Assessments of Diverse Climate Change Impacts on Agriculture and Food Security

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Abstract- Agriculture production is dependent on climatic and weather conditions but now-days increasing in temperature, precipitation, and CO2 concentration directly affects crop production. This paper presents an empirical analysis of the effects of global warming on Nigerian agriculture, food security, and estimation of the determinants of adaptation to climate change. Data used for this study are from both secondary and primary sources. The set of secondary sources of data helped to examine the coverage of the three scenarios (1971-1980; 1981-1990 and 1991-2000). The primary data set consists of 900 respondents' but only 850 cases were useful. This study analyzed determinants of farm-level climate adaptation measures using a Multinomial choice and stochastic-simulation model to investigate the effects of rapid climatic change on grain production and the human population in Nigeria. The model calculates the production, consumption, and storage of grains under different climate scenarios over a 10-year scenery. In most scenarios, either an optimistic baseline annual increase of agricultural output of 1.85% or a more pessimistic appraisal of 0.75% was used. The rate of natural increase of the human population exclusive of excess hunger-related deaths was set at 1.65% per year. Results indicated that hunger-related deaths could increase if grain productions do not keep pace with population growth in an unfavorable climatic environment.

Indexed Terms- Assessment, Diverse, Climate, Change, Impact, Agriculture, Food, Security

I. INTRODUCTION

There is a growing consensus in the scientific literature that in the coming decades the world will witness higher temperatures and changing precipitation levels. The effects of this will lead to low/poor agricultural products. Evidence has shown that climate change has already affecting crop yields in many countries (Deressa et'al, 2008). This is particularly true in low-income countries, where climate is the primary determinant of agricultural productivity and adaptive capacities are low. Many African countries, which have their economies largely based on weather-sensitive agricultural productions systems like Nigeria, are particularly vulnerable to climate change (Dinar et al, 2006). This vulnerability has been demonstrated by the devastating effects of recent flooding in the Niger Delta region of the country and the various prolonged droughts that are currently witnessed in some parts of Northern region. Thus, for many poor countries like Nigeria that are highly vulnerable to effects of climate change, understanding farmers' responses to climatic variation is crucial, as this will help in designing appropriate coping strategies.

Evidence from literature and past studies has revealed that the recent global warming has influenced agricultural productivity leading to declining food production (Lobell et al, 2008). In order to meet the increasing food and non-food needs due to population increase, man now rapidly depleting fertile soils, fossil groundwater, biodiversity, and numerous other non-renewable resources to meet his needs (Ehrlich, 1990).

This resource depletion was linked with other human pressures on the environment. Possibly the most serious of human impacts is the injection of greenhouse gases into the atmosphere. The reality of the impact of climate change on agricultural development has started showing signs (Abou-Hadid et'al, 2003). A substantial body of research has documented these wide-ranging effects on many facets of human societies (Apata et'al, 2009). Rough estimates suggest that over the next 50 years or so, climate change may likely have a serious threat to meeting global food needs than other constraints on agricultural systems (BNRCC, 2008). Specifically, population, income, and economic growth could all affect the severity of climate change impacts in terms of food security, hunger, and nutritional adequacy. If climate change adversely affects agriculture, effects on human are likely to be more severe in a poorer world. Adams et al, (2010) worry that rising demand for food over the next century, due to population and real income growth, will lead to increasing global food scarcity, and a worsening of hunger and malnutrition problems particularly in developing countries.

Recently, international tensions and concerns are heightening over what the impact of climate will have on the environment and agricultural produce. Also, how agricultural and food-distribution systems will be further stressed up by the shifting of temperatures and precipitating belts, especially if changes are rapid and not planned for (NEST, 2004). The crucial issue in this study is whether agricultural output supply can keep pace with population increase under this climate variability. This will depend; both on the scope for raising agricultural productivity (including reducing waste during distribution), availability of inputs used in the agricultural sector (land, labour, machinery, water resources, fertilizers, etc.) and having sufficient information on climatic variables for possible effective adaptation and mitigation strategies.

Consequently, attempt is being made in this study to investigate the effects of climate change on food demand and production as well as population increase in Nigeria. Past studies that have examined the impact of climate change on food production at the country, regional, or global scale (IPCC, 2007 and Apata et al, 2009), have failed to provide critical insights in terms of effective and future adaptation strategies, although

insights from these studies created the background for the present study.

Studies on the impact of climate change (particularly rainfall and temperature) and climate related adaptation measures on crop yield are very scanty.

Studies by Ayinde et'al, (2010) and Mano (2006) are some of the economic studies that attempt to measure the impact of climate change on farm productivity. These studies imputed the cost of climate change as a proxy for capitalized land value and which are captured from farm net revenue. However, while these studies were conducted using sub-regional agricultural data as well as household-level it did not identify the determinants of effective adaptation methods to predict efficient adaptive measures. Also, it's likely future effects on food production and population growth were not assessed. Consequently, the objectives of this study are to examine effects of key climatic variables on food production and its likely effect on population increases and to identify the determinants of effective adaptation methods to predict efficient adaptive measures in a typical developing country, using household-specific survey data from Nigeria.

