VULNERABILITY OF THE NIGERIAN PEASANT HOUSEHOLD TO PROJECTED CLIMATE CHANGE DURING THE 21ST CENTURY

AUTHOR  James O Adejuwon

ADDRESS  Department of Geography
          Obafemi Awolowo University
          Ile-Ife NIGERIA
          E-mail – jadejuwon@yahoo.com

ABSTRACT

The objective in this paper is to analyse the vulnerability of the Nigerian peasant household to the changes in climate projected for the 21st Century. Vulnerability is conceived simply as a function of exposure, sensitivity and adaptive capacity. \( V = f(\text{exposure}, \text{sensitivity}, \text{adaptive capacity}) \). A household could be defined as a group of related persons, living in a dwelling unit or its equivalent, eating from the same pot and sharing a common house keeping arrangement. The word peasant may sound pejorative, but there is no alternative terminology to capture not only the small scale of farming operations, but also the diseconomy which it connotes. The significant changes in climate expected during the current century in Nigeria are with respect to temperature which is projected to increase. Marginal to significant increases in precipitation and atmospheric humidity are also projected for all parts of the country. The projected climate represents both opportunities and risks for the peasant householder in the country. Because of his dependence on agriculture, a sector that is by itself exposed and sensitive to climate, the peasant householder’s livelihood, including his food and nutrition, is indirectly exposed to the projected climate change. Droughts with decadal frequencies and temperatures that are supra optimum for most of the major crops are the drivers of the potential risks to crop producing households. Vulnerability of the Nigerian peasant household to changes in climate will also be determined by a number of existent characteristics which imposes limits on its adaptive capacity. Among these, the most significant is existent poverty which signifies lack of resources necessary for adapting to climate change. In addition, relatively low levels of educational attainment could also constrain the ability to acquire the technological capacity for combating the negative consequences of climate change. The rates of population increase which at present stand at 28 per thousand could increase the rates of child dependency burden, increase pressure on social infrastructure, and also constrain the capacity to adapt to possible negative impacts of climate change. Based on the analysis, it could be observed that considerable contrasts in vulnerability to climate change exist between the various regions of the country. It appears that the northern parts where the risks posed by projected changes in climate are the highest are the same areas where peasant households’ adaptive capacity is least and consequently the most vulnerable.

1 INTRODUCTION

The paper is designed to assess the vulnerability of the Nigerian peasant household to potential changes in the climate during the 21st century. The IPCC Working Group II in the glossary to its Contributions to the Third Assessment Report defines
vulnerability as “the extent to which climate change may damage or harm a system; it depends not only on a system’s sensitivity, but also on its ability to adapt to new climatic conditions” (IPCC, 2001a). The United Nations Department of Humanitarian Affairs (UNDHA, 1993) seems to agree with the IPCC by defining vulnerability as the “degree of loss resulting from a potentially damaging phenomenon”. However, the organization does not add the requirement of dependence on the system’s sensitivity and its ability to adapt to new climate. According to the UNEP, “Vulnerability is susceptibility to harm or damage potential. It considers such factors as the ability of a system to cope or absorb stress or impacts and to “bounce back” or recover”. (Burton, et al., 1998). This is essentially a recast of the IPCC definition. Downing et al (2001), defines vulnerability as the probability of an adverse perturbation or hazard. In this definition, the focus has shifted from the damage or harm in the system to the driver or the cause of the harm or disaster in climate. However, some definitions insist on distinguishing between hazard, which is the driver and vulnerability which is the consequence. Thus, as noted by Burton et al. (1993), “hazard is the potential threat to humans and their welfare”; while vulnerability is simply “exposure and susceptibility to losses”. Bohle, et al. (1994, 37-39) defines vulnerability as “an aggregate measure of human welfare that integrates environmental, social, economic and political exposure to harmful perturbations”. In this definition, there is another shift in the focus from both the harm done to the system and the driver causing the harm, to the innate nature of the system. Another concept of vulnerability which appears to have been derived from the linguistic roots of the word agrees with Bohle. According to Kelly and Adger (2000) the expression originated from a Latin word, *vulnerabilis*, which was the term used by the Romans to describe the state of a soldier lying wounded on the battlefield. In this classic sense, vulnerability is defined by previous damage (the existing wound) that predisposes the soldier to disaster by any further attack. In this context, vulnerability is determined basically by the existent state of the system in question, that is by its inherent capacity or lack of capacity to respond to an imminent hazard, in the sense of cope with, recover from, or adapt to, any external stress placed on its livelihood and well-being, rather than by what may or may not happen in future. It is this concept of vulnerability that informed IPCC (2001a) observation to the effect that, “the ability of human systems to adapt and to cope with climate change depends on such factors as wealth, technology, education, information, skills, infrastructure, access to resources, and management capabilities”. In summarising the literature on vulnerability, Downing et al (2001) contends that “vulnerability is a relative measure”; that “each person is vulnerable and his vulnerability differs in its causal structure, its evolution and the severity of its likely consequences”; that “the locus of vulnerability is the individual human being related to social structures of household, community, and society and world system”; and that “vulnerability relates to the consequences of a perturbation, rather than its agent”.

In the present paper, vulnerability is conceived simply as a function of exposure, sensitivity and adaptive capacity. $V = f(\text{exposure, sensitivity, adaptive capacity})$. In the glossary of IPCC (2001a), exposure is defined as the nature and degree to which a system is exposed to significant climatic changes. Sensitivity, on the other hand, is the degree to which a system is affected, either adversely, or beneficially, directly or indirectly by climate related stimuli. Adaptive capacity is defined as the ability of a system to adjust to climate change (including variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the
consequences. Neither exposure, nor sensitivity, nor adaptive capacity by itself can be used to determine vulnerability. The logical structure of this paper is based mainly on the concept of vulnerability just outlined.

The paper is organized into twelve sections including this introduction. In Section 2, the main sources of data are described while in section 3 the details of the analytical techniques are provided. Section 4 summarizes contemporary pattern of climate as well as its variability. It also provides an outline of the climate change scenario against which the vulnerability of the Nigerian peasant household is to be assessed. Section 5 is a characterization of the profile of the Nigerian peasant household with a summary of the available statistics on households. In section 6, the indirect exposure and sensitivity of the peasant household to climate change, through its dependence on agriculture, a sector that is itself sensitive to climate, is described. Sections 7 and 8 analyse the sensitivity of crop yield respectively to climate variability and climate change. Risks and beneficial effects of climate variability and climate change are outlined in section 9. Adaptive capacity is the subject matter of section 10. By limiting adaptive capacity, poverty is considered a major cause of vulnerability to climate change. Other existent characteristics of the peasant household do limit its adaptive capacity. For example, current demographic trends, including the explosive growth of the population, are set to constrain the capacity to adapt to climate change by their contributions to pressure on socio-economic infrastructure and increases in child dependency burden. The extent to which inadequate education statuses impose limitations on adaptive capacity is also considered. Attributes indicating: sensitivity to climate variability, sensitivity to climate change, and inherent capacity or lack of capacity to respond to, in the sense of cope with, recover from, or adapt to climate change are adopted and used to derive a summary index of vulnerability in section 11. The summary and conclusions are presented in section 12.

2 SOURCES OF DATA

Sourcing the Climate Data

Data collected from the Meteorological Agency of Nigeria were used to characterize climate variability. For the description of climate change scenarios, we used observed and model simulated data available at the IPCC’s Data Distribution Centre in 2002. Observed data were available for the entire grid of 0.5° x 0.5° latitude and longitude cells. After acquisition from the IPCC DDC the simulated data on a grid of 2.5° x 3.75° latitude and longitude were downscaled by simple empirical methods to the higher resolution grid. Extraction was manually conducted and the data for each grid cell were assigned to the meteorological station lying within it. We adopted Hadley M2, Members 1, 2, 3, 4 and the average, and scenarios assuming 1 % and 0.5 % annual increases in CO₂ equivalents. These were used to construct climate scenarios with four time slices: 1961 – 1990; 2010 – 2039; 2040 – 2069; and 2069 – 2099.

National Integrated Survey of Households

The social and economic data came from the National Integrated Survey of Households (NISH). This is probably the main preoccupation of the Federal Office of Statistics, which is the central data generating organization in the country. It is designed to provide data on areas not covered by the various ministerial and non-
ministerial departments. NISH is an on-going programme of household surveys probing various aspects of households including: housing, health, education, employment, etc. The core module of the programme is the General Household Survey (GHS). GHS, which is designed to collect basic data on households, runs from year to year. There are supplemental modules each of which concentrates on a specific aspect, elaborating on it beyond what is covered in the GHS. Two of the supplemental modules are the National Agricultural Sample Survey (NASS) and the National Consumer Survey (NCS).

In view of the importance of agriculture to the economy, the module on agriculture is also designed to run on an annual basis; but the scope is restricted to traditional agriculture. The other important module of NISH is the National Consumer Survey, which has now gone through four rounds: 1980/81, 1985/86, 1992/93, and 1996/97. Basically, the surveys were designed to generate data for assessing income and expenditure pattern of Nigerian Households, computing weights for consumer price indices (CPI) and for preparing aspects of the national accounts. However the most important use for which we have found this survey is in the assessment of the poverty situation in the country. Data were collected on household income from various sources and their expenditure on various goods and services. The household income covered cash income, income-in-kind, consumption from own production and imputed rent. Their expenditure covered food and non-food items which were grouped into twelve commodities: food, accommodation, fuel and light, drinks and tobacco, household goods, transport, other purchases, clothing, other services, monetary transactions, as well as income-in-kind, imputed rent and consumption of own production. The data on observed crop yield used in this study came from the agricultural sample survey while the data on poverty came from the NCS. The data on the other attributes of the household came from the GHS.

3 ANALYTICAL TECHNIQUES

Analysis of climate variability and climate change

In our analysis of climate variability, we attempted to capture the totality of interannual variability of climate with respect to monthly maximum temperature, monthly minimum temperature and monthly rainfall for locations representative of the main climate zones from the coast to the Sahel. The spatial disposition of these zones is depicted in Fig 1. Variability indices were computed as the coefficients of variability. The latter is the standard deviation divided by the mean. The data used in the analysis are for the period, 1961 to 1990. The resulting fractions have been converted to percentages.

The potential climate of Nigeria during the 21st Century was extracted from the data available on the website of IPCC Data Distribution Centre in February 2002 (IPCC-DDC, 1999). It is an output of Hadley M2 General Circulation Model based, respectively, on a 0.5% and 1% per annum compound increase in CO2 concentrations. The data represent a choice of GCM experiment and a choice of emission scenario. Each choice was made from dozens that are equally plausible. However, the data based on 1.0% increase was selected as a “worst case.” The strategy of the selection is to hope for the best while preparing for the worst. It is a “worst case” because it falls into a group including: IS92e, IS92f, SRES A1F1 and SRES A2, each of which is
projected to result in the highest concentrations of greenhouse gases and highest radiative forcing of climate change by the end of the 21st century (IPCC, 1995, 2000). The overall IPCC assignment is based on the agreement among scientists that it is a bad thing for the climate to change. Otherwise there would have been no mitigation agenda, no Kyoto Protocol. Theoretically, the “best case” is one in which there is no change in climate as a result of human induced increases in the concentration of greenhouse gases in the atmosphere. Our practical “best case” scenario is one based on an annual increase of 0.5% per annum, which falls into the group of low emission scenarios including: IS92d, SRES B1 and SRES A1T. In the main AF23 project report, we use both cases for our crop yield simulation exercises. However, it is the “worst case” that is first presented while the “best case” is used to highlight the uncertainties.

Assessing sensitivity to inter-annual climate variability

The study area for the analysis of sensitivity to climate variability is coterminous with the present Bornu and Yobe states in Nigeria Fig 2. It covers an area of about 70,000 square km lying between latitudes 10° N and 13° N and between longitudes 12° E and 15° E in the north eastern corner of the country. It is part of the Arid Zone of Nigeria, which consists of the Sudan Savannah and the Sahel Savannah ecological zones. The Sahelian area lies to the north, with an east-west alignment. It occupies about 40 percent of the study area. The Sudanic area occupies the southern 60 percent. The climatic data used for the analyses were from the records of the two meteorological stations within the area of study, namely: Maiduguri and Potiskum. The crop yield and climate data covered the 17-year period from 1983 to 1999. The major food crops included in the analyses were maize, sorghum, rice, millet, cowpeas and groundnut.

Bivariate correlation analysis was used to derive the coefficients of correlation and determination respectively (r and r²) where climate was considered as a single variable. The output of the bivariate correlation indicated the level of significance. Multiple correlation analysis was used to derive the coefficients of correlation and determination respectively (R and R²) where the climate factor was presented as a multiplicity of variables. R (r) was interpreted as measures of the sensitivity of crop yield to climate variation. On the other hand, R² (r²) was interpreted as estimates of the proportion of the variability in the dependent variable that was explained by the independent climate variable or variables.

The climate variables used in the various linear model analyses include not only the annual and seasonal totals, but also the rainfall of each month during the growing season. Thus while the dependent variables consisted of the yields of the various crops, the independent variables were disaggregates of seasonal rainfall at the two meteorological stations, (Maiduguri and Potiskum Fig 1). JUNM (June Maiduguri) is June rainfall for Maiduguri while SEPTP is September rainfall for Potiskum.

Assessing the varying significance of annual impacts of climate

Inter-annual changes in crop yield are usually interpreted as consequences of the corresponding inter-annual changes in climate. There is a basic assumption of a state of normality in the system of concern from which there is a departure that is
interpreted as the consequence of the changes in the environment factor. It is not every change in yield that could be interpreted as a significant departure from normality. One could index the varying significance of annual effects of climate on crop yield with a parameter computed as annual yield minus mean annual yield divided by the standard deviation. The produced a Z- distribution array with values varying from approximately –3 to approximately + 3. Values < –1.6 or > + 1.6 indicate anomalies that are significant at 95 percent confidence levels. Higher confidence limits could be set. For example values < –2.3 and > 2.3 define anomalies that are significant at 99 percent. The interpretation is that the yields observed during the years with significant V.I.s lie outside the normal range.

Assessing sensitivity to Climate Change

The main tool used in the analysis of sensitivity to climate change is the EPIC Crop Model. Data based on the adopted climate change scenario were used in creating EPIC data files for twenty-eight sites and four time slices. The time slices were, respectively: 1961-90, 2010-39, 2040-69, and 2070-2099. The sites represent eight ecological zones which, respectively were: the Niger Delta, Rain Forest, Derived Savannah, Southern Guinea Savannah, Northern Guinea Savannah, Jos Plateau, Sudan Savannah and Sahel Savannah. The five crops involved in the assessment included: maize, rice, sorghum, millet and cassava. The other major staple food crops were not in the EPIC list of modelled crops. The files were used to simulate crop yield to demonstrate changes corresponding to the potential changes in climate during the 21st century. The data were analysed, using bar graphs for each crop and each zone. We have assessed the suitability of EPIC Crop model for the assessment of the impacts of climate change on crop yield in Adejuwon (2005)

Assessing household adaptive capacity

The extent to which adaptive capacity is constrained by existent household characteristics was derived as the proportion of the households affected. Thus in the case of poverty, the first question addressed was: “how poor is the poor household”. The second question pertains to what proportion of the households was poor. This proportion was adopted as a measure of the adaptive capacity of householders within each social structure, including: household, community, society, nation and world system. The data available allows us to compare householders at state level and at regional levels, for example, the six geopolitical zones of North West, North East, North Central, South West, South East and South-South.

Index of vulnerability

As intimated earlier, everyone is vulnerable, what varies from person to person is the degree of vulnerability. Vulnerability of the peasant households is assessed at the level of the component states of the Nigerian Federation. Index of vulnerability was derived from measures of the drivers of sensitivity of crop yield to climate, and measures of adaptive capacity. For example, it will be established later in the paper that the severe drought of 1990 resulted in the lowest yields of crops between 1983 and 1999. The probability of drought occurrence is related to the variability of the climate. Highly variable climate is more likely to produce severe droughts than less variable climates. The rainfall variability indices for the mean annual total, computed
for the climatic stations were adopted as indicators of drought occurrence and therefore of the driver of risks related to climate variability. Each of the 30 states was assigned the value for the meteorological station either located within it or closest to it. With respect to sensitivity to climate change, high temperatures projected for the later parts of the century will be demonstrated to cause reductions in yield. The temperatures projected for the 2070 to 2099 period were for this reason adopted as one measure of the drivers of the risks of climate change. It was demonstrated that poverty limits adaptive capacity. The proportion of the population in each state of the country falling into the extremely poor category was used as indicating adaptive capacity in each state. The various values attached to each of the 30 states with respect to the drivers and the factors constraining adaptive capacity, or their surrogates, were used to rank them. The ranks were subsequently added across the indicators and used to derive a single vulnerability index for each state. It must be admitted that data availability rather than any objective criteria determined which indicators were included and which were left out. However all those included are judged to be relevant to either exposure, sensitivity or adaptive capacity.

4 CLIMATE VARIABILITY AND CLIMATE CHANGE

Contemporary regional climate

For the characterisation of the climate of the country, the template of the ecological zones as depicted in Fig 1 was adopted. Mean monthly maximum temperature varied between 28 °C and 40 °C. In coastal locations monthly maximum temperatures were lowest in August at about 28 °C and highest in March at around 34 °C. In the Middle Belt, mean monthly maximum temperature was also lowest in August and highest in March or April. However, the mean maximum temperatures were higher than what they were along the coast, varying between 30 °C in August and 38 °C in March or April. In the far North, that is, in the Sudan and Sahel zones, maximum temperatures were still much higher than in the Middle Belt. The highest maximum temperatures were recorded in May and could be as high as 40 °C. On the other hand the lowest maximum temperatures of around 28 °C were experienced in December or January.

Minimum temperatures were on the average about 8 °C lower than the maximum temperatures in coastal locations varying between 21 °C in January and 24 °C in April. While the highest minimum temperatures were observed in May, that is the same month in which the highest maximum temperatures were observed, the month with the lowest minimum temperatures had shifted from August to January. Differences between minimum and maximum temperatures being of the order of 10 °C higher in the Middle Belt than in the coastal and forest based locations. For Lokoja at the confluence of Rivers Niger and Benue, the lowest monthly minimum temperatures were recorded in January, while the highest were observed in April. The mean monthly minimum temperature for January was 17 °C while the mean minimum for April was 24 °C. In the Sudan and Sahel zones, the differences between minimum and maximum temperatures averaged about 15 °C. For Kano in the Sudan zone, the lowest minimum mean monthly temperature, which is for January, was 12 °C compared to the lowest mean maximum temperature of 28 °C, which was also for January. For the same location, the highest mean minimum and the highest mean maximum both of which were for May, were respectively, 26 °C and 40 °C. All these go to confirm the well known fact that diurnal variations in temperature are more
pronounced than intra-annual variations and the usual conceptualization of the night as the winter of the Tropics.

In locations along the coast and within the forest zone, mean annual rainfall could be as high as 3000 mm, but usually not less than 1250 mm. Although rain could be expected during each month, there is usually a dry period of two to four months with significantly low rainfall. During this period, the air, which comes in from the Atlantic Ocean, remains very humid. The dry conditions of this period could give stress to plants and crops, but such stress was not serious enough to discourage the growth and cultivation of trees and tree crops. Garnier (1961) submits that a rainfall of 75 mm per month is needed to balance potential evapo-transpiration and therefore supply the water needed by plants. According to Garnier in his prescriptions for delimiting the Humid Tropics, any month with rainfall lower than 75 mm could be regarded as dry while months with rainfall more than 75 mm were regarded as humid. Using this rule, the dry season is about three months long in the southeast and four months in the southwest. In the Guinea Savanna zones constituting the Middle Belt, the year is sharply divided into rainy season and dry season. During the dry season the area is overlaid by a dry air mass, which comes in from the Sahara Desert. Drought is expressed in terms of both low rainfall and low humidity of the air. There is little difference between the northern, drier boundary and the southern wet boundary in terms of total annual rainfall. However, the dry season is about seven months long in the northernmost areas while it is only five months long in the south. The boundaries between Northern Guinea Zone and the Sudan, corresponds to a sharp drop in mean annual rainfall from 1200 mm to about 900 mm. In the Sahel, the rainy season is barely three months long, while in the Sudan, the rainy season extends over a period of four months.

Climate variability

In this analysis of climate variability, we shall first attempt to capture the totality of inter annual variability of climate with respect to monthly maximum temperature, monthly minimum temperature and monthly rainfall for locations representative of the main ecological zones from the coast to the Sahel. Variability indices were computed as the coefficient of variability. The latter is the standard deviation divided by the mean. The data used in the analysis were for the period, 1961 to 1990. The resulting fractions were converted to percentages.

Inter annual variability of maximum temperature as depicted in Table 1 is spectacularly low, averaging less than 5 percent across climate zones and from January to December. The implication of this is that each year is very much like the other with respect to daytime temperatures. The monotony of high daytime temperatures from month to month and from year to year is a well-known trademark of typical tropical climates. This notwithstanding, one could discern temporal and spatial patterns in the variability of mean monthly maximum temperatures. In coastal locations, variability is uniformly low compared with the Middle Belt and the Sudan and Sahel climate zones. In the latter zones, coefficients of variability appear to be relatively higher in the months of December, January and February compared with the other months of the year.
The coefficients of variability of minimum temperature, depicted in Table 2, demonstrate an unmistakable contrast between December-January-February on the one hand and the rest of the year on the other. In almost all the stations, the highest coefficients were for January followed by December. This pattern is much more pronounced in the drier northern areas than in the south. While the average for December is more than 10 percent, the averages for April, May, June, July, August, September and October were respectively less than 5 percent.

The generally low variability of temperature depicted in Tables 1 and 2 provides the explanation for the usual relegation of these parameters in the literature on climate variability in tropical areas and the emphasis placed on rainfall. The need for extended weather forecasts is therefore not for anticipating unusually low or high temperature, but to enable farmers to prepare for a highly unreliable growing season rainfall. Mean rainfall usually covers periods with heavy to excessive rainfall alternating with periods of sub-average rainfall. This is true irrespective of the time interval over which the mean is computed. While the coefficient of variation of monthly temperature normally falls between 1 and 5 percent that of rainfall could be as high as 600 percent and hardly ever falls below 20 percent.

Table 3 depicts the monthly and total annual coefficient of variation of rainfall. The very low coefficients of variability of the annual totals compared with the variability of monthly totals are noteworthy. While the coefficients for annual totals vary from 9 percent to 26 percent, those of monthly totals vary from zero to 600 percent. There is no significant spatial pattern in the variability of annual total rainfall. Among the seven weather stations with the most variable annual totals, two are located in the forest zone, two in the Guinean zones in the Middle Belt and three in the Sudano- Sahelian zones. However, one can still discern a tendency for variability of annual totals to increase as the totals decrease. The station with the least variable annual total, Jos, has the distinction of being the only high altitude location among the list selected for this analysis.

December and January are perennially dry in Northern Guinea, Sudan and Sahel zones. Therefore the coefficients of variability for these months and for these stations are zero. Apart from these, dry season months, throughout the country are characterized by very high coefficients of variability. The dry season months with coefficients greater than 100 percent in Sudan and Sahel zones are February, March, April, October and November. In the Northern Guinea zone, the affected months are February, March, April and November. In the areas extending from the coast through the forest zone to the Southern Guinea, coefficients greater than 100 percent are recorded for December, January and February. Within the rainy season, very high coefficients are recorded for the months representing onset and cessation of the rains throughout the country. Such months include June and September in the arid zones, and March, April, October and November in the forest zone. In summary, the percentage periodic change is greatest in months with the smallest average precipitation and decreases as rainfall increases.

Climate change

The climatic parameters investigated included cloud cover, precipitation, minimum temperature, maximum temperature and vapour pressure. Figs 2, 3 and 4 depict respectively, the projections for maximum temperature, precipitation and vapour pressure. Compared with the contemporary climate, and without prejudice to the
impacts they may cause, the most significant changes are with respect to temperature and temperature related parameters. There has been a tendency to emphasize changes in temperature in the temperate latitudes and to imply that changes in temperature in tropical areas will be less spectacular, or less significant, in the tropical areas (IPCC, 2001b). Following experience with contemporary climate variability, the emphasis is directed to moisture-related parameters. The scenarios adopted for this paper indicate that changes in minimum and maximum temperatures of the order of 7°C or more could be expected in certain parts of the country. This is likely to create a significantly different world with implications in impacts and vulnerability. Night time (minimum) temperatures will in general increase at a higher rate than day time temperatures. This has a potential to alter the thermo-period to the detriment of biodiversity. For example, high day temperatures favour rapid photosynthesis and low night temperatures reduce respiration, so that the photosynthesize produced during the day is conserved. Thus the greater the disparity between day and night temperatures, the more efficient is the energy economy of the plant (Daubenmire, 1974). Crops and other plants requiring low temperature conditioning may in the short run survive through autonomous adaptations, but in the long run may have to contend with the possibility of relocation or extinction. Day time (maximum) temperatures may in future attain levels unknown to areas outside the hot desert regions at present. In areas with perennally humid air, this has the potential to produce sultriness and the oppressive heat usually associated.

On the average, vapour pressure may rise by as much as 5 to 8 h*Pa with the potential for a significant increase in atmospheric energy. One would expect from this scenario, an increase in the frequency and intensity of stormy weather (IPCC, 2001b). A general decrease in cloudiness is projected. This could improve the availability of sunlight for primary biological productivity. There has been an observed trend towards aridity in Sub Saharan West Africa (Adejuwon et al. 1990, Nicholson, 2001, Hulme, et al. 2001). Our findings are that this trend will be put on hold or reversed as the century progresses. There are possibilities however, that the additional water need created by higher temperatures may not be met by the increases in rainfall projected. One aspect of the current climate pattern that will be carried forward into the potential climate of the future is zonation. Rainfall, cloudiness, and humidity will decrease, while temperature and incident solar energy will increase with distance from the ocean.

The scenario based on 0.5 percent per annum increases in CO₂ concentration, when compared with the scenario based on 1 percent per annum increases in CO₂ concentration shows that uncertainties regarding climate change will be in terms of magnitude rather than of direction. Positive changes are projected with respect to either moisture or temperature whatever the scenario. However, the changes are of a higher magnitude where the rate of increases in greenhouse gas concentrations is higher. The more significant uncertainties pertain to temperature and temperature related parameters in respect of which the expected changes are relatively large. With respect to moisture, the projections are for an increase rather than a decrease. However, while increases will be marginal in the case where the rate of increase is 0.5%, they could be well marked where concentration rates increase at 1%.

5 PROFILING THE NIGERIAN PEASANT HOUSEHOLD
The data used for this analysis came from the General Household Survey (FOS, 1996b). A household could be defined as a group of related persons, living in a dwelling unit or its equivalent, eating from the same pot and sharing a common house keeping arrangement. Household sizes varied from one person to over 20 persons in some cases. Nearly one-quarter of the households consisted of more than six persons. Households with more than 10 persons accounted for more than 3.7 percent of the households, while households with more than 15 persons constituted only 0.4 percent. One-person households made up only 12.2 percent of the households, while households with 2 or 3 persons constituted about 25 percent.

On the average, the Nigerian household consisted of 4.75 persons. Using the 30-state structure, the average size of the Nigerian household per state varied from 3.2 persons in Ogun state in the south-west, to as high as 5.6 persons in Plateau state. The states with the lower average household sizes (less than 4 persons), were all to be found in the south western parts of the country, while all the states with average household sizes of over 5 persons were in the north of the country. This implies that the size of the household is, in part, determined by ethnicity.

Apart from ethnicity, the size of the household was determined by certain characteristics of the head of the household such as gender and education status. It was also determined, in part by the number of wives in the household. According to the NCS of 1995 (FOS, 1996b), male-headed households without a wife had an average size of 1.9 persons. On the other hand, households with one wife, on the average consisted of 4.85 persons, those with two wives had an average size of 7.52, those with 3 wives had an average size of 10.14, those with 4 wives had an average size of 12.76, while those with 5 wives or more had an average size of 14.31 persons. As should be expected, male-headed households were larger than female-headed households. The average size of male-headed households was about 5 persons and that of female-headed households was about 3 persons. The relationship between size of households and education status is not straightforward. There was a tendency for households headed by persons with secondary school education to consist of fewer persons than households headed, on the one side by persons with primary education, and on the other, persons with post secondary education. The figures were 4 for households headed by persons with secondary education, about 5 for those headed by persons with primary education or less and 4.6 for those headed by persons with post secondary education. It is understandable why persons with less education should have larger families because they are less likely to use modern family planning methods. However, it is quite surprising that persons with post secondary education should have larger families given the fact that they have better access to family planning clinics. The explanation may be in the Islamic religion which permits those persons with the means to have up to four wives.

6 INDIRECT SENSITIVITY OF PEASANT HOUSEHOLD TO CLIMATE

By definition, a peasant household depends on agriculture and related activities for whatever livelihood he is able to eke out of his environment. It is the view in certain quarters that “one major cause of vulnerability to climate change is dependence of the exposure unit on sectors such as agriculture, forestry and fishery that are sensitive to changes in climate” (Sperling, 2003). The logic of this view point is quite easy to appreciate. Crop production, on which the peasant householder depends for his
livelihood is sensitive to climate variability and climate change. Whatever climate affects crop production affects the peasant household. In essence sensitivity of crop production to climate is a good measure of the sensitivity of the peasant household to climate variability and climate change.

The National Agricultural Sample Survey (NASS) (FOS, 1997) indicated that 94 percent of agricultural holdings were involved in crop farming, 68 percent in livestock farming, and only two percent in fishing and one percent in forestry activities. (The figures do not add up to 100 because of multiple activities e.g. many holdings have both crop and livestock). With the exception of Lagos State, over 25 percent of the holdings within each state, was involved in crop farming during the 1993/94 season. The figure for Lagos was 5 %. With respect to livestock farming, while some states like Katsina and Jigawa at the northernmost extremity of the country, recorded over 90 percent, Delta and Ogun, along the coastline, recorded 15% and 27% respectively. For fish farming, only three states recorded significant figures, Delta (11%), Rivers (11%) and Ondo (7%). The other states recorded less than 2%. The major crops grown by the households include: maize, guinea corn and cassava. During the 1993/94-crop season maize was the most widely cultivated (FOS, 1997). The crop was grown on 54 percent of the holdings. On the other hand, guinea corn (sorghum) was cultivated on 48 percent and cassava on 47 percent of the household holdings. Most of the states of the Nigerian Federation recorded high percentages for maize. The exceptions were the states of Jigawa, Sokoto and Yobe, located in the Sudan and Sahel, which recorded percentages less than 10 respectively. Guinea corn (sorghum) cultivation was concentrated in the same Sudano-Sahelian zones, where more than 90 percent of the households cultivated the crop. In the Guinean, (Middle Belt) zones, from 60 t0 70 percent of the households cultivated guinea corn, whereas, in the southern forest zones less than 10 percent of the households was engaged in cultivating the crop. The core of high intensity cultivation of cassava was in the south, eastern states of Anambra, Imo, Enugu, Akwa Ibom and Abia. The areas of intensive cultivation of cassava extended westwards into Delta, Edo and Oyo states, all lying outside the main Cocoa Belt. Intensity of cultivation of cassava decreased northwards. The Sudano-Sahelian zones could be considered as lying outside the proper cassava growing areas. What all these imply is that any disaster overtaking maize, sorghum, or cassava cultivation as a result of climate variability or climate change is also a disaster for the Nigerian Peasant Household. Beans, millet, yam and groundnuts are also regionally important crops, cultivated by between 30 and 40 percent of the households during the 1993/94 growing season. Yam cultivation is intensive in the South East and the Middle Belt, while beans and millet are important crops in the Far North.

A good measure of the extent of dependence on agriculture is the percentage of employed persons in the sector. For the country as a whole, the percentage of employed persons in the agricultural sector for 1993 was 65 (FOS, 1997). The data for 1993 also indicated that the percentage was above 50 in 20 out of the 30 states constituting the Federation. Fig 6 depicts the spatial pattern of dependence on agriculture. In general, the proportion of employed persons in agriculture tended to be higher in the northern, drier parts of the country than in the wetter south. It shows that the degree of dependence on agriculture for employment is highest among the states at the northern boundary with Niger Republic. In Kebbi and Sokoto states, in the extreme north-west, the percentage for 1993 was 93 and 92 respectively. All the states with boundary with Niger Republic had over 85 percent of their employed persons in
agriculture. By contrast, dependence on agriculture for employment was lowest in the south-west where the percentage was generally less than 50. In Lagos, consisting essentially of the city, the percentage was 2.37, while in Ogun, Oyo and Osun, the percentage was 20.66, 23.52 and 25.60 respectively.

7 SENSITIVITY OF CROP YIELD TO CLIMATE VARIABILITY

The Determinants of inter-annual changes in crop yield

The main observation from the bivariate correlation analysis was that the observed crop yields in the area of study were in general, not particularly affected by the components of rainfall variation in Maiduguri. However, the situation was different with respect to Potiskum where crop yield demonstrated appreciable sensitivity to rainfall variability. This observation is confirmed by the results of the multiple regression analysis depicted in Table 4. Fourteen out of sixteen most powerful determinants of crop yield were derived from Potiskum rainfall compared with two derived from Maiduguri rainfall. The interpretation one could give to this result is that the rainfall data of Potiskum were more representative of the crop producing areas of the areas of the two states. This is quite understandable because Maiduguri is located in the drier, Sahelian parts of the area while Postikum is located in the wetter Sudanic areas. It is conceivable that more of the outputs from the farms would be derived from the Sudanic than from the Sahelian areas. Such a pattern would tend to make the total farm output to correlate more with Potiskum than with Maiduguri rainfall.

Judging by the number of entries and especially the significance attached to its multipliers in Table 5, June rainfall is a more powerful predictor of crop yield than any of the other monthly rainfall variables. This is explained by the fact that June is the month of the onset of the rainy season. Low or insufficient June rainfall implies a delayed onset and a rainy season not long enough for the needs of most crops. In the respective cases of each of the four crops in the table, September rainfall also serves as a powerful predictor of yield. September is the month of cessation of the rainy season. Low or inadequate rain in September is evidence that the season is truncated before it could provide adequate moisture for crops during the critical phases of grain filling.

Differential effects of climate on the six crops

The results of the multiple correlation analysis are depicted in Table 4. The coefficients of correlation were significant only with respect to four crops, namely: maize, groundnut, cowpea and millet. Going by the magnitude of the coefficients, cowpea is the most sensitive to climate variability with an R of 0.872. The other relationships indicated with significant Rs were with millet (0.739), maize (0.714) and groundnut (0.697). R^2 values show that as much as three quarters of the variability in the yield of cowpea was determined by rainfall variability. For the other crops, the proportion of the variability in yield determined by rainfall variability was around 50 percent. We can now offer some explanation for the relatively weak sensitivity of the yields of rice and sorghum to rainfall variability. In the case of rice, a substantial proportion of the crop is produced at fadama sites. These are poorly drained to swampy valley bottom locations where soil water is available for plant growth for a period much longer than the rainy season. Irrigation is also practiced, based on water stored in shallow hand dug pits, especially where an impermeable, clayey sub-surface
soil layer is present. Such practices as these are likely to reduce significantly the dependence of crop yield on seasonal rainfall. In the case of sorghum, the low sensitivity may be connected with the drought tolerance of the crop plant. Adaptation of sorghum to the very harsh agronomic situations characteristic of the semi-arid regions of West Africa is based largely on its ability to withstand very high temperatures and to remain dormant through prolonged dry spells and then resume growth as soon as there is some rain (Johnston, 1958). This could result in low sensitivity of the crop to rainfall variability especially at the lower ends where the departures from the mean are small.

The variable significance of the annual impacts of climate on crop yield

Anomalies of crop yield are depicted in Table 6. Out of the 102 anomaly records, only 7 are significant, that is with a magnitude of 1.66 or higher. Six of these anomalies were significant at 95 percent confidence limits and only one significant at the 99 percent level. Three negative anomalies, significant at the 95 percent limit were recorded for 1990. One negative anomaly, significant at 95 percent level was recorded for 1988. One positive anomaly, significant at the 99 percent level was recorded for 1993. Two other positive anomalies, significant at 95 percent level were recorded for 1994 and 1997 respectively. It thus appears that 1988 and 1990 were the years with negative anomalies while 1993, 1994 and 1997 were the years with positive anomalies of crop yield.

For rice, there was no year with significant anomaly of crop yield. This observation tallies with the weak sensitivity of rice to climate variability as indicated by the correlation analysis. The yield recorded for maize in 1990 represented a significant negative anomaly while that for 1993 represented a significant positive anomaly. Two significant anomalies were also recorded for millet: one negative, 1990, and the other positive, 1994. For sorghum, the only significant anomaly was negative and was recorded for 1990. Also only one significant negative anomaly was recorded for cowpeas and that was for 1988. Groundnuts yields also rose significantly higher than the normal in 1997. It thus appears that the worst year for crop yield was 1990 during which the yields of all crops represented negative anomalies, three of which were significant at 95 percent confidence level. The significant negative anomalies were with respect to maize, sorghum and millet.

It is clear that the crop yields vary from year to year as hypothesized. For a great majority of the years, the departures from the mean were not significant, normal yield levels were the order. In certain years, negative yield anomalies corresponded to unfavourable weather. However significant positive anomalies signified absence of unfavourable weather rather than any discernible favourable weather. The years during which negative yield anomalies were recorded for just one crop did not correspond to any discernible unfavourable weather. However, when significant negative anomalies were recorded for all or most of the crops the weather was almost always unfavourable. For example, in 1990 negative yield anomalies were recorded for all the crops. The anomalies were significant with respect to three crops, namely: maize, sorghum and millet. The weather for that year in Potiskum was abnormally dry. In 1988, the negative cowpea yield anomaly was significant at 95 percent confidence limit even though there was no discernible negative weather anomaly. Positive significant crop yield anomalies were recorded in 1993, 1995 and 1997, respectively.
for maize, millet and groundnut. In the other years crop yield anomalies did not attain the levels at which they could be considered as significant.

It could be justifiably assumed that the departures from the mean yield represented by these anomalies are indeed measures of the variable impacts of climate from one year to the other. The justification is based on the fact that among the crop environment factors, climate is the only one with an annual time resolution. The implication of this for our analysis is that for most years, the effect of climate was not enough to cause a significant departure from the mean yield. This corresponds to the recollections of the peasant farmers which were limited to the drought years when negative anomalies were recorded for all the crops. All the other years were normal as far as they were concerned (Participatory Rapid Appraisal Survey).

The impact of the 1990 drought on crop yield

In 1990, with the exception of cowpeas, all the crops recorded their highest negative yield anomalies for the period from 1983 to 1999. Cowpeas also recorded yield anomaly that was the second highest for the period. The daily rainfall patterns for the months of April to November for Potiskum in 1990 are depicted in Table 6. First, the year recorded the lowest growing season rainfall from 1983 to 1999. This amounted to 319 mm for the four months, June, July, August, and September compared with an average of 748 for the 1983 to 1999 period. Given the fact that at least 3 to 5 mm of rainfall is required to balance evaporation and transpiration (Garnier, 1961), the 25 mm rainfall of June was grossly inadequate to wet the fields in preparation for tilling the soil and planting the crops. For this, June could be counted out of the 1990 growing season. Another observation is that, rain stopped abruptly in September. There was no rain during the first two weeks of the month when cereal crops planted in the middle of July would be about at the period of grain filling. The 19.3 mm of rain for that month fell in two ineffective showers of 12 mm and 7 mm respectively. One could therefore also disregard September as part of the growing season. Thus the growing season in that year lasted only two months. With this pattern of rainfall, 1990 was an example of a drought year. The widespread drought of 1973–74 was observed at Potiskum (PRA Survey). However the droughts observed in 1983 and 1987 in other parts of the Nigerian Arid Zone was remembered by only a few. The people could recall bad harvests in 1973 which resulted from early cessation of the rains. It was not only crops that were affected by droughts. Animals also suffered when the grass dried up for prolonged periods. Apart from this particular year, their recollection is of good harvests during the past thirty years. According to the farmers in this area, the drought of 1990 was not as severe as that of 1973-74. It appears that there were major droughts which were widespread in occurrence and local droughts such as the one observed in Potiskum in 1990. According to the peasant householders in responding to our questionnaire, the drought of 1973-74 caused more damage than the drought of 1990. Most droughts are local and could occur in different years in different places (Adejuwon, et.al, 1990).

8 SENSITIVITY OF CROP YIELD TO CLIMATE CHANGE PROJECTIONS

Our analyses of sensitivity of crop yield to projected climate change based on simulations using the EPIC Crop Model indicate benefits and risks. The case of maize is depicted in Figure 5 as an example. Port Hacourt, Benin, Enugu, Ilorin, Kaduna,
Kano and Maiduguri represent different zones along the climatic profile from the humid areas along the coast to the semi arid Sahel. Jos is presented to represent the high altitude ecology. Outputs of the EPIC runs include, in addition to biomass production and economic yield, water stress, temperature stress, nitrogen stress, phosphorus stress and aeration stress. These are useful in identifying the limiting environment factors.

The general picture is that in the immediate future, up to 2040, there will be substantial increases in crop yield. The positive impacts will result from increased solar radiation, increased rainfall, increased atmospheric moisture, and increasing levels of carbon dioxide concentration in the atmosphere. Increased solar radiation will promote higher levels of biomass productivity which is the fundamental determinant of crop yield. Increased rainfall and atmospheric moisture will reduce the level of water stress for crops as a result of which yield is enhanced. The beneficial impacts are likely to affect the present day northern, drier, regions more than the southern wetter regions. There are possibilities of a northern extension of the areas for the cultivation of certain crops; especially those presently based in the rain forest and sub-humid zones for example, cassava and yam. The positive impacts in the earlier parts of the century are absent at some locations within the rain forest with regard to maize and rice for example Benin and Enugu. What this implies is that the negative impacts described in the following paragraph are projected to start earlier in these stations. The pattern at the high altitude location is the exact opposite. For each of the five crops whose yields were simulated, increases in crop yield, starting early, will continue to the end of the century. This is quite understandable. Because of current relatively lower temperatures, global warming will take a longer time to reach the levels at which high temperatures will become detrimental to crop yield.

Projections based on the crop model simulations indicate that the second half of the century will, in general, be marked by significant reductions in crop production. The beneficial effects of increased radiation and increased moisture will be masked by increasing temperature stress resulting from the breaching of the upper limits of tolerance for most crops. A similar breaching of the upper limits of tolerance for CO₂ is also likely to contribute to the relative decline in yield during the second half of the century. At some locations, reductions in water stress are replaced by increases probably as a result of increased rates of evaporation and transpiration. Aeration stress, resulting from very high intensity rainfall could also serve as a contributing factor to the decrease in crop yield during the second half of the century.

9 CLIMATE DRIVEN RISKS AND BENEFITS

The Risks

According to Downing et al, (2001) risks are the expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. From the foregoing analysis, the risks to the livelihood of peasant households are related to reductions in the yields of their crops. The risks vary from widespread crop failure affecting all crops in the arid zone or some of the crops throughout the country, to regional, local and individual farm-level crop failures affecting the more sensitive crops. Depending on its severity, crop failure could result in food inadequacy and famine, loss of livelihood and long
distance emigration from the arid zone to the rain forest belt. Usually, it is the able-bodied young men that emigrate. A large proportion of those left behind, especially the women and the children could be made to pay with their lives. Contemporaneously, the crop production systems are constrained by poor soils, disease and pest infestation and chronic peasant production diseconomies. These serve as amplifiers of the climate factor as the chief driver of the risks.

Climate variability-driven risks

The drivers of crop failure are droughts, that is, inadequate growing season rainfall. Droughts have always been a common, though irregular feature of the arid region of Nigeria. The areas most exposed to the incidence of disastrous droughts are the Sudan and Sahel ecological zones which respectively cover about 240,900 km² and 20,700 km², and thus constitute about 26.6 percent of the country’s land area. These areas are characterized by a mean annual rainfall averaging 600 mm to 800 mm and a short, rainy period of 100 to 120 days. From the records, five major drought periods with resultant human deprivation were documented in the Nigerian arid zone during the 20th Century. These were the 1913-14, 1931-32, 1942-43, 1972-73, and 1983-84 droughts (Mijindadi and Adegbesin, 1991). Recurring drought periods were not limited to the 20th Century. Oladipo (1988) traced the occurrence of periodic droughts in Africa from before the birth of Christ up to the 20th Century.

The farmers in the arid zones are quite conscious of the weather factor in their lives. According to the farmers interviewed during field work, when the seasonal rains are early, they come in May and crop performance is high. When seasonal rain onset is delayed until July however, crop yield is low. This is because unless cessation of rain is delayed, the growing season is shortened and there is insufficient time for crops to mature. Rain coming in June is judged to be favourable and is associated with good yields of crops. Most crop failures are however associated with premature cessation of the rainy season. There could also be low yield of crops when there are prolonged dry spells within the growing season. However, the significant negative impacts of climate on crop production are delivered by extreme events such as season-long droughts with decadal frequencies of occurrence. Disaster usually comes in the form of a late arrival and/or a premature termination of the growing season. In the broad band of years that could be described as normal, noticeable rather than significant responses of crops to changes in climate could be observed. The responses reflect changes in the environmental drivers from one locality to another. Thus for the impacts to be noticeable at the sub-regional scale, at which data are usually summarised, the type of weather described for Potiskum in Table 7, must occur over wide areas.

Climate change driven-risks

For the rest of the current century, the risks outlined above will remain with the Nigerian peasant household. However, the severity, the reference period, spatial and temporal resolutions will differ as the century progresses. Instead of oscillating or periodic timing, the risks will tend to gather momentum as the century progresses. Instead of cellular occurrence, the risks will tend to affect the entire sub-continent of West Africa with comparable severity. The risks will be least during the first half of the century during which crop yields increase in response to higher levels of solar
radiation, atmospheric humidity, rainfall and carbon dioxide. Also the risks will be
driven by a new set of climatic factors. The current moisture-based drivers will be
replaced by temperature-based factors. In the context of ecological factor interaction,
the negative impacts of supra-optimum temperatures will tend to mask the positive
impacts of increased solar radiation, moisture and carbon dioxide during the second
half of the century.

10 CONSTRAINTS TO ADAPTIVE CAPACITY

Adaptative capacity is the ability of a system to adjust to climate change, to moderate
potential damages, to take advantage of opportunities, or cope with the consequences.
Resources, including: social, financial, natural, physical and human capital, are
required for planning, preparing for, facilitating and implementing adaptation
measures. Among the factors imposing limitations on adaptative capacity, the most
significant is existent poverty which signifies lack of the resources necessary for
adapting to climate change (Sperling, 2003). In addition, there are disabilities such as
poor health that could undermine labour availability for the farming activities both in
quality and in quantity. Relatively low levels of educational attainment could also
constrain the ability to acquire the technological capacity for combating the negative
consequences climate change. The rates of population increase which at present
stands at 28 per thousand could increase the rates of child dependency, increase
pressure on social infrastructure, and constrain the capacity to cope with the negative
impacts of climate change.

Poverty

Widespread poverty has been cited as the main cause of a low capacity to adapt to
climate change in Africa (IPCC, 2001a). Poor persons, poor communities and, poor
nations do not have enough of these resources, hence their low adaptative capacity. A
low capacity to adapt to climate change automatically implies vulnerability. Hence
existent or pre-impact poverty connotes vulnerability. Summary of the latest results
from the National Integrated Survey of Households 1995 (FOS, 1996c) showed that
practices that could have boosted the adaptative capacity of the peasant households
were still being constrained by lack of funds at the individual household level. With
respect to livestock production, 99 % were not using vaccine, 96 % were not using
drugs, while 95 % were not using supplementary feeds. With respect to crop
production, the use of pesticides and insecticides was limited to 4 %, the use of
improved seeds was limited to 11 %, while the use of chemical fertilizers was limited
to 32 % of the peasant holdings. Among those who did not use fertilizer, 51 %
considered the cost too high, 8 % found the distance to the source to be too far, 23 %
did not know where to obtain fertilizer, while 12 % felt they did not need fertilizers.
Of those who were not using pesticides and insecticides, 36 % felt the cost was too
high, 24 % felt no need for them and 22 % did not know where to obtain them All
these boil down to inadequate financial resources and ignorance, which are the
hallmarks of the poor. 94 % of the holders had no credit for their farm work. Only 1
% had credit through formal banking and cooperative society system. Informal credit
system accounted for only 2.7 %.

The current, official poverty line for Nigeria was defined in a study to assess the
poverty trend in the country between 1980 and 1996. The study, conducted by the
World Bank in collaboration with the Federal Office of Statistics, used data generated by the National Consumer Expenditure Survey, and adopted two-thirds of the mean household expenditure as the poverty line. The approach used in the report titled: *Poverty Profile for Nigeria 1980-1996* (FOS, 1999a) is based on the classification of the poor and non-poor households in relation to their total expenditure (food and non-food). This involves setting two lines relative to the standard of living in Nigeria:

i. A moderate poverty line equivalent to two-thirds of the mean per capita expenditure

ii. A core poverty line, equivalent to one-third of the mean per capita expenditure.

Households are classified into one of three mutually exclusive groups, separated by the lines specified either as core poor, moderately poor, or non-poor.

There is significant difference in the incidence of poverty between households engaged in agriculture and households with occupation in the other sectors. With the dominant role played by agriculture in the provision of employment, it is not surprising that most of the poor were found on the farmlands, in the rural areas. About 77 percent of farming households were poor, while 48 percent fell into the core poor category. Male farmers were poorer than female farmers.

Most of the poor live in rural areas (FOS, 1999b). Nigeria’s Poverty Assessment Study indicates that 87% in 1985 and 67% in 1992, of the core poor were in agriculture and all basically resided in the rural areas. 75 percent of the population of the country live in rural areas. The southern parts of the country suffer less poverty than either the central or the northern parts. This pattern is depicted in Table 8 and in Fig 8. In 1980, the core poor constituted 11.8 percent of the population of the states in the North East, 8.3 percent of the population of the states in the North West and 5.7 percent of the population of the states in the North Central zone. By comparison, 2.1 percent of the population in the South West, 2.4 percent of the population in the South East, and 3.3 percent of the population in the South-South were classified as core poor (FOS, 1999c).

Demography Induced Constraints

Table 9 depicts the age-sex distribution of Nigeria’s population in 1981/82, 1990, 1993/94 and 1995. It could be observed from the table that the country has a youthful population. In youthful populations, high proportions of the members are children. Going by the estimates for 1995, children under the age of 15 years constituted 44.0 percent of the population. Also, the youthful age structure creates a built-in momentum for future population growth. Even if it were possible to reduce the growth rate to replacement level, births would outstrip deaths and the population would continue to increase until the very large number of young females had passed through their reproductive years. The percentage of the female population that is in the reproductive age brackets, after declining between 1980 and 1990, increased from 1990 to 1995, giving indications that the growth rate might be accelerating. In 1981/82, 1990, 1993/94 and 1995, women in the reproductive age brackets constituted 44.3%, 36.8% 46.6% and 46.0% of the female population respectively (FOS, 1996a). (It should be noted that these were results of different surveys). With such high percentages within the reproductive age range coupled with the youthful nature of the population, policies aimed at reducing fertility may not produce the desired results.
within a short time. In the short run, the population of children would remain high relative to total population even if the fertility rate declined.

Nigeria is thus characterized by a high and stable birth rate, which has varied between 5.6 and 7 percent since 1960. Also the death rate has been declining as a result of improvements in medical and community health facilities. The balance between the stable high birth rates and the steadily declining death rates has produced a steady annual growth rate of about 28 per thousand.

The importance of a vigorous and effective population policy was noted in the 1988 National Policy for Development, Unity, Progress and Self Reliance. The policy adopted specific demographic objectives and called for the extension of family planning services to half of all women of child-bearing age by 1995 and to 80% by the year 2000 (FOS, 1994). Neither the general nor the specific objectives spelt out in the policy statement have been achieved. The main problem has to do with entrenched cultural and religious practices. The use of modern methods of contraception remains very low in spite of significant increases between 1982 and 1984 and between 1993 and 1995 (FOS, 1996b).

It is therefore not surprising that the Nigerian population remains youthful; that the percentage of the population in the age range 0-15 years is above 40 and that the rate of population increase remains very high. All these result in problems that may rank higher on the priority lists of governments at all levels than the need to combat the consequences of climate change. At the very least, these problems will compete for attention with those that are consequent upon climate change and hence contribute to the vulnerability of the household to climate change. Among such problems are: inadequate social infrastructure and child dependency burden.

Inadequate Social and Economic Infrastructure

The rapidly expanding population is exerting increasing pressure on the social and economic infrastructure of the country. Schools, hospitals, and houses become inadequate almost as soon as they are completed. Similarly, electricity, water and waste disposal facilities designed for a given population are being made to serve much more than that population on the day they are commissioned. Existing facilities are being put to a higher rate of usage than they were designed for. This is resulting in a high rate of infrastructure deterioration. There is the possibility that these inadequacies will tend to command greater attention from policy makers and draw away funds from pro-acting to the consequences of a potential climate change.

Child Dependency Burden

The youthfulness of the population is directly responsible for the high rate of child dependency burden in the country. Child dependency burden, calculated as the population of children below the age of 15 divided by the population of working adults aged from 15 to 59, is depicted in Fig 8 for the year 1993. The South West has the least burden followed by the South East and the North West. The main consequence of this at the household level is that each pair of hands has to strive to provide for many more persons than it can conveniently cater for. In countries with such high proportions of children, relative to the proportions of the working age
population, high percentages of national income is expended on consumable goods for these children. The higher the percentage of income expended on these consumables, the lower the percentage of income left for savings and investments. The capacity to cope with any additional stress in the form of negative consequences of climate change will also be lower in situations with high dependency burden because the first inclination would be to care for children rather than to prepare for a future under a changed climate.

Educational Statuses and Adaptive Capacity

Education will definitely enhance personal, community and national capacity to respond to external stresses placed on human livelihood and well-being. Therefore inadequate or substandard education is a measure of the vulnerability of human exposure units to expected negative impacts of climate change. It is easy to appreciate the fact that education is one of the means for achieving the goals of better health, higher labour productivity and more rapid GDP growth; all of which are required as the need arises to anticipate, manage or adapt to a worsening climatic factor (Hulme, 1996, WMO, 2000). The higher levels of education are especially called for to enable individuals and countries understand and participate more fully in the technological and administrative processes of the modern global economy. Since achieving independence from colonial rule in 1960, a considerable proportion of the national income has been invested in raising the standard of education. Because of this, enrolment ratios have been on the upward trend. However, there are considerable differences between the component regions in this regard. The northern, semi arid zones, where the impacts of climate variability are most severe, and the potential consequences of climate change are expected to be most damaging, are the same regions least prepared in terms of education capacities to meet the challenges of climate variability and potential climate change.

The national adult literacy rate averaged 25 percent in 1970 (FOS, 1996a). By 1995, it had climbed up to 49 percent. The 1995 statistics showed a gender disparity with the female rate at 41 percent while the male rate was 58 percent (UNDP, 1995; FOS, 1996a; and National Population Commission, 1984). Regional disparities were also well marked. Literacy rates among male adults varied from a low of 19 percent in Jigawa state located in the far north, to a high of over 93 percent in Lagos state, located in the humid forest zone. Lagos is dominated by the city of Lagos and this may explain its high rate of adult literacy. However in the predominantly rural states in the forest zone, such as Abia, Akwa Ibom, Cross River, Rivers, Imo, and Delta, the rate was over 80 percent. Regional disparities were also indicated in the female adult literacy rate. For example, the rate in such northern states as Kebbi, Sokoto, Jigawa and Yobe were respectively less than 10 percent. For all the forest zone states, the rate of female adult literacy was over 50 percent and was in fact more than 70 percent in Abia, Anambra, Edo and Rivers states. Intermediate values were recorded for the sub humid Middle Belt. Fig 9 depicts the pattern of adult literacy rate based on 1995 statistics.

Primary school enrolment stagnated at about 3 million in the 1960s. By 1975, primary school enrolment was still less than 5 million (FOS, 1996a). Thereafter, increases became more consistent, reaching 16 million in 1994. The regional disparities observed with respect to adult literacy were also observable with respect
to primary school enrolment. In every state based in the humid forest zone, the most recent statistics (1994) indicated primary school enrolment of over 90 percent with little or no difference between the sexes. In the far northern states, the rate was generally less than 40 percent for male and less than 30 percent for female. Similar patterns were repeated for enrolments in secondary schools and tertiary educational institutions. Secondary school enrolments in all the forest-based states exceeded 80 percent, compared with less than 30 percent for male and less than 10 percent for female in Sokoto state in the Sudan Zone. In 1993/94, tertiary institution enrolment depicted in Fig 10, ranged from 2.0 percent in Sokoto state, in the arid zone, to 41.0 percent in Ondo state, in the forest zone.

Health and Adaptive capacity

The view has been expressed that climate change impact on human health would increase vulnerability and reduce opportunities by interfering with education and the ability to work (Sperling, 2003). In the absence of mechanisation and other forms of modernisation, the main input to crop and animal production in Nigeria is labour. Most of the labour used on peasant farms is supplied by members of the household. In households headed by women, hired labour could be employed for the more strenuous activities such as tilling in preparation for planting. Households engaged in cash crop production use more hired labour than households engaged in food crop production. During the harvest season, the households cooperate to ensure that farm output is brought in as soon as possible. There is always limited time available for harvests as delay may expose the output to pests, diseases and destruction by the weather. Thus sufficient and timely availability of labour is crucial to the level of yield realised. The effect of the HIV/AIDS epidