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CLIMATE CHANGE TREND AND APPROPRIATE MITIGATION AND ADAPTATION STRATEGIES IN SOUTHEAST NIGERIA

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Abstract
This study analysed climate change trend and the appropriate mitigation and adaptation strategies in Southeast Nigeria. Multistage sampling technique was used to select a sample of 312 cassava based food crop farmers whose responses formed part of the data for this study. Secondary time series data on climate variables were collected from National Root Crop Research Institute Umudike, an agro-metrological station found within the study location. Data were analysed using appropriate descriptive statistical tools like mean, frequencies, percentages and frequency polygon/line graphs. Result showed that temperature and rainfall which are the two most significant climate elements that affect food crop production in Nigeria, exhibited increasing trend. It was found also that adaptation strategies that were more appropriate to farmers in the study area were late commencement of planting, use of fertilizers, choice of cropping systems, breakage of daily work schedule and planting of cover crops among others. It was concluded that the climate system is indeed adversely changing and hence concerted effort/sacrifice should be made by government, individual households and private investors towards supporting environmentally sustainable production activities and capacity building to alleviate the farmers' adaptation and resilience to climate change.

Keywords: *Adaptation, Climate Change, Appropriate, Multistage, Mitigation, Temperature Rainfall, and Descriptive.*

1.0 Introduction
In relatively poor societies where majority of the citizens are fully engaged in the agricultural sector in search of food and other means of livelihood, any challenge to such sector poses a threat to their existence. This is typical of Nigeria where climate change is threatening the agricultural sector that is wholly dependent on the climate system for sustenance. Projections suggest that, by the end of the 21st century, climate change would have had substantial impact on agricultural production and, hence, on the scope for reducing poverty (Slater *et. al.*, 2007). Evidence has shown that changing climate is already affecting crop yields in many countries (IPCC, 2007; Deressa *et.al.*, 2008; BNRCC, 2008). This is particularly true in low-income countries like Nigeria where climate is the primary determinant of agricultural productivity and adaptive capacities are low (SPORE, 2008; Apata *et. al.,* 2009). Many African countries including Nigeria, which have their economies largely dependent on weather-sensitive agricultural production systems, are particularly vulnerable to climate change (Dinar *et. al.*, 2006). According to Apata *et. al.,* (2010), this vulnerability has been demonstrated by the devastating effects of recent flooding in different parts of the country and the various prolonged droughts that are currently being witnessed in some parts of Northern region. Although the understanding and perceptions of farmers in Sub-Saharan Africa about what climate change is and the extent to which it has changed are still vague, it is not in doubt that the climate system has deflected from its original status.

Evidence from literature and past studies revealed that the recent global warming has influenced agricultural productivity leading to declining food production (Kurukulasuriya and Mendelsohn, 2006; IISD, 2007; Lobell *et. al.*, 2008). The IPCC 4th African Assessment Report estimates that by 2020 between 75 and 250 million people are likely to be exposed to increased water stress and that rain fed agricultural yields could be reduced by up to 50% in Africa if production practices remain unchanged. In order to support humanity's growing population, fertile soils, fossil groundwater, biodiversity and numerous other non-renewable resources are seriously being depleted (Abrahamsonn, 1989). This resource depletion has been linked with anthropogenic factors on the environment. The most serious of these factors is the injection of greenhouse gases into the atmosphere. The reality of the impact of climate change on agricultural development has started showing signs (Adama *et. al*., 1998; Fischer *et.al*., 2002; SPORE, 2008).

Climate change has been identified as one of the greatest challenges to the persistent low agricultural productivity amidst myriads of efforts by government and other stakeholders to control it (Buckland, 1997; Matarira, *et.al.*, 1995;Adama, *et.al.*, 1998; Apata, *et.al.*, 2009, and Nwaiwu *et. al.,* 2013a). In recent times, studies germane to the ravaging effects of climate change on agricultural productivity,(Slater *et.al.*, 2007; IPCC, 2007; Deressa *et.al.*, 2008, BNRCC, 2008; Nwajiuba, 2008; Nwajiuba, *et. al*; 2008, Nhemechena, *et al*; 2009; Nwajiuba and Onyeneke, 2010, and Nwaiwu *et. al.*, 2013b) have been carried out but little or none has dwelt on determining mitigation and adaptation strategies appropriate to Southeast Nigeria. Consequently, this study is made to close such knowledge gap by identifying those strategies that have worked for food crop producers in the study area as a prelude to improving on them and developing more sustainable approaches.

