

## Climate Change Impacts, Awareness and Perception of Africa Rural Farming Communities

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Received date: September 14, 2017; Accepted date: September 21, 2017; Published date: September 28, 2017

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### Abstract

The Nigerian agricultural sector is threatened by changing weather patterns that has been shown to have been influenced by climate change. This work investigates how environmental forcing influenced crop productivity over a 30-year period in Enugu State, Nigeria. Environmental components such as, precipitation, humidity and extreme temperatures were directly compared with annual crop yield variations of the key staple food crops. Regression models constructed around the Environmental forcing data showed increasing temporal trends in all assess areas, with R2 values that ranged between 1% and 23%. While, similar models related to crop yield also identified increasing trend in most crops, an important exception being Yam and Melon with R2 values ranging between 4% and 70%. Fertilizer use dramatically increased during the same period, but no correlation could be found with overall crop yield. Pearson correlation matrices were mostly positive between environmental forcing with crop yield but highlighted that Yam production was negatively influenced by increasing precipitation and humidity will precipitation was positively correlated with melon yield. A study conducted using questionnaires assessed the farming communities knowledge, awareness and perception of climate change (n=227). Result show that 61% of respondent are experiencing climatic impacts, while 63% are concerned of potential effects. Further, 55% believe that it is already too late to do anything to mitigate against likely consequences. In terms of knowledge and information sources, most farmers questioned (64%) sources their information from the media. This poses challenges for more robust scientific methods and dissemination of that data, something that needs to be considered by local, regional and international government and policy makers. Questionnaire evaluations showed that the majority of Nigerian farmers were fully aware of climate change and its impacts, with most complaining that due to higher costs there was little or nothing they could do to address the issues. Furthermore, 64% of Nigerian farmers trusted information received from mass media, while the majority attributed climate change to anthropogenic factors (41%). Results showed that most farmers were more concerned about increasing rainfall and drought than other environmental issues.

**Keywords:** Climate change; Agriculture; Perception; Farmers; Temperature; Precipitation; Humidity; Rainfall; Crop yield

### Introduction

Scientific consensus suggests climate change is having impacts on the world, socially, economically and ecologically, during the 21st century in Nigeria [1]. Climate change has resulted in desertification, flooding and drought which in turn, are having impacts on agricultural systems. These growing concerns have been attributed to increased use of fossil fuel during the current industrial era. Globally, farmers are faced with tackling climate change impacts through various mitigation and adaptation strategies [2,3]. Mitigation requires reducing greenhouse gas emissions, while adaptation finds ways of coping with current impacts example of mitigation processes having been through encouraging the use of renewable energies and carbon trading, while adaptation have been through irrigation and conservation. Therefore, adaptation strategies are more directly applicable to farmers [4,5].

Food is essential to human life, health and well-being. As a result, quantity and quality is essential and sufficiency is required, given rapid human population increases. It is therefore critical to understand farmer's views in relation to their experiences and how they have been coping with these climatic impacts. This knowledge assists adaptation

and implementation strategies for improving the agricultural sector [6]. However, agriculture is also having an adverse environmental impact contributing to greenhouse emission. Globally, the agricultural sector is more vulnerable to climate change than any other sector and is faced with numerous challenges, such as coping with the adverse impacts of drought and flooding more especially in Asia and Africa [7,8]. There have been efforts made by the Nigerian government to improve national food security and agricultural sector, as this provides revenues and employment to the citizens. Yet up until now no sector opinions or views have been considered when establishing adaptation strategies, but farmers can provide practical accounts of how crop growth is affected [9]. This has been experienced in Sub Saharan Africa, where most farmers have reported similar evidence on how they have been affected by climate change. Local people and farmers live closer to nature when compared to those living in urban areas, and as a result have more knowledge and are greatly informed about the effects of climate change on natural systems [10].

Many farmers also unwittingly contribute to climate change when clearing forest tracts, e.g., deforestation, which subsequently leads to reduced resilience. Those same farmers are also affected by climate change and are more vulnerable as they lack the capacity to cope and adapt [11]. Therefore, understanding impacts at the local level is critical for government moving forward as they seek adaptive strategies