1.1 Quantification of Major Indicators of Climate Change on Agriculture

Past studies have used a variety of approaches to capture climate change effects on agriculture (Hassan, 2010). These approaches range from simply equating average future impacts to yield losses observed in historical droughts to more quantitative crop simulation modeling, statistical time series, and cross-sectional analyses. To date, simulation studies have been limited by a lack of reliable data on soil properties and management practices, and have provided only `best-guess' estimates with little to no information on uncertainties that result from choices in model structure, parameter values, and scaling techniques (Fischer et al 2002). In addition, past studies have observed that statistical analyses have been limited by the poor quantity and quality of historical agricultural data relative to other regions, resulting in model estimates with wide confidence intervals (Dewit and Stankiewicz, 2006). Besides, studies have shown that Statistical and econometric techniques can be employed to establish a logical

association between climate variation and change (IISD, 2007).

A substantial amount of research has been conducted on the potential impacts of climate change on agricultural productivity (Deressa and Hassan, 2010). Attempts are made in these studies to link the state-of-the-art models developed by researchers in separate disciplines, including climatology, agronomy, and economics, in order to project future impact of climate change on agriculture and implication for population growth. The review of these studies helped to have an understanding of the physical and economic responses, and adjustments on climate change and agricultural production. However, in line with adaptation scenario of how farmers are coping or surviving under this climate variability, these studies assumed that farmers could adapt to climate change by changing crop varieties and timing of planting and harvesting, while in the without adaptation scenario it is assumed that farmers do not make any adjustments over time.

The global production and distribution of food is inadequate for a large fraction of the rapidly expanding global population of 5.8 billion people under present and foreseeable economic systems (Ehrlich & Ehrlich 1990). The agricultural and food-distribution systems may be further stressed by shifting of temperature and precipitation belts, especially if changes are rapid and not planned for (ODI, 2007).

In this paper investigation of the possible positive or negative effects of climate change on Nigerian food security was carried out by using a computer model and Statistical software packages of LIMDEP 6.0. Focus was on grain because it supplies over half of the calories in the average diet (of developing countries Nationals) and accounts for the vast majority of the international trade in food (ANAP, 2006). The model adopted in the study is a simple, aggregate representation of agricultural systems and human populations that have been used by Daily & Ehrlich (1990).

II. METHODOLOGY

2.1 Method of Data Collection

Both primary and secondary data were used for this study. Secondary data came from National Core Welfare Indicator (NCWI)/National living Standard Survey (NLSS)/National Consumer Survey/Demographic/Health Survey (DHS)/National Population Commission (NPC), and National Bureau of Statistics. These set of secondary sources of data helped to examine the coverage of the three climate scenarios (1971-1980, 1981-1990 and 1991-2000) used for this study. The primary data consists of 900 respondents' (150 respondents from each zone) but only 850 responses were useful. In addition weather alerts, forecast, and measurements over these periods were examined. This study analyzed determinants of farm-level climate adaptation measures in Nigeria using a Multinomial choice model in all the six zones in Nigeria. Also, a simple, nationally aggregated, stochastic-simulation model was constructed to investigate the effects of rapid climatic change on agriculture (grain production) and the human population in Nigeria.

The level of grain consumption in each year to the scenario is calculated as the product of the current population size and the average consumption per person per year. Our estimate of average consumption, 0.35 T grain per person-year, is equal to the average global per-capita production level over 1955-88 (FAO 1956, 89; PRB 1988; UN 1987). Grain lost to wastage estimated to be 40% between production and consumption; (Akinyosoye, 2006), diverted to livestock, and otherwise not consumed directly. The grain carry-over stock is set at the beginning of each simulation. For most runs, the initial stock was set at 35,003T, an intermediate level equal to 21% of consumption for the initial year.

2.2 ANALYTICAL PROCEDURE

2.2.1 Model of Effect of Stochastic Perturbations in Food Production on Population Size

The model is used to simulate the effect of stochastic perturbations in food production on population size. In yearly increments, the model calculates human population size, number of hunger related deaths, and the production, consumption and storage of grain under different climatic scenarios. Parameters that

may vary in each run of the model include the initial population size, the initial level of grain production and grain stores, and the rate of change in population size. It is hypothesized that climate change will have unfavorable impact on agricultural production. Therefore, there is the need to capture the frequency and magnitude of changes in the harvest. The climate scenarios are described in terms of two parameters: the frequency and the magnitude of changes in grain production caused by changing weather patterns. All of the parameters in the model represent aggregates for the whole. The model is adapted from the study of Daily and Ehrlich, (1990) and was modified to capture the scope of the study.

$$N_{t+1} = (1 + 0.01 \times \Delta N) \times N_t \quad (1)$$

Where, N= population size, and ΔN is the annual percentage rate of increase of population size.