2.0 Materials and Methods

This study was conducted in Southeast Nigeria characterised by tropical rainforest nature. The zone lies within latitudes 5^oN to 6^o N of the equator and longitudes 6^oE and 8^oE of the Greenwich (prime) meridian (M.S corporation, 2009). The zone occupies a total land mass of 10,952,400 hectares with a population of 16,381,729 people (NPC, 2006). There are two major seasons experienced in this zone. These are the Dry season and the Rainy season. The dry season occurs between November and March while the rainy season occurs between April and October. Although over the recent decades, it appears very difficult to create a clear cut distinction between the periods we refer to as rainy season and dry season due to climate change. This is epitomized by heavy rains that fall during the supposed dry spells and obvious dry spells suffered during seasons that heavy rains are expected.

Despite this observed erratic nature of both rainfall and dry spells, the location of the zone within the tropical rainforest belt of the country encourages and allows the growth and survival of most tropical food crops like yam, cassava, vegetables, rice, etc, and livestock production. Hence about 60-70% of the inhabitants of this zone are observed to engage in agriculture, mainly crop farming and animal rearing (Okoye *et .al.,* 2010).

The multi-stage sampling technique was adopted in sample selection. In the first stage, two states were purposively selected from the five states that make up the zone based on their topographic status. One state typical of hilly terrain, (Ebonyi) was chosen from category one and one typical of flat terrain, (Imo) was chosen from category two. . In the second stage, two agricultural zones were randomly selected from each of the two states to get a total of four (4) agricultural zones for the study. The agricultural zones chosen in these states were Orlu and Owerri from Imo state and Ebonyi south, and Ebonyi north from Ebonyi state. Thirdly, three Local Government Areas (L.G.As) were randomly selected from each of these agricultural zones to get twelve (12) L.G.As. The LGAs in these states are; In Imo we have Ohaji/egbema, Owerri west, and Ahiazu Mbaise for Owerri zone and Oru West, Oru East and Nwangele for Orlu zone. In Ebonyi state we have Afikpo north, Ohaozara and Onicha for Ebonyi south; and Abakiliki, Izzi and Ebonyi for Ebonyi north. In the fourth stage, three communities were purposively selected from each of the 12 L.G.As. This gave a total of 36 communities. These were purposive due to the fact that the selections were based on the high proportion of food crop contact farmers (cassava farmers) as contained in the register of each L.G.A Extension Department. Finally one village was randomly selected from each community to get a total of 36 villages used for the study.

To ensure that adequate and representative sample was drawn at this stage, a pre-survey sampling frame was determined by compiling a list of the cassava producer households available in the chosen 36 villages. This was done with the assistance of village heads and extension agents. When this frame was determined,(331 from Imo state and 195 from Ebonyi state), the adequate sample size from each state was computed using the formula;

$$n = \frac{N}{1 + N(e^2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 3.1$$

(Yamane, 1967)

Where n = sample size

N = population (sample frame)

e = level of precision in percent.

Following this model, the total sample size used for the study was 312; 181 from Imo state and 131 from Ebonyi state. These were randomly selected from the sample frame.

Data for this study were collected from both primary and secondary sources. Secondary data concerning the annual mean climate variables like temperature, rainfall, relative humidity, and sunshine duration for a period of forty years were collected from the Agro-metrological unit of the NRCRI, Umudike. Primary data for this study were collected from cassava farmers with the use of questionnaire /interview schedule . The type of data collected included those that bother on the socio-economic characteristics of farmers like (age, sex, level of education, household size, annual income, etc.) and the mitigation and adaptation strategies that has worked for them in the past.

Data were analysed with relevant descriptive statistical tools such as mean, frequency distribution, frequency polygon/histograms and percentages.

3.0 Results and Discussion

3.1 Socioeconomic Characteristics of the Respondents

Table 3.1 shows the distribution of respondents according to their socio-economic characteristics.

Table 3.1 Distribution of Respondents According to their Socio-economic Characteristics

Socio-economic Characteristic	Mean	Standard deviation	Range
Age(years)	51.3	9.65	28-75
Household size(persons)	8	2.86	2-8
Annual Income(₦)	391,530.64	0.000022	113290-1634271
Level of Education (years)	9.60	5.94	0 – 22
Farming experience(yrs)	20.96	9.28	2-60
Farm size(hectares)	0.84	0.83	0.05- 5.00
Number of extension Contact(no. of visits)	0.73	1.2	0.00- 12.00

Source: Field Survey Data, 2012.