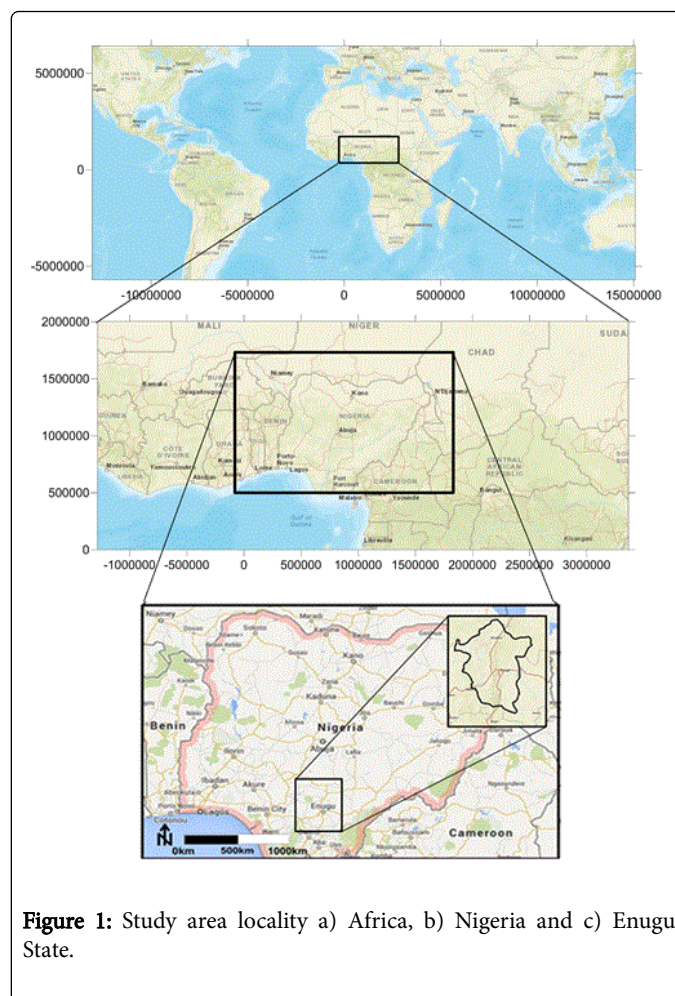
to many diverse challenges of climate change [12]. Climate change impacts are experienced more in rain-fed agriculture because of the rapid changes in seasonality experienced across Nigerian regions. Any changes in water availability will directly or indirectly impact crop growth and development. Farm lands located along the coast are vulnerable due to sea level rise and storm surges. Many regions are also experiencing changes in landscape caused by drought and desertification [13]. Small-scale farming predominates in Nigeria and it occupies circa 94% of the total agricultural sector [14]. Agricultural sectors employ >70% of citizens and contribute >5% of total export GDP. There are a number of governmental and non-governmental institutions supporting farmers and small-scale farming in Nigeria such as Oxfam GB, FAO, among others. They have embarked on projects that have helped change the lives of many communities and small-scale farmers across regions. Drought and flooding is the most complex issue faced by Nigerian agricultural systems, with unexpected increased rainfall and sunshine intensity having devastating impacts. In recent years, Nigeria has experienced heavier rainfall and the dry periods have increased over time. Eastern parts are significantly affected. Globally, drought causes annual damages to millions of hectares of cultivated land [15]. This in turn, reduces access to food for rural communities and urban supply; once again small-scale farmers are most vulnerable as they lack coping capacity. As a means of adapting, some farmers have implemented crop diversification, mixed cropping and trialled new crop varieties.

After the oil and gas industry, the agricultural sector is the backbone of the Nigerian economy. Few studies have been conducted on farmers perception of climate change and previous studies have focused on the effects of climate change on agricultural productivity, e.g., changes in weather patterns and extreme weather impacts on crop output. Understanding farmers' perceptions will help improve and focus current economic, social and environmental risk policies for mitigating and adapting to climate change [16]. Therefore, farmers' attitudes and opinions can help improve policies and decision-making at local level. Consequently, this paper will seek to determine the extent to which Nigerian agriculture is affected by climate change. Its principal focus is on productivity and as a result, farmer awareness and perception will be collected for their in-depth knowledge of the extent to which climate change affects agricultural productivity. In this case, the physical characteristics of crop output and farmer's perception and experience was investigated to assess how climate changes impact on the Nigerian agricultural system. However, results of this study have much wider Implications for agricultural and economic development policy-making. Particularly, within the African continent where there is a need to focus on providing flexible options that maximise sustainable agricultural output in uncertain climate change scenarios.

## Physical Background

Nigeria one of the worlds largest countries (Figure 1a). With an average annual temperature of around 27°C, and average rainfall of 600 mm (Enugu State, 2014). Since 2009, an estimated US\$ 185 million has been invested in commercial agricultural development projects in Nigeria, with core aspects of developing agricultural production and commercialisation, rural infrastructure and project administration [17]. In general, this is used to develop and improve agricultural production system efficiency and is targeted at improving small and medium scale farms with the aim of supporting improvements in technology among rural farms, support the production of staple crop systems, and facilitate capacity for the agricultural sector.

Located north of the equator (Figure 1b), Nigeria has 36 states and this study was developed in Enugu located in the south-eastern part of Nigeria (657'05"N; 7°28'14"E) has a population of 722,664 (Figure 1). Agro-ecologically, Enugu can be described as mainly Derived savannah and Humid Forest, Geographically, the topography of Enugu is mainly mountainous and hilly but also consists of vast areas of vegetation and forest. Some vegetation and forest areas have been cleared for agricultural use as population increases [17]. Communities are largely made up of farmers and to a lesser extent are employed in tourism. Enugu City was locally known as the coal city, because of its heavy reliance on coal extraction in the early 20th century. The State has relied on agriculture as a major source of income since the 1950s and suitable soil and favourable climatic conditions enable the area to produce many forms of cash crop. Additionally, a smaller proportion of livestock farming exists [18]. Enugu state has been described as the hotspot of agricultural activities and more or less as one of Nigeria's bread basket [17]. It is also proving to be the most vulnerable to climate change, as weather conditions in the region have changed more rapidly particularly, increasing rainfall has resulted in increased flooding. The majority of the population live in rural areas, where their major sources of income and employment are farming and agriculture. As a result, they are in the best position to tell of their experiences and how they have been affected. Nigeria is situated in the tropics with a generally seasonally, humid and damp climate consisting of large natural vegetative zones.