$$G_{p,\,t+1} = (1 + 0.001 \times \Delta G) \times G_{p,\,t} \qquad (2)$$
$$G_{nf,\,t+1} = G_{p,\,t+1} + 0.01 \times v \times G_{p,\,t+1} \qquad (3)$$
$$G_{a,\,t+1} = G_{nf,\,t+1} + 0.01 \times m \times G_{nf,\,t+1} \qquad (4)$$

Where; G_p = potential grain production and ΔG the annual percentage rate of increase of grain production; G_{nf} = potential grain production modified by 'normal fluctuations'; v = is a number selected randomly (and uniformly) from the set (-4.0, -2.0, 0, 2.0, 4.0) to produce an expected variance of 7.5%; G_a = actual production for the given year; m = the amount by which grain production is enhanced or reduced in years where climatic events affect agriculture(determined stochastically). Grain consumption(C) is calculated as $C_t = (0.33T \text{ percapita}) \times N_t$. Grain stock (S) has a lower bound of zero and is calculated as follows: T: $S_{t+1} = S_t + G_{at+1} - C_{t+1}$

The number of hunger-related deaths (D) occurring in a year is assumed in this study as a function of grain stocks and distribution. In the case of a huge grain surplus, where stocks constitute greater than 40% of consumption (i.e. $S \times 100/C > 40$), it is reported that about 25,605 death occurs between 1991-2000 (Demographic and Health Survey (DHS), 2003), 21,819 deaths were reported during, 1981-1990 (DHS, 1990) and 35,003 deaths from 1971-1980 (National Population Commission, 1983). It is estimated that 82,427 deaths were recorded during the 3 scenarios covered. If there is a grain surplus (i.e. S > 0) but stocks constitute no more than 40% of consumption

(i.e. $S \times 100/C > 40$), then $D_t = 2 \times 106 + d - d/40) \times X$, where d = number of deaths per year when stocks equal zero, and is set at 35,003 here; $x = 5 \times 100/C$. If there is a grain deficit, then $D_t = 2 \times 106 + d + 2x$ (deficit).

Based on monthly/annually meteorological weather related data collected from the Nigerian Meteorological station/Unit and Central Bank of Nigeria (CBN) annual reports, the model was used to calculate the production, consumption, and storage of crops (grains) under different climate scenarios over a 30-year period. In most scenarios, either an optimistic baseline annual increase of agricultural output of 1.85% or a more pessimistic appraisal of 0.75% was used. The rate of natural increase of the human population exclusive of excess hunger-related deaths was set at 1.65% per year.

The model has several important limitations. First, it accounts for local heterogeneity only by including deaths caused by mal-distribution. This is a crude approximation because inequitable distribution of food (and wealth in general) and extreme heterogeneity in population density, in agricultural productivity (over space and time), in climate regimes, and in the variability of weather patterns are key factors in generating regional famine. Secondly, the model does not include mechanisms whereby compensation for imminent food shortages could be made.

Thirdly, the model implicitly assumes that the underlying 'trend' (rate of change) in grain production will remain constant even in the face of the social and economic turmoil. Furthermore, maintaining a growth rate in agricultural output of 1.7% per year embodies a series of optimistic assumptions of success in the development and implementations of better agricultural practices and technologies. In addition, the effects of climate change are assumed to be constant. These assumptions would all have the effect of underestimating the number of deaths that may result from the impacts of deleterious climate change. Finally, a few comments relative to our validation of the model must be made. It is very difficult to quantify the actual number of people that have starved to death over the past two decades. Aside from poor censoring in famine-stricken areas, malnutrition compromises

the immune system and the immediate cause of death of severely malnourished people is thus usually reported as disease. The rough estimate of over 82 thousand deaths is considerably lower. The numbers of deaths produced by the distributional aspects of the model are therefore probably conservative. Despite these limitations, however, the model still captured the scope of the study.

2.3 Choice of the Multinomial Logit Model for Adaptation Scenery

The analyses presented in this study identify the important determinants of adoption of various adaptation measures for policy direction. The analytical approaches that are commonly used in an adoption decision study involving multiple choices are the Multinomial Logit (MNL) and Multinomial Probit (MNP) models. Both the MNL and MNP are important for analyzing farmer adaptation decisions, and are also appropriate for evaluating alternative combinations of adaptation strategies, including individual strategies. This study uses a MNL logit model to analyze the determinants of farmers' decisions because it is widely used in adoption decision studies involving multiple choices and is easier to compute than its alternative, the MNP (Babcock, 1998). MNL has computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987). The main limitation of the model is the Independence of Irrelevant Alternatives (IIA) property, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Nhemachena, 2008).