According to Table 3.1, the mean age of cassava producer farmers in southeast Nigeria was 51.30 years with a standard deviation of 9.65years. This implies that there was high variability in the ages of farmers, however they were still within the productive age limit during which they could fully and efficiently engage in all forms of productive labour

especially farm labour. The mean household size of farmers in the study area was 8 persons per home, mean annual household income was ₦391,530.64 and mean farm size was 0.84 hectares. These categorised the farmers in the study area as smallholder and resource poor farmers because they farm on land between 0.1-5.99 hectares (Olayide,1980; Ogungbile and Olukosi, 1991, and Nwaiwu, 2007). This implies that they were mainly subsistence farmers who have very limited capacity to practice commercial farming. Consequently, they are also expected to have very weak capacity to adapt to the fast changing climate which has very adverse effects on agriculture and food production, if some abatement strategies are not strictly adopted. Furthermore, the farmers are said to be food insecure because according to the world Health Organization WHO, an individual is said to be food insecure if that person subsists on below $1.25 dollar per day (Todaro and Smith, 2011). Obviously $1 is currently equivalent to about one hundred and sixty (₦160.00) Nigerian naira which implies that $1.25 will be about ₦200. From Table 3.1 the per capita income of the farmers per day was about one hundred and thirty-four naira (₦134.00). This implies that they leave below $1.25 USA dollar per day. The Table also shows that the mean frequency of extension visits to the farmers was 0.73 times. This implies that extension education in the study area was very poor as such farmers will be lacking a lot in terms of availability and use of innovations including climate change adaptive and mitigation strategies that would have helped them overcome the dangers of climate change. Finally, the mean level of education of farmers in the study area was approximately ten (10) years. This implies that they would have acquired post-primary education which makes them enlightened enough to be able to adopt available innovations when introduced to them.

3.2 Climate Change Trend Variables.

According to Nwaiwu et al, (2013) the two major climate parameters that significantly affect the growth and productivity of most food crops are rainfall and temperature. In this study, the trend of rainfall and temperature were fully analysed.

3.2.1 Trend of Temperature

Table 3.2 shows the analysis of temperature records in Southeast Nigeria between the periods of 1972 through 2011.

Table 3.2 Analysis of Temperature Records from 1972-2011.

Temperature	Values
Mean (^{o}c)	26.77
Standard deviation (^{o}c)	0.441
Maximum temp. (^{o}c)	27.65
Minimum temperature (^{o}c)	25.95
Trend (^{o}c/year)	1.192*
Correlation coefficient (r)	0.425*

*Significant at 1%

Source**:** NRCRI, Umudike, 2012

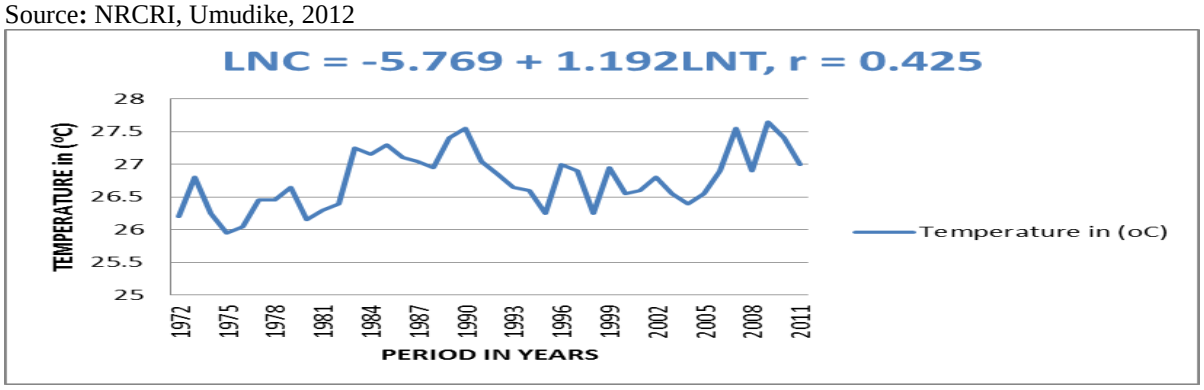

Figure 3.1. Trend of temperature of Southeast Nigeria between 1972-2011.

Source**:** NRCRI, Umudike, 2012.