**Figure 1:** Study area locality a) Africa, b) Nigeria and c) Enugu State.

## Methodology

Nigerian Meteorological Office (NIMET) operates a series of weather stations located at approximately 50 km centres across Nigeria that calculate a variety of Meteorological parameters [19]. For this research, they supplied environmental data that comprised of monthly average temperature extremes, humidity and precipitation for the period between 1971 and 2011. Previous studies have provided that, backdated environmental forcing agent dataset aids to provided vital information of the physiological and biological characteristics of crop [20]. The Nigerian Ministry of Agriculture (NIMoA) supplied annual crop yield and fertiliser use data for each of the studied States. The data for the important staple crops has been available since 1980, therefore, NIMoA supplied a dataset for the period between 1980 and 2011.

In Nigeria, agricultural output is measured annually across each State. This is conducted by the Federal government in collaboration with the Ministry of Agriculture. This is aimed at deriving the quantity of crop yield form each State for both quantity and quality. Since agriculture is a major source of the economy, this exercise compulsory and taken very seriously. Farmers are visited across the States by agricultural extension workers who conduct the exercise. They weigh each crop produce, take and keep records and document all produce for each State across Nigeria which is then published by the Ministry of Agriculture.

In addition to temporal trend analysis questionnaires were used to collect responses from farmers in order to assess crop production and practices across the region. In total, there were 28 questions aimed towards understanding knowledge and opinions regarding the impact of climate change on agricultural production, the questionnaire also had column for additional comments.

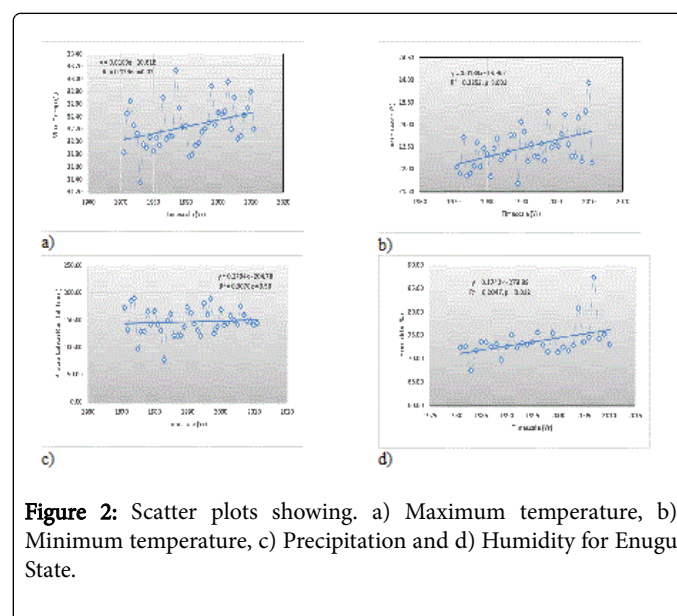
Data was obtained from a comprehensive field study over for a period of 2 weeks, targeting both individual and publicly owned farms. Most were located in isolated rural areas. Farmers were questioned about their views and perception of climate change. Data acquisition comprised was collected using structured questionnaires demographic characteristics and their awareness, knowledge and perception of climate change. Additionally, modes of implementation and adaptation strategies were determined. Some climate change literature has focused on adaptation to climate change, through understanding of farmer viewpoints and perceptions. Questions were structured in a manner whereby farmers were able to understand their intentions and meaning. A total of 227 questionnaires were collated and analysed. Initial questions focused on demographics while the rationale behind the questionnaire was critical as it aimed to investigate farmers' experiences of environmental factors and climate change mitigation and adaptation measures. It also considered physical and biological processes of the environment and seasonal changes, i.e., mainly dry and wet states. The ability for farmers to do anything on a large scale is limited, so the survey attempted to assess their own coping mechanisms. The second part of the questionnaire assessed farmers' perception, knowledge and awareness as they cope with consequences of climate change impacts. This also takes into account the tenure systems, their definition of climate change and their awareness and mode by which they fund agricultural activities. It also considered factors that they were more influenced or concerned about.

## Results and Discussion

### Environmental change (1971-2011)

The first analysis looked at whether climate variables i.e., temperature, humidity and precipitation changed appreciably within this time frame. When maximum temperature change was statistically assessed, a positive low correlation and definite small relationship existed, highlighting a slight increase in temperature over time. The regression model ( $y=0.0109x+10.618$ ) R2 value only explained circa 13% of data variation, the temporal trend was statistically significant at >95% confidence  $p=0.02$  (Figure 2a). Similarly, a positive correlation indicated increasing temperature over time when minimum temperature was assessed. With greater statistical significance, a moderate correlation and a substantial relationship represented by the regression model ( $y=0.0188x-14.962$ ), where R2 explained circa 24% of temporal temperature variation and with 99% confidence a statistically significant rising minimum temperature trend  $p=0.00$  (Figure 2b).