2.4 Model Specification

Let Ai be a random variable representing the adaptation measure chosen by any farming household. We assume that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of climate attributes, socioeconomic characteristics, and other factors X. The MNL model for adaptation choice specifies the following relationship between the probabilities of choosing option Ai and the set of explanatory variables X as (Greene, 2003):

$$\text{Prob}(A_i = j) = \frac{e^{\beta_j' x_i}}{\sum_{k=0}^{j} e^{\beta_k' x_i}}; \quad j = 0, 1, ..., J \quad (5)$$

A 'universal' logit model avoids the IIA property while maintaining the multinomial logit form by making each ratio of probabilities a function of the attributes of all the alternatives. After considering all the economic model and interpretation, the effects of explanatory variables on the probabilities, marginal effects are usually derived as:

$$\delta_j = \frac{\partial P_j}{\partial x_i} = P_j \left[\beta_j - \sum_{k=0}^{J} P_k \beta_k \right] = P_j \left(\beta_j - \bar{\beta} \right) \quad (6)$$

The marginal effects measure the expected change in probability of a particular choice being made in respect to a unit change in an explanatory variable (Greene, 2000). The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients. The explanatory variables used in the Multinomial Logit Models and hypothesized as determinants of respondents poor in the level of perception and adaptation to climate change(that is specialized in only (mono) cropping) are:, 1 for mono and 0 otherwise. Increased temperature ($X1$),fall temperature(X_2),altered climate range (X_3),changed timing of rains(X_4), frequency of droughts (X_5), noticed climate change (X_6), cereal/legume intercropping (X_7), mulching (X_8), practiced zero tillage (X_9), making ridges across farms (X_{10}), farm size (X_{11}), own heavy machines (X_{12}), household size (X_{13}), farming experience (X_{14}), education (X_{15}), age of farmers (X_{16}) access to extension facilities (ACEXT) (X_{17}) Dummy, if access 1, otherwise 0, access to credit facilities (ACCRE)(X18) and Sex (X19).

III. RESULTS AND DISCUSSIONS

The Simulations Run Model of the climate scenarios (1971-2000). To generate the output presented here, the model was iterated three-times per simulation (i.e., 3 scenarios), a run is a set of simulations done under the same initial conditions. The annual rate of natural increase of the population size (ΔN) is a constant percentage. For most runs, the initial population size and growth rate were set at 45576200 and 1.7% per scenario, respectively. Population size may be sharply reduced by grain shortages (which might likely cause rapid increases in deaths by starvation). These periods of population increase are assumed to be instantaneous. Following such scenarios, the constant

rate of increase is applied to the new lower population size. For most scenarios, initial production was set at 2374 metric tons (T) grain. The underlying rate of change in grain production (the ' trend ') also remains constant. For reference, the average value of the trend was 2.6 % per scenario from 1981 to 1990, and 1.4% per year from 1991 to 2000 (ANAP, 2006). To simulate normal stochastic fluctuations in production, the amount harvested in a given year is caused to deviate from the trend by one of five values (0.0,+2.0,-2.0, +4.0, or -4.0%) selected at random each year. These values were selected to create a pattern resembling a relatively favourable decade for local agriculture. The fluctuations in grain production generated by the model (expected variance 8.0%) are roughly comparable to those that actually occurred over the decade 1971-80 (observed variance 8.5%) a decade with little variation in the upward production trend. By contrast, the observed variances in grain production in the preceding (1981-1990) and following (1991-2000) decades were 51.0% and 20.4%, respectively. Thus the choice of the magnitude of 'normal' fluctuations was conservative.

The model iterates a set of equations describing this system for a projection time of ten years for each scenario. We consider that period sufficiently long to reflect trends, but not so long that agricultural and economic systems are likely to change fundamentally. The mean and the standard deviation of several statistics are recorded on the completion of each run: the total number of deficits, the total number of deaths and maximum that occurred, and the final population size were studied. To determine the number of simulations required per run, we produced multiple sets of runs consisting of 100 and 1000 simulations each using initial conditions with high variance in output parameters (run E, table 1). The coefficient of variation of the mean number of deaths was 2.4, 1.3, and 0.3 respectively. We therefore considered 1000 simulations per run sufficient to produce reasonably consistent results.

The output of the model under a variety of scenario' is displayed in Tables 1-3. In most cases we contrast the output under different scenarios with reference to the average number of deaths produced in a run, a figure that reflects both the frequency and magnitude of changes in grain stocks. Generally, in what follows

'deaths' here refers to hunger-related deaths in excess of those subsumed in the natural rate of increase. The model was done in the absence of unfavourable climatic events and under the assumption that annual growth in grain production (ΔG) would keep pace with that of the population (ΔN), which was 1.7% in 1981-1990 scenarios (ΔN is now 1.8%). Over the 10-year projection time under this scenario (run A, Table1), although there are no grain deficits (0.0+0.0), 31+14 thousand deaths occur because of mal-distribution of food. The variance in the output statistics is quite high, as indicated by the occurrence of over 35 thousand hunger related deaths in one of the 1000 simulations. Thus, there will be increase in the population size at a constant growth rate of 1.7%, with no hunger-related reductions. The model was run under several climatic scenarios with negative changes in harvest ranging from 3 to 10% per event. These seem reasonable values, because a reduction of about 5% (from the 1971-80 trend of 2.1% growth per annum) can be attributed to weather-caused harvest failure during 1961-1970 scenarios. The first set of the following runs assumes that $\Delta N = \Delta G = 1.7\%$ and that the initial carry-over stocks totaled 35,003 T (table 1). Under these growth rates, a 5% reduction in harvest every five years (on average; probability of event, $P_e = 20\%$ causes 0.1 ($\Delta 0.3$). Current trends in agriculture suggest that assuming grain production levels can increase by 1.7% annually is very optimistic. Growth averaged just 1.4% annually from 1981-90. Achieving either of these growth rates (1.7 or 0.9%) could well require substantial technological innovation, and maintaining productivity in the long run will clearly require major changes in farming practices.

