh OR. Technological Challenges of Climate Change Adaptation in Nigeria: Insights from Enugu State. Enugu: African Technology Policy Studies Network Publication; 2010. pp. 24-28

[40] Odjugo PAO. Regional evidence of climate change in Nigeria. Journal of Geography and Regional Planning. 2010;**3**(6):7-9

[41] Oladipo E. Towards Enhancing the Adaptive Capacity of Nigeria: A Review of the Country's State of Preparedness for Climate Change Adaptation. Ilorin Nigeria: Heinrich Böll Foundation; 2010. pp. 23-25

[42] Adenola OA, Akinwumi JA. Maize production constraints in Nigeria. Maize Improvement, Production and Utilization in Nigeria. Maize Association of Nigeria. 1993. pp. 223-232

[43] Anyadike RNC. Climate Change and Sustainable Development in Nigeria: Conceptual and Empirical Issues, Lecture Series. Enugu: African Institute for Applied Economics; 2009. pp. 12-28

[44] Yohe GW, Lasco RD, Ahmad QK, Arnell NW, Cohen SJ, Hope C, et al. Perspectives on climate change and sustainability. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE, editors. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; 2007. pp. 811-841

[45] Magadza CHD. Climate change impacts and human settlements in Africa: Prospects for adaptation. Environmental Monitoring and Assessment. 2000;**61**(1):193-205

[46] Kurukulasuriya P, Mendelsohn R. A Ricardian analysis of the impact of climate change on African cropland. CEEPA Discussion Paper No. 8. Centre for Environmental Economics and Policy in Africa, University of Pretoria. 2006

[47] Nzeadibe TC, Egbule CL, Chukwuone NA, Agu VC. Climate change awareness and adaptation in the Niger Delta region of Nigeria. In: African Technology Policy Studies Network (ATPS) Working Paper Series. Nairobi: ATPS; 2011. pp. 7-13

[48] Knoema. Anambra-Production of Maize, 1000 metric tons. 2018. Available from: https://knoema.com/atlas/Nigeria/Anambra/Production-of-Maize [Accessed: May 3, 2018]

[49] FAO—Food and Agriculture Organization. Two Essays on Climate Change and Agriculture. A Developing Country Perspective. Rome, Italy: Food and Agriculture Organization (FAO). 2000. pp. 25-29

[50] Nhemachena C, Hassan R. Micro-Level Analysis of Farmers Adaption to Climate Change in Southern Africa. Southern Africa: International Food Policy Research Institute (IFPRI). 2007. pp. 56-59. Discussion Paper 714

[51] GISGeography.com. What is geographic information systems (GIS)? 2018. Available from: https://gisgeography.com/what-gis-geographic-information-systems/ [Accessed May 12, 2018]

[52] Ozor N. Understanding climate change; implications for Nigerian agriculture, policy and extension. In: Paper presented at the National Conference on Climate Change and the Nigerian Environment, Organized by the Department of Geography, University of Nigeria Nsukka, 29 June–2 July. 2009. pp. 23-28

[53] USDA—United States Department of Agriculture. Nigeria: Grain and Feed Annual. 2017. Available from: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_Lagos_Nigeria_4-12-2018.pdf [Accessed: Apr 25, 2018]

[54] Greene WH. Econometric Analysis. 5th ed. New Jersey: Prentice Hall; 2003. pp. 3-6

[55] Nwaiwu IU. Effects of climate change on labour use efficiency and sustainable Food Crop Production Systems in Southeast Nigeria [unpublished Ph.D thesis submitted to the Postgraduate School]. Owerri: Federal University of Technology; 2014. pp. 32-56

[56] Okali D. Climate Change and Nigeria: A Guide for Policy Makers. Nigerian Environmental Study Action Team (NEST). 2004. pp. 20-25

[57] Nwajiuba CU. Adaptation to Climate Change: Challenges and Opportunities, Lecture Series. Owerri, Nigeria: Department of Agricultural Economics, Imo State University; 2010. pp. 34-45