A slightly positive and almost negligible relationship existed when precipitation was considered, with the regression model ( $y=0.1764x-204.78$ ) explaining <1% of data variation  $p=0.56$  (Figure 2c). Despite these statistically insignificant results, precipitation patterns have varied cyclically throughout the assessment period. The smaller humidity dataset between 1981 and 2010, showed a low correlation but definite and small relationship, indicative of a slight increase. The regression equation  $y=0.1742x-273.98$ , has an R2 value that explains circa 20% of humidity variation over time but importantly, represents a significant increase in humidity  $p=0.01$  (Figure 2d). These analyses indicate that environmental factors influence crop yield in Enugu State.

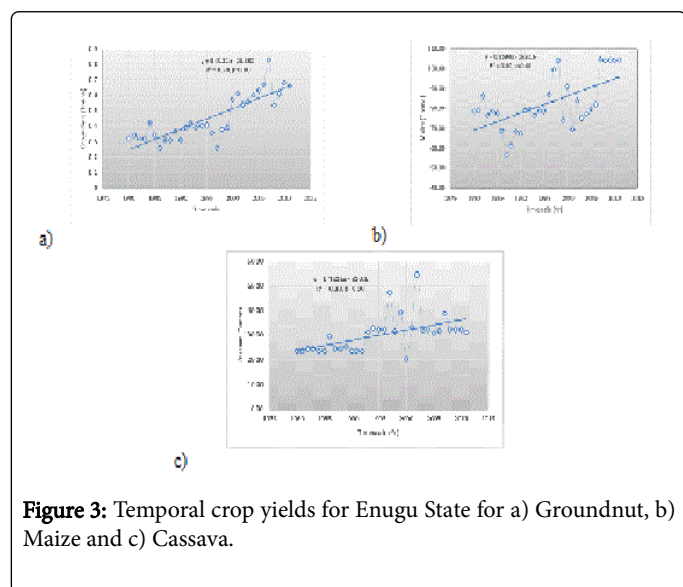


**Figure 2:** Scatter plots showing. a) Maximum temperature, b) Minimum temperature, c) Precipitation and d) Humidity for Enugu State.

### Crop yield (1980-2010)

This section details temporal change in crop output, with results tabulated and statistically significant outcomes highlighted in scatter plots. When Groundnut production was assessed, a high positive correlation and marked relationship was found, indicative of increasing crop yields over time, i.e., illustrated by the regression equation  $y=0.01324x-25.892$  and Coefficient of Determination

(R<sup>2</sup>=70%) where the significant trend indicates increased yield (p=0.00; Figure 3a). Similarly, the temporal assessment of Maize also showed a significant trend of increasing yields with p=0.00; Figure 3b). There was also a moderate correlation and substantial relationship indicated by the regression model (y=0.8594x-1632.6), with (R<sup>2</sup>=40%) of data variation. Temporal crop yield data for Cassava also showed positive correlation, given by the equation y=0.4211x-810.1, with (R<sup>2</sup>=30%) indicative of a moderate correlation and substantial relationship. However, once again Cassava showed a statistically significant temporal increase in crop yield p=0.00 (Figure 3c). Therefore, throughout the period between 1980 and 2010, groundnuts, maize and cassava all showed statistically significant increasing crop yields.



**Figure 3:** Temporal crop yields for Enugu State for a) Groundnut, b) Maize and c) Cassava.

Table 1 shows regression results for the remaining staple crops grown in Enugu State. Bean production showed a low positive correlation and a definite but small relationship existed, indicative of a slight crop yield increases over time. The regression model (y=0.0056x-10.186), (R<sup>2</sup>=14%) of data variation (p=0.03; Table 1). In contrast, a slight negative correlation and almost negligible relationship existed when Yam production was assessed, highlighting a slight decline in crop yield over time. This was given by the regression equation y=-4.911x+ 1220 and an R<sup>2</sup> value that explained just 4% of data variation (p=0.16; Table 1). Similar to Bean production results, Rice and Cocoyam also highlighted that a low positive correlation and a definite but small relationship existed, indicative of a slight increase in production through time. This was given by the regression equations y=0.1367x-216.52 and y=0.1441x-254.04 respectively, and R<sup>2</sup> values that explained 10% of data variation, and in contrast to Bean production, both results were statistically insignificant (p=0.10; Table 1). In contrast, the assessment of Melon showed a low negative correlation but definite small relationship existed, given by the regression equation y=-0.0061 x=13.012 and similar to Rice and Cocoyam results, the R<sup>2</sup> value explained 10% of the data variation (p=0.10; Table 1). The table below shows beans, yam, rice, melon and cocoyam because of their low graphical representation.

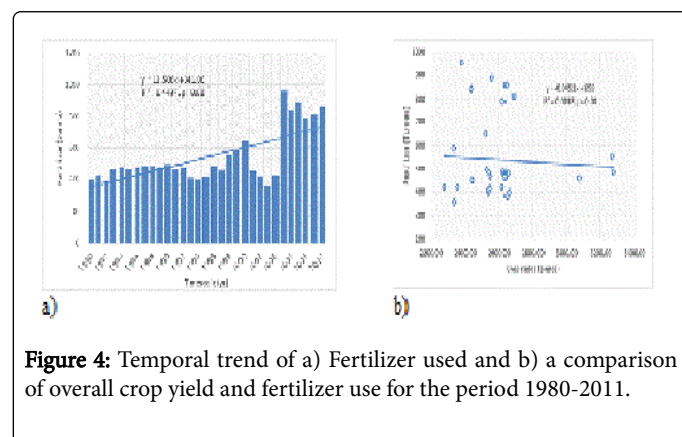
### Fertilizer use

Chemically synthesised inorganic fertilizers are widely used for both subsistence and commercial farming across most Nigerian States and the Federal and State governments are responsible for its supply [21].