Therefore, we repeated the set of runs presented in table 1 under the assumption that $\Delta G = 0.9 \%$ over the 10 year projection time. Table 2 displays the output of these simulations. Even in the absence of unfavorable climatic conditions (run J, table 2), the imbalance between ΔN (1.7%) and ΔG (0.9%) leads to a staggering 82,427 thousand deaths over the 30-year projection time. Under each scenario with climate-induced reductions (runs K-R), over 20 thousand people die on average. However, imposing various deleterious climatic regimes (runs K-R) on grain production does not increase the resulting average number of deaths as much as when ΔG equals ΔN runs.

Table 1: Each run represents 1,000 simulations of the same conditions: (1971-1980)

Run	Net p/n	ΔN and ΔG	Prob. of event	Mag. of change	Initial stock (000 tonnes)	No. of deficit per simulation mean ± s.d	No. of deaths per simulation (000 tonnes) Mean ± s.d. MAX	
A	N	1.7	0	0	35	0.0±0.0	31±10	36
B	N	1.7	10	5	35	0.1±0.3	33±19	42
C	N	1.7	10	10	35	0.6±0.8	41±11	31
D	N	1.7	20	5	35	0.2±0.9	42±16	41
E	N	1.7	20	10	35	1.2±1.1	71±08	33
F	N	1.7	30	5	35	0.1±0.0	46±10	48
G	N	1.7	30	10	35	0.8±1.0	38±22	30
H	N	1.7	50	5	35	2.4±1.3	31±14	45
I	N	1.7	50	10	35	3.3±1.1	43±13	51

SOURCE: Computer Output Results (2008).

To test the sensitivity of the model to different rates of increase in grain production relative to those of population growth, we ran an identical set of climate scenarios on both the conditions that ΔN = 1.7% and ΔG = 1.3% (runs S-U, table 3), and that ΔN = 1.7% and ΔG = 2.4% (runs V$_X$, table 3). The number of deaths that occur with ΔG = 1.3 is appreciably less than under the comparable scenarios with ΔG= 0.9 (runs K, M, and L, table 2). The number of deaths that occur when ΔG = 2.4% (runs V-X, table 3) is roughly comparable to that where ΔN = ΔG = 1.7 and no unfavorable weather patterns occur (run A, table 1). The number of deaths produced with ΔN = ΔG = 09 %is only slightly less (7%, on average) than under the same climatic scenarios with ΔN =ΔG=1.7% (runs B, D and C, Table1).

Table 2: Each run represents 1,000 simulations of the same conditions: (1981-1990)

J	N	1.7	0.9	0	0	35	2.5±1.9	43±16	41
K	N	1.7	0.9	10	5	35	4.1±2.6	47±21	35
L	N	1.7	0.9	10	10	35	1.6±1.8	51±14	41
M	N	1.7	0.9	20	5	35	3.2±1.9	48±10	38
N	N	1.7	0.9	20	10	35	4.7±2.2	32±12	51
O	N	1.7	0.9	30	5	35	3.1±0.8	31±12	45
P	N	1.7	0.9	30	10	35	2.1±2.1	44±31	32
Q	N	1.7	0.9	50	5	35	3.4±1.3	45±17	32
R	N	1.7	0.9	50	10	35	2.6±1.1	51±23	41

SOURCE: Computer Output Results 2008.

Table 3: Each run represents 1,000 simulations of the same conditions: (1991-2000)

Run	Net p/n	ΔN	ΔG	Prob. of event	Mag. of change	Initial stock (000 tonnes)	No. of deficit per simulation mean ± s.d	No. of deaths per simulation (000 tonnes) Mean ± s.d. MAX	
S	N	1.7	1.3	10	5	35	2.1±1.1	33±11	41
T	N	1.7	1.3	10	5	35	3.1±2.5	42±10	33
U	N	1.7	1.3	20	10	35	1.6±1.2	32±14	37
V	N	1.7	1.3	20	5	35	1.2±1.0	46±15	30

| W | N | 1.7 | 1.3 | 30 | 5 | 35 | 1.2±1.1 | 41±18 | 43 |
| X | N | 1.7 | 1.3 | 30 | 10 | 35 | 2.3±0.7 | 20±12 | 46 |

SOURCE: Computer Output Results 2008

- Climate Change measurement (average rainfall) population growth and grain production

Tables 4 & 5 present the results of climate change (captured by average rainfall), population growth, and food production (grain production). The climate change scenarios (1971-2000) analysis revealed that population growth during the 1st -2nd scenarios (1971-1980 & 1981-1990) increased by 58.04%, while food production during the same period increased by 68.69% (Table 4). However, in the 3rd scenario, analysis revealed a decline in food production by 76.92% as population continues to grow. This portrays an alarming situation that food production does not keep pace with population growth. Average rainfall according to the study reflects a fairly steady growth during these periods. This finding corroborated with other past studies that at this period, 1981-1990; poverty levels in the country recorded the highest (CBN 2006).