According to the statistical records of temperature in southeast Nigeria as recorded by the Agromet unit of the NRCRI, Umudike from 1972-2011, temperature showed an increasing trend with the highest temperature occurring in 2009 at 27.65^{o}C and the lowest occurring in 1975 at 25.95 ^{o}C (Table 3.2 and Fig.3.1). Also the mean and standard deviation of the temperature record are 26.77 ^{o}C and 0.441 ^{o}C respectively (Table 3.2). This shows that there was a very small variability in temperature from year to year. The trend coefficient is 1.192 and is statistically significant at 1% level (Table 3.2). The correlation coefficient is 0.425 and is statistically significant at 1% level implying that temperature has a significant positive relationship with time. These therefore indicate that climate with respect to temperature is really changing and increasing, hence there is indeed global warming. This finding is consistent with the report of Nwajiuba and Onyeneke, (2010) that temperature is positively and significantly increasing with time, hence the global warming is real. According to Monteith, (1981), if temperatures continue to increase beyond a specific threshold, a crop's productive summer growing season could become shorter, thus reducing the yield. Consequently, efforts to devise and propagate appropriate mitigation and adaptive strategies to this menace become very pertinent.

3.2.2 Trend of Rainfall

Table 3.3 shows the analysis of rainfall records in southeast Nigeria between the periods of 1972 through 2011.

Table 3.3 Analysis of Rainfall Records from 1972-2011.

Rainfall	Value
Mean(mm)	2158.89
Standard deviation (mm)	288
Maximum (mm)	2751.9
Minimum (mm)	1511.4
Trend (mm/year)	2.09
Correlation coefficient (r)	0.091

Source: NRCRI, Umudike, 2012

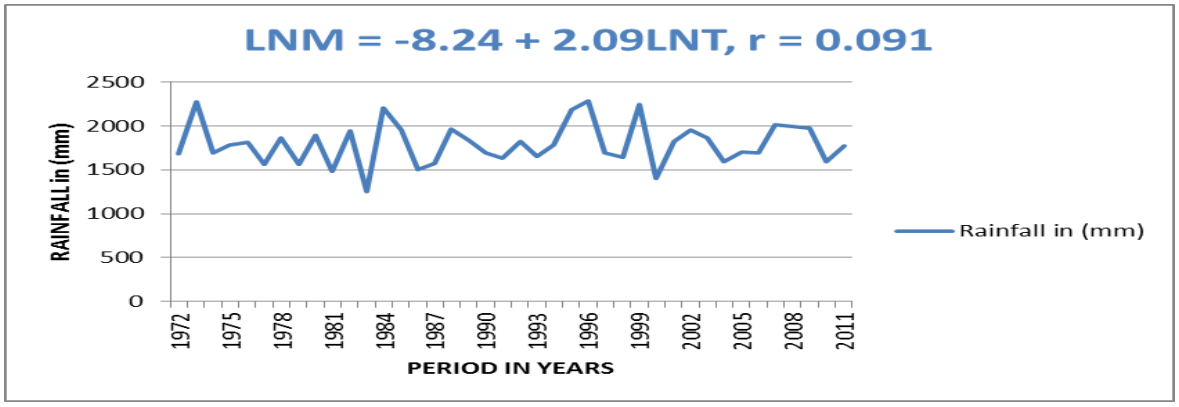

Figure 3.2 Trend in Volume of Rainfall of Southeast Nigeria between 1972-2011.
Source: NRCRI, Umudike, 2012.

Statistics of rainfall volume in Southeast Nigeria between the periods of 1972-2011 showed an increasing trend with the highest occurring in 1996 and lowest occurring in 1983 with values of 2751.9mm and 1511.4mm respectively (Table 3.3, Fig.3.2). The mean and standard deviation were 2158.89mm and 288mm respectively(Table 3.3). This implies that there was a high variability in rainfall within this period hence the observed positive trend though not statistically significant. The coefficient of correlation was 0.091, but not statistically significant. This indicates that there was a weak positive relationship between rainfall and time. This finding slightly disagrees with the observation of Nwajiuba and Onyeneke (2010) who reported a decreasing trend in rainfall. The deviation could be as a result of the fact that they used rainfall records between 1978-2007 which did not account for the changes that may have occurred before 1978 and after 2007, which is captured in this study. According to Falkenmark, (1989) rainfall is the major limiting factor in the growth and production of crops worldwide and adequate moisture is critical for plants, especially during germination and fruit development. Obviously, food crops grown in Southeast Nigeria which is dominantly a rainforest zone require high amount of rainfall. Cassava particularly requires about 1000-1500mm of rainfall for optimum production (Wheatley *et al;* 1995). This favourable rainfall volume may account for the good performance of Nigeria as the world's largest producer of cassava (FAOSTAT, 2012).