Crop Type	Regression equation	p-value	R <sup>2</sup> value (%)
Beans	y=0.0056x-10.186	0.03	14%
Yam	y=-4.911+12203	0.03	4%
Rice	y=0.1367x-216.52	0.1	10%
Melon	y=-0.0061x+13.012	0.1	13%
Cocoyam	y=0.1441x-254.03	0.1	10%

**Table 1:** Crop Yield in Enugu State.

Figure 4a highlight that there has been a significant increase in fertilizer use in Enugu State, confirmed by a moderate positive correlation and substantial relationship existed. This was given by the equation (y=12.506x+341.06), and R<sup>2</sup> value that explained almost 50% of data variation, that was statistically significant at 99% confidence. However, Figure 4b results are influenced somewhat by a reduction in fertilizer used between 2001 and 2005 and a significant increase thereafter to the end of the assessment period. Consequentially, this is because of the changes in governmental policies and political changes during this period. Importantly, when overall fertilizer uses and temporal crop yields were assessed there was no statistical evidence to suggest that fertilizer use was beneficial to crop growth in this State. This was given by the regression equation y=-0.0452x+656 and an R<sup>2</sup> value that explained none of the variation in the data (p>0.05; Figure 4b).



**Figure 4:** Temporal trend of a) Fertilizer used and b) a comparison of overall crop yield and fertilizer use for the period 1980-2011.

### Evaluating implications

Groundnut is one of the most important food crops grown in Nigeria, but poor soil quality, lack of nutrients, disease and pest prevalence, flooding and drought stress can severely hinder productivity [22,23]. Despite fluctuation almost cyclic temporal precipitation (Figure 2c) and humidity (Figure 2d) trends, Groundnut production increased. This was confirmed statistically, by a high correlation and substantial relationship (Figure 2a) and reinforced with the increasing in temperature trends (Figures 2a and 2b respectively) and an increase in fertilizer use (Figure 4). Characteristically, Groundnut is self-pollinated producing flowers, above ground [24].

Increased temperature and improved fertilizer application are the key components which foster Groundnut yield [25]. Table 1 produced from temporal crop yield, fertiliser use and environmental forcing data confirms that increased humidity and fertilizer use, positively influences Groundnut yield ( $r=0.54$  and  $0.68$  respectively,  $p<0.01$ ). Results suggest that provided current climate variation persists, this food crop may be capable of meeting anticipated future demands.

Maize is a popular cereal crop used for both human and livestock consumption and is highly sensitive to extreme temperature conditions [26]. Production is influenced by both climatic and socio-economic factors. Climatic or physical factors that impact upon Maize production include, flooding, drought, increase in pest infestation and disease, as well as, poor soil quality [26]. Statistically, Figure 2b highlighted a moderate correlation and substantial relationship existed in overall output ( $p<0.01$ ), indicative of a temporal increasing yield. This result is unsurprising as Maize outputs are generally relative to stable concentrations in precipitation and humidity (Figures 2c and 2d) and while, showing cyclic fluctuations both variables remained relatively stable overall. This concurs with Rashid and Rasuel [27] who argued that precipitation and humidity are crucial to foster suitable growth.

	Maximum Temp	Minimum Temp	Precipitation	Humidity	Fertilizer
<b>Groundnut</b>	0.15	0.37	0.25	0.54	0.68
<b>Maize</b>	0.04	0.35	0.27	0.31	0.54
<b>Cassava</b>	0.12	0.14	0.2	0.29	0.11
<b>Beans</b>	0.15	0.24	0.17	0.31	0.13
<b>Yam</b>	0.05	0.02	-0.04	-0.15	-0.11
<b>Rice</b>	0.04	0.21	0.01	0.23	0.24
<b>Melon</b>	-0.05	-0.1	0.14	-0.09	-0.19
<b>Cocoyam</b>	0.01	0.05	0.38	0.06	0.1

**Table 2:** Correlation matrix comparing the stable crop yield and environmental forcing agents. Note; bold italic statistical significance at 99% confidence ( $p<0.1$ ) and bold 95% confidence ( $p<0.05$ ).

Maize also responds well to a reasonable amount of inorganic fertilizer, particularly those containing, Nitrogen (N), Phosphorous (P) and potassium (K) and this element has increased through time. Both humidity and fertilizer use were positively correlated to increasing yield ( $r=0.31$ ,  $p<0.05$  and  $r=0.54$ ,  $p<0.01$  respectively; Table 2). While, precipitation showed positive correlation with less statistical significance ( $r=0.27$ ,  $p>0.05$ ; Table 2). However, other factors affecting Maize yield, are planting period and soil fertility. For instance, if cultivation is conducted after the rainy season low outputs can be expected, this is because the crop is expected to be planted before the rainy days [28]. Snaga et al. [28] also suggested that fertilizer application timing is also crucial and late application, may result in an inability for nutrients to be absorbed by the crop, whereas, early application supports yield. In mitigation, Maize growth practice has changed within Enugu State and even though precipitation has not significantly increased, additional irrigation alongside, increased fertilizer use, during early production stages has improved overall crop yield.