Table 5 presented the disaggregation analysis results. Results show that all the zones in Nigeria experienced about 23.04% population growth across the 3 scenarios. However, grains production and rainfall have been declining. For instance, in the Northern regions there is a decline in food production to about 178.37% with high deficit recorded in the North West zone of the country (339%). The Southern part shows a decline of about 20%, while the South-south recorded a high decline (281%). The impact of climate change or global warming (as captured by average rainfall) revealed that all the Northern regions experienced decline (11.03%) during period under review (1971-2000), with North West region most affected (13.32%). The Southern region however, climate change (as captured by average rainfall) show a beneficial response with the exception of South east that recorded a decline (9.09%), while the South west show a high figure of 20.58% and South-south of 2.45%. Findings indicate that the agricultural impacts of climate change in Nigeria need a holistic and quickly interventions. The total average impact may be positive or negative depending on the climate scenarios and zones. They are positive in the South particularly in the Southwest in most scenarios, but negative in the North in some scenarios

Table 4: Frequency Distribution of Average Total Rainfall, Population, and Food Production for all the Scenarios considered

Scenarios	Average Total Rainfall(mm)	Population	Food Production (Grains) ('000 Tonnes)
1971-1980	1257.02	45576200	147.30
1981-1990	1415.88	78524000	214.60
1991-2000	1436.64	102081200	58.20

SOURCE: Central Bank of Nigeria Statistical Bulletin and National Bureau of Statistics, 2008

3.1 Farmer's Actual Adaptation Measures and Practices

Table 6 presents farmers' actual adaptation measures and practices actually followed, thus, grouped into ten categories. These strategies, however, are mostly followed in combination with other strategies. These are grouped into the following adaptation options: diversifying into multiple and mixed crop-livestock systems, and switching from crops to livestock and from dry land to irrigation, practicing zero tillage, making ridges across farms and cereal/legume intercropping. Table 6 reveals that making ridges across farms is the dominant system (18.75%). Multiple crops under dry land is the second most common strategy (18.46%), and Multiple cropping mixed with livestock rearing under dry land conditions (15.41%) comes third. Change use of chemicals, fertilizers, and pesticides is the most common adaptation practise (14.56%). The implication is that when necessary inputs are available at the right time and are utilized, it tends to improve productivity. The main adaptation strategic measures followed Food and Agriculture Organization (FAO) classification (Dixon et al., 2001) and were used to classify the strategic measures into thirteen.

Table 5: Frequency Distribution of Average Total Rainfall, Population, and Food Production (Grains) 1971-2000

Zone	North Central (7) NC	North West (7) NW	North East (5) NE	South West (6) SW	South East (5) SE	South South (6) SS
1971-1980						
Average Total Rainfall (mm)	1074.85	952.03	783.68	1696.41	-	3034.15
Population	7346380	11649891	5427094	8978946	-	12175889
Food Production (Grain) ('000 Tonnes)	23.74	37.65	17.54	29.02	-	37.34
1981-1990						
Average Total Rainfall (mm)	1173.43	762.50	762.52	1226.20	2194.50	2376.10
Population	12657202	20071793	9350432	15469976	9188059	11786539
Food Production (Grain) ('000 Tonnes)	34.59	54.85	25.55	42.28	25.11	32.21
1991-2000						
Average Total Rainfall (mm)	1087.43	840.15	701.06	1543.90	2011.70	2435.59
Population	16454363	26093331	12155561	20110969	11944476	15322500
Food Production (Grain) ('000 Tonnes)	11.56	12.48	11.16	11.91	11.13	11.46

SOURCE: Central Bank of Nigeria Statistical Bulletin, 2008 and National Bureau of Statistics, 2008

Table 7 presents the estimated marginal effects and t-levels from the MNL model. The results show that most of the explanatory variables considered are statistically significant at 10%. This study uses specialized (mono) cropping as the base category for no adaptation and evaluates the other choices as alternatives to this option. The results show that altered climate change, frequency of droughts, age and sex all had no significance effect on adaptation. While the increased temperature, intercropping of cereal/legume, mulching, zero tillage making ridges, farm size, farming experience, educational status access to extension and credit facilities are factors influencing adaptation positively (Table 9). However, fall in temperature, change timing of rains, own heavy machines and household size are also significant factors that influence adaptation negatively. This result suggests that the larger the occurrence of these variables, the poorer the adaptation.

Summary of the results revealed that fall in temperature influences the probability of switching away from mono-cropping more than changes in increased temperature. Similarly, the magnitudes of the marginal coefficients suggest that low outputs warming is a strong factor influencing the probability

of switching to other systems that are better adapted to changes in temperature. Better access to extension and credit services seems to have a strong positive influence on adaptation. In addition, access to other farm assets such as heavy machinery is found to promote the use of large –scale farming. These results suggest that capital, land and labour serve as important factors for coping. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources). The more experienced farmers are, the more likely to adapt. Sex of the farmer did not seem to be of significance in influencing adaptation, as the marginal effect coefficient was statistically insignificant and signs do not suggest any particular pattern. These results suggest that it is the experience rather than sex that matters for adaptation.

Table 6: Actual Adaptation Measures used by Farmers (N=850)

Adaptation measure	Respondents (%)
Specialized crop under dry land	121 (8.97)
Specialized crop under irrigation	15 (1.11)

Specialized livestock under dry land	13	(0.96)
Specialized livestock under irrigation	5	(0.37)
Multiple crops under dry land	249	(18.46)
Multiple crops under irrigation	14	(1.04)
Mixed mono-crop/livestock under dry land	144	(10.67)
Mixed mono-crop/livestock under irrigation	25	(1.35)
Mixed multiple crops/livestock under dry land	208	(15.41)
Mixed multiple crops/livestock under irrigation	31	(2.30)
Practiced zero Tillage	47	(3.48)
Making ridges across farms	253	(18.75)
Cereal/legume intercropping	182	(13.49)
Number of observations		1349*

Multiple Responses indicated

Table 7: Marginal Effects of Explanatory Variables from Multinomial Logit Adaptation

Variable	Estimate	t-value
Increased	0.090E-02	5.107***
Temperature (X_1)	-0.0308E-01	-2.917**
Fall in Temperature	0.4211	0.128
(X_2)	-0.161E-01	-3.427***
Altered Climate	-0.8851	-0.315
Range (X_3)	0.6272	1.7061
Changed timing of	0.5783	2.408**
rains (X_4)	0.22E-05	2.1371*
Frequency of	933E-06	3.412***
Droughts (X_5)	0.717	2.762**
Noticed Climate	0.827E-07	2.1262*
Change (X_6)	-0.923E-01	2.1262*
Cereal/legume	-0.135E+11	-4.4262***
Intercropping (X_7)	0.5196E-04	2.5931*
Mulching (X_8)	0.1162	5.011***
Zero Tillage (X_9)	0.2364	0.3472
Making Ridges	0.3681	2.5272**
across Farms (X_{10})	0.2606	1.9621*
Farm size (X_{11})	-0.5190	-0.9428
Owned heavy machines (X_{12})		
Household size (X_{13})		
Farming experience (X_{14})		
Educational status (X_{15})		
Age (X_{16})		
Access to extension facilities (X_{17})		
Access to credit facilities (ACCRE) (X_{18})		
Sex (X_{19})		

Source: Computer Printout of Logit Regression Analysis

*** = Significant at p<0.01, ** = Significant at p<0.005, *Significant at p<0.001

Log-likelihood function: -201.44, Significant level: (P<00001) Constant = 0.71

CONCLUSION

Findings from this study indicated that agricultural impacts of climate change in Nigeria are uncertain. The total average impact may be positive or negative

depending on the climate scenario. But in most scenarios it was shown that climate change will have an overall positive impact on Nigeria's agriculture. Impacts also vary both quantitatively and qualitatively by zone and season. They are positive in the Southern region of Nigeria in most scenarios, but negative in some Northern part of the country in some scenario. Farmers appear to be abandoning monocropping for mixed and mixed crop-livestock systems, considering risky, mono-cropping practicing under dry land. Farming experience and access to education were found to promote adaptation. This implies that education to improve awareness of potential benefits of adaptation is an important policy measure for future adaptation and mitigation strategies.

Moreover, the study found out that lack of effective access to information on climate change. Thus, there is need for effective and reliable access to information on changing climate. In addition, empowerment (credit or grant facilities) is crucial in enhancing farmers' awareness. This is vital for adaptation decision making and planning. Combining access to extension and credit ensures that farmers have the information for decision making and the means to take up relevant adaptation measures.

RECOMMENDATIONS

It is evidenced from this study that grain crop farmers are experiencing change in climate and they have already devised a means to survive. It is from this point that policy of reliable and effective measures of adaptation need to be implemented and must be accessible to the end users. People responses to the issue of climate change are at low pace. Thus, there is a need to design strategies that could help the farmers/rural communities' responses effectively to global warming through early warming alerts and interpretations in the language useful to farmers/rural communities.

REFERENCES

[1] Abou-Hadid, A. F., Mougou, R., Mokssit, A. and Iglesias, (2003). Assessment of impacts, adaptation and vulnerability to climate change in North Africa: food production and water resources. AIACC AF90 Semi-Annual ProgressReport.

[2] Adams, R., Brian, H. Stephanie, L. and Leary, N. (2010). Effects of global climate change on agriculture: an interpretative review CLIMATE RESEARCH Vol. 11: 19–30, 19 98

[3] Akinyosoye, V. O. (2006). Government and Agriculture in Nigeria: Analysis of Policies, Programme, and Administration. *Macmillan Nigeria Publishers Limited, Ibadan, Nigeria.*

[4] Apata T. G., Samuel, K. D., and Adeola, A. O. (2009). Analysis of Climate Change Perception and Adaptation among Arable Food Crop Farmers in South Western Nigeria. Contributed Paper prepared for presentation at the International Association of Agricultural Economists' 2009 Conference, Beijing, China, August 16-22,209

[5] Assessment of Nigeria Agricultural Policy (2006). Agriculture in Nigeria: Identifying Opportunities for increased commercialization and investment. *IITA press, IITA Ibadan.*

[6] Ayinde, O. E., Ajewole, O. O., Ogunlade, I. and Adewumi, M. O. (2010). Empirical Analysis of Agricultural Production and Climate Change: A Case Study of Nigeria .Journal of Sustainable Development in Africa (Volume 12, No.6)

[7] Building Nigeria's Response to Climate Change (2008). Annual Workshop of Nigerian Environmental Study Team (NEST): The Recent Global and Local Action on Climate Change, held at Hotel Millennium, Abuja, Nigeria; 8-9th October, 2008.

[8] Central Bank of Nigeria (2006). Statistical Bulletin, Publication of Central Bank of Nigeria

[9] De Wit, M. and Stankiewicz, J, (2006). Changes in surface water supply across Africa with predicted climate change. Science 311, 19 17–21.

[10] Deressa, T. T. and Hassan, T. (2010). Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from Cross-section Measures. Journal of African Economies, Volume 18, number 4, pp. 529–554

[11] Deressa, T., Hassen, R., and Ringler, C. (2008). Analyzing the determinants of farmers' choice of

adaptation measures and perceptions of climate change in the Nile Basin of Ethiopia. International Food Policy Research Institute (IFPRI) Discussion Paper No. 00798. Washington, DC: IFPRI.

[12] Dinar, A. Hassan, R. Kurukulasuriya, P. Benhin, J. and Mendelsohn, R. (2006). The policy nexus between agriculture and climate change in Africa. A synthesis of the investigation under the GEF/WB Project: Regional climate, Water, and agriculture: Impacts on and adaptation of agro-ecological systems in Africa. CEEPA Discussion Paper No. 39. Centre for CBN Journal ofApplied Statistics Vol. 2 No.147

[13] Dixon, J, Gulliver, A., and Gibbon, D. (2001). Farming systems and poverty: Improving farmers' livelihoods in a changing world. FAO (Food and Agriculture Organization), Rome, and World Bank, Washington, DC.

[14] Ehrlich, P. R. and Ehrlich, A. H. (1990). How the rich can save the poor and themselves: lessons from the global warming In Global warming and climate change: perspectives from developing countries. New Delhi: Tata Energy Research Institute.

[15] Fischer, G., Shah, M. and van Velthuizen, H. (2002). "Climate Change and Agricultural Vulnerability". International Institute for Applied Systems Analysis. Report prepared under UN Institutional Contract Agreement 1113 for World Summit on Sustainable Development. Laxenburg, Austria.

[16] Greene, W. H, (2003). Econometric analysis. Fifth edition. Prentice Hall, New Jersey.

[17] Hassan, R (2010). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. African Journal of Resource Economics; Vol 2 No1 March 2008, Pp 83-104

[18] Intergovernmental Panel on Climate Change (2007). Climate Change Impacts, adaptation, and vulnerability. Contribution of Working Group II to the third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, pp. 1000

[19] International Institute for Sustainable Development (2007). Community based adaptation to climate change Bulletin. A Summary of the Second International Workshop on Community-Based Adaptation to Climate Change. IISD Reporting Services.

[20] Lobell, D. B., Burke, M. B., Tebaldi, C,(2008)."Prioritizing climate change adaptation needs for food security in 2030". Science 319(5863):607–10

[21] Mano, R. (2006). Assessment of the economic impacts of climate change on agriculture in Zimbabwe: A Ricardian approach. A Discussion Paper No. 11. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

[22] Nigerian Environmental Study Team (2004). Regional Climate Modelling and Climate Scenarios Development in Support of Vulnerability and Adaptation Studies: Outcome of Regional Climate Modeling Efforts over Nigeria, NEST, Ibadan, Nigeria

[23] Overseas Development Institute (2007) Climate change, agricultural policy and poverty reduction how much do we know? Overseas Development Institute (2007).

[24] Tebaldi, C. and Knutti, R. (2007). The use of the multi-model ensemble in probabilistic climate projections Phil. Trans. R. Soc. A 365 2053–75

[25] Tse, Y.K, (1987). A diagnostic test for the multinomial logit model. Journal of Business and Economic Statistics 5 (2), 283–86.

[26] Yesuf, M., DiFalco, S., Deressa, T., Ringer, C.and Kohlin, G (2008). The Impact of Climate Change and Adaptation on Food Production in Low-Income Countries: Evidence from Nile Basin, Ethiopia. International Food Policy Research Institute (IFPRI) Discussion Paper, 00828.