3.3 The Measures Employed by Farmers to Mitigate and Adapt to the Effects of Climate Change.

Table 3.4 shows the distribution of respondents according to measures/strategies being adopted by food crop farmers to mitigate/adapt to the effects of climate change on their food production activities.

Table 3.4 Mitigation/Adaptation Strategies to Climate Change.

Strategy Adopted	Imo		Ebonyi		Pooled	
	Freq*	%*	Freq*	%*	Freq*	%*
Late com.. of planting	124	68.50	125	95.40	249	79.80
Digging of ditches	70	38.70	07	20.60	97	31.10
Use of fertilizer	126	69.60	122	93.10	248	79.50
Use of pesticide	49	27.10	121	92.40	170	54.50
Const. of farm shed	85	47.00	117	89.30	202	64.70
Use of irrigation	61	33.70	13	9.90	74	23.80
Choice of crop. syst	163	90.10	131	100.00	294	94.20
Breaking of daily wk	150	82.90	131	100.00	281	90.10
Mulching strategy	144	79.60	99	75.60	243	77.90
Planting of cov. crops	127	70.20	131	100.00	258	82.70
Making of structures	50	27.62	85	64.80	135	43.27
Contour ploughing	56	3.30	04	3.10	06	1.90
Crop rotation	139	76.80	131	100.00	270	86.50
Shifting cultivation	103	56.90	126	96.20	229	73.40
Continuous cropping	90	49.70	04	3.10	94	30.10
Mixed farming	175	96.70	128	97.70	303	97.10
Mono cropping	14	7.73	40	30.50	54	17.30
Mixed cropping	181	100.00	131	100.00	312	100.00

*Multiple responses recorded, hence frequency and percentage not additive
Source: Field Survey Data, 2012

According to Table 3.4, the farmers in the study area adopted the following strategies to adapt to the menace of climate change; (i) late commencement of planting, (ii) use of fertilizers, (iii) use of pesticides, (iv) construction of farm sheds, (v) selection of cropping pattern/system, (vi) breaking of daily work schedules or periods, (vii) mulching, (viii) planting of cover crops, (ix) crop rotation, (x) shifting cultivation, (xi) mixed farming, and (xii) mixed cropping. According to the Table, 79.8%, 79.5%, 54.5%, 64.7%, 94.2%, 90.1%, 77.9%, 82.7%, 86.5%, 73.4%, 97.1%, and 100% respectively responded positively to the use of these strategies.

Table 3.4 showed that only 23.8% of the studied population used irrigation facilities in their production process. This fact goes a long way in explaining the rudimentary level of farm production system in the study area where farming is wholly dependent on rain-fed water source. The 23.8% that used irrigation may have been using non-automated irrigation facilities but manual operation using borehole water, and pumping from streams and rivers.

It was also observed from this Table that while making of high planting structure was a strategy in Ebonyi State where about 65% of the farmers adopted it, only 27.6% of farmers in Imo State adopted it. This could be attributed to the nature of soils and the water logging terrain of Ebonyi State fields where small planting structures were usually submerged in water, hence their decision to avert that menace by making very high and large planting structures. The reverse is the case in Imo where most of the plantings were done on zero-tilled or minimum tilled soil, and smaller planting structures. It was also observed from the Table that contour ploughing was almost not adopted by the farmers as adaptive strategy to climate change. This could be because contour ploughing is usually used to control erosion on hilly farms. Therefore the farmers studied may not have had farms on hilly fields where such practices were adoptable.

4.0 Conclusion

This study revealed that there has been a positive and significant trend in temperature hence confirming the findings of previous research works that the weather is getting hotter otherwise referred to as global warming. Furthermore, it was found that rainfall shows an increasing trend which corroborates with the observed torrential rains being experienced in recent times. Adaptive strategies such as late commencement of planting, use of fertilizers, choice of cropping systems, breakage of daily work schedule, planting of cover crops among others were those appropriate to the situation found in the study area. It was concluded that in view of the predicted deleterious consequences of higher temperatures of the earth and obvious evidences of such occurrence as confirmed in this study, both government and indeed the citizenry should work hand in glove to ensure that the mitigation strategies as enunciated by the United Nations Organization under the aegis of the United Nations Framework Convention on Climate Change should be strictly adhered to. This will not only protect the survival of the present generation but for the future generation to come. Finally, government at all levels should make use of the proceeds from the naturally endowed economic resources (which their exploitation and use exacerbate the climate system), to improve the lots of the resource poor farmers so that they can afford the appropriate adaptation strategies to ensure increased food production, hence food security.

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