Cassava a tuber crop, highly tolerant to extreme weather but fertilizer application improves soil quality supporting its growth and yield conditions [29]. However, when excessive amounts are applied there is an impact on overall quality and yield. When Cassava yield were analysed (Figure 2c), a positive correlation existed, indicative of increasing yields. Literally, Cassava is tolerant to higher temperature extremes, therefore, temporal increase in maximum and minimum temperature (Figure 2c and 2b) would have a very limited effect on output. Similarly, relatively stable precipitation and humidity conditions would also have limited effects. With less statistical significance, Table 2 results show positive correlations between crop yield and all environmental forcing agents with ( $r$ ) values ranging between 0.12 and 0.29 ( $p>0.05$ ). Surprisingly, fertilizer use also showed statistically insignificant positive correlation suggesting that fertilizer was not being applied at the optimum time or that Cassava food crops do not respond well to the type of fertilizer being applied.

According to Snaga et al. Bean yield is reliant on suitable temperature extremes and precipitation and climate variation is a potential threat to production. Temporal change analysis (Table 2) showed a positive correlation albeit small, indicative of a very slight increase in yield, corresponding to temperature and precipitation increases during the assessment period. However, except for humidity ( $r=0.31$ ,  $p<0.05$ ), Table 2 results show, statistically insignificant, positive correlation between crop yield and the remaining environmental forcing agents with ( $r$ ) values ranging between 0.15 and 0.24 ( $p>0.05$ , Table 2). Once again, fertilizer use also showed statistically insignificant positive correlation alongside bean yield.

Yam is a climbing tuber-bearing plant which is annual or perinately produced. There are over 600 species and varieties and it is one of the major cultivated crop in Nigerian derived savannah and humid forests. The species is tolerant to extreme weather conditions, fostering high yields. Yam requires higher temperatures in comparison to other crop types. Therefore, derived savannah and humid forest is particularly well suited to this particular crop production [30]. However, there was a slight almost insignificant decline in production over time (Table 2). Even though this decline is relatively small, the trend is of concern as Yam constitutes a major staple food stock in Nigeria. According to Amusa et al. [31], pest and diseases are the major issues faced by most Yam farmers in Nigeria, arising from issues such as mosaic virus, and ultimately contributing to the decline in overall yield. However, Yam farmers have now been applying better adaptation strategies such as crop rotation and fallowing [32]. Table 2 results show statistically insignificant ( $p>0.05$ ) variable positive/negative correlations with all environmental forcing that ranged between  $r=0.25$  and  $r=-0.15$ . There was negative correlation between fertilizer use and crop yield ( $r=-0.11$ ,  $p>0.05$ ) suggesting that fertilizer application may not contribute to overall crop production.

Rice is the most widely cultivated crop across agro-ecological zones in Nigeria and requires excessive quantities of water when compared with other crops [33]. Therefore, Rice growth is highly dependent on increased precipitation and higher temperature than other crops. However, poor soil quality or lack of sufficient fertilizer application could play a role in the overall output [34]. Statistically, a low positive correlation indicated that a slight increase in production throughout the period of assessment (Table 2) and influential were stable levels of precipitation through time (Figure 2c). Table 2 show a statistically insignificant, positive correlation between crop yield and all assessed environmental forcing agents with ( $r$ ) values ranging between 0.01 and 0.23 ( $p>0.05$ ), suggesting that there may well be a combination of

factors contributing to relative crop yield stability. Once again, fertilizer use also showed statistically insignificant positive correlation ( $r=0.24$ ,  $p>0.05$ ). The results concur somewhat with Odjugo, who argued that Rice yield is commonly attributed to both climatic and non-climatic factors. Issues such as poor fertilizer quality or late application, poor irrigation practices or soil quality, increased pest and disease prevalence, surface runoff, improper farming techniques, lack of land availability, erosion, leaching and poor agricultural management inter-alia.

According to CCPGS [35], insect infestation and disease are major factors that influence a declining Melon crop yield. The crop requires a substantial volume of water to provide an effective yield and within Enugu State irrigation is required to maintain production. Statistically, crop yield showed low negative correlation, indicative of a temporal reduction in crop yield albeit small (Table 2). The stability of precipitation throughout the assessment period alongside the increased temperature extremes, may have influenced in production but since irrigation is used it is difficult to assess probable cause. Except for precipitation ( $r=0.14$ ,  $p>0.05$ ), Table 2 results show, statistically insignificant, negative correlation between crop yield and the remaining environmental forcing agents. With ( $r$ ) values ranging between  $-0.05$  and  $-0.10$  ( $p>0.05$ ), this suggests that there may well be a combination of factors that contribute to relative crop yield stability. Once again, fertilizer use also showed statistically insignificant positive correlation ( $r=-0.19$ ,  $p>0.05$ ). Cocoyam is another widely-cultivated tuber crop, grown mainly in sandy loamy soil and since it is a water retention crop, precipitation is crucial to its eventual yield. According to Ukonze, production is highly influenced by climate variation if exposed to an inadequate water supply, together with increased temperature, erosion and increased pest and diseases, these factors can cause the crop decline. However, statistical results demonstrated a positive correlation indicative of a slight increase in crop yield throughout the period of assessment, despite precipitation rates showing very little change. Notwithstanding rainfall correlation, ( $r=0.38$ ,  $p<0.05$ ) Table 2 results show statistically insignificant, positive correlation with remaining environmental forcing agents. The ( $r$ ) values ranging between  $0.01$  and  $0.23$  ( $p>0.05$ ). Once again, this suggested that there may well be a combination of factors that contribute to relative crop yield stability. Similar to previous analyses,

fertilizer use also showed statistically insignificant positive correlation ( $r=0.10$ ,  $p>0.05$ ).

### Climate change perception

Of the sampled group, 58% were female and 42% male with most falling within the 36-45 age bracket. Most women supported their husbands on farms and for many, their entire families worked together. Generally, education levels were minimal although some were qualified to Masters Level. More important to this study experience and how exposure to climate events affects their perception of climate change. Increasingly farmers are engaging in other occupations such as forestry in order to diversify and support their families.

The second part of the survey concentrated on knowledge, awareness and perception of climate change. This section attempted to investigate the major sources by which farmers are informed issues of climate change and its potential impacts. They have been adapting to climate change, and identifying major environmental constraints. Given the weak institutional governance in the agricultural sector, farmer knowledge is required for enhancing policy. Eighty per cent of respondents felt that climate change could be tackled and that energy consumption should be reduced consequently (75%). While three quarters felt that climate change was a natural phenomenon, 80% believe that changes are inevitable and may even improve Nigeria's weather (63%). Many however cite uncertainty (62%) as a reason to be either concerned or nonchalant (Table 3). Fifty-five per cent believe it is too late to do anything remedial, while 58% were non-committal unless others took action also. Many blame other sources for the impacts experienced to-date i.e., developed countries (62%) while 60% believe significant societal changes are needed if current trends are to be reversed. Some firmly suggest that society is too selfish to make substantial adjustments and 63% believe no action is required at all. Farmers have had to develop various coping strategies already however and this is mainly through the application of traditional methods such as mixed cropping. Others use companion planting, such as growing maize with yam, or have developed some form of agroforestry. When it comes to sourcing additional knowledge and information, respondents rely upon various organisations and community groups.

	Very concerned	Slightly concerned	Somewhat concerned	A little concerned	Moderately concerned	Not concerned
Increase in rainfall	60%	21%	8%	4%	3%	4%
Decrease in rainfall	30%	29%	12%	6%	6%	17%
Increase in runoff	25%	30%	15%	9%	4%	17%
Increase in groundwater level	33%	31%	16%	10%	6%	15%
Decrease in groundwater level	19%	29%	15%	12%	7%	19%
Increase drought	63%	29%	0.40%	0.90%	0.90%	15%
Decrease change of drought	41%	41%	15%	0.40%	0.90%	0.40%

**Table 3:** Concern about environmental factors.

Assessments of survey results showed that the media was the most trusted source of information (64%) for climate change impacts, while the government was the least trusted (24%). Asked whether they were already feeling the impact of climate change, 61% agreed, while 20% expected consequences in the next 10 years. Therefore, the majority questioned recognised the effects of climate change.

The study shows that most farmers 60% were very concerned about the increase in rainfall which causes loss of property, farmlands and crops. However, an increase in rainfall may be favourable to certain types of crops such as rice, but may have adverse effects of other crops. Further, farmers were also very concerned about decrease in rainfall which accounts for 30%. Climate change will alter weather and hydrological balances causing changes in precipitation and climatic patterns. Increasing runoff causes erosion and loss of soil nutrients which affects crop growth and development. Some farmers use different adaptation strategies to address the issues of increase in runoff, such as crop diversification, changing planting dates, and soil and water conservation techniques. Many studies have tried to explore the different ways by which farmers cope with water adequacy for crop (Table 4). Water is the most essential component needed for plant germination, growth and maturity. Storm water can damage crops, as this can lead to increase in runoff or decrease in runoff. The study shows that 34% of the farmers were very concerned about the decrease in runoff water. Even when there is availability of water for agricultural purposes reducing agricultural runoff water from streams and lakes is very important because it affects aquatic lives and aquatic plants. More especially, in farm areas where fertilizers, insecticides and herbicides is applied. Farmlands in the eastern part of Nigeria are typically rain fed and such is quite difficult to control the amount of runoff. Water management needs to be initiated into the agricultural systems especially studies have proven that there is a relationship between runoff and incidences of erosion. With accelerated removal of soil and nutrients and increase in groundwater levels of 33%, the potential for further flooding and reduced productivity must be addressed.

13	Drought mitigation	24%	43%	33%
14	New or revised legislation	32%	39%	29%
15	Economic incentives or financial mechanism	31%	40%	29%
16	Awareness raising or campaigns	34%	37%	29%

Table 4: Which of the following have been implemented?

There are numerous adaptation strategies that have been put in place to address the issues of climate change. The table shows that they are various ongoing adaptation strategies and approaches which are now being put in Nigeria. Flood protection and drought protection have been implemented. Studies show that the farmers are aware of these impacts and effects have been done to work on this. Measures of improving water balances are also ideal, since agriculture requires water to forge. Other forms of legislation, incentives, and financial involvement were not as high when compared to flooding and drought that have been the major problem faced in Nigeria. The knowledge, concerns, and perception of climate change of a large sample (n=227) of the Nigerian farming community. Similar research carried out in other developing countries [36], has been shown to contribute towards developing mitigation and adaptation approaches, and at the same time providing important information that may be used to improve policy and decision making in the agricultural sector. Most the Nigerian farmers interviewed were from age groups ranging between 36 and 45. The major sources of the farmer's income was agriculture. Majority of the Nigerian farmers are of the view that climate change is already happening. The farmers claimed that climate change is posing a threat in Nigeria. In addition to this, majority of the farmers believed that climate change is caused by anthropogenic factors. The media was the major sources of information that passed information of climate change and other environmental issues. The farmers also trusted the information which they derived from the media. The State government oversees funding farming activities in the country, and majority of the farmers are self-dependent as most of the farmers are non-member of a farming organisation.

In Enugu State, data analysis showed that crops such as groundnut, maize and cassava, increased in yield and these were correlated with increasing temperatures and precipitation. This concurs with the perceptions of the majority of the farmers (60%), who said that they have been experiencing increased temperature extremes. However, the majority of the farmers (63%), confirmed that increasing precipitation was a major cause of concern to the Nigerian agriculture. The increasing precipitation caused increase in runoff, increase in groundwater, and flooding. Furthermore, the majority of the Nigerian farmers were of the view that climate change is already affecting Nigeria. However, other crops such as guinea corn, groundnut, maize and rice were affected. This was attributed to increase in increase in rainfall, ground water, and increase in runoff. Other associated factors resulting to lower crop yield included flooding, soil erosion and infertile soil. In Enugu State, both Groundnut and Maize were positively correlated with minimum average temperature and humidity. Beans was only positively correlated to humidity. In addition, Cocoyam was positively correlated to only precipitation. In Kano State, Millet yield showed high positive correlated with precipitation and humidity. Groundnut yield was positively correlated with precipitation. Beans was negatively correlated with precipitation.

		Implemented	Planned	Needed
1	Flood protection	61%	20%	19%
2	Drought protection	52%	28%	20%
3	Coastal protection	47%	26%	27%
4	Natural retention of flood water	38%	41%	21%
5	Restricting development in risk areas	23%	53%	24%
6	Improved standards for development	31%	47%	22%
7	Improved weather forecasting and monitoring information	22%	52%	26%
8	Improved insurance schemes against flooding	27%	51%	22%
9	Increased supply of water	27%	48%	25%
10	Economic instruments such as water pricing	30%	38%	32%
11	Restrictions of water use	21%	42%	37%
12	Measures to improve water balance	21%	44%	35%

and humidity. Guinea corn was negatively correlated with maximum and minimum average temperature. Maize was negatively correlated with maximum temperature, precipitation, and humidity.

Education is very important to the farmers as aids in spreading information about climate change and other environmental issues. This will aid towards coping with the issues. There are increasing chances for the climate change risk on crop yield in the State which is evident. There are also limited studies carried out in this area especially in Enugu State, as a result this aids towards contributing to Knowledge in respect to climate change and crop yield. As a result, additional studies in needed in this context more especially in the area of climate change and farmers perception across States in Nigeria. This studies will be of benefit to farmers and policy makers as this will aid towards climate change mitigation, adaptation and policy making.

## Conclusions

This study highlighted the importance of assessing agricultural outputs against environmental forcing over suitable temporal periods. While, farming community perceptions of climate change were generally attuned to the changing environment.

The study showed that Enugu state temperature extremes, humidity and precipitation increased during the period of assessment. The majority of the crops cultivated in the State also increased possibly as a consequence of the increased use of fertilizers. However, further studies related to actual fertilizer use by crop type is required con firm suitability. Bean production results, Rice and Cocoyam also highlighted that a low positive correlation and a definite but small relationship existed, indicative of a slight increase in production through time. Farming communities in the eastern part of Nigeria are aware of the impacts of climate change. Climate change is having impacts on Nigeria agricultural systems and needs to be addressed. Majority of the farmers in the eastern part of Nigeria are very considered about climate change. Irrespective of age, education and years of experiences large percentages of the farmers perceive climate change as an ongoing threat and something that is happening now and needs to be addressed. The media have been their major sources of information and which they rely upon. Even though, some of the farmers are affected by climate change, they still lack the capacity to adapt to the uprising issues. Farmers are also aware that climate change is causing increase temperature which in influencing crop productivity. Adaptation has been the approaches; however, this is far from being addressed as so many of the farmers are threatened. Increase in rainfall and flooding happens to be the major issues faced by the farmers, more especially, in areas which are rain-fed. Mitigation and adaptation strategies needs to be considered in this context, so as to aid reduce the impacts of climate change on farmers. Generally, education plays a vital role in passing information regarding climate change, and other environmental issues Additional studies is required more especially in the area of climate change and farmers perception across States in Nigeria. This will be of benefit for climate change mitigation, adaptation and policy making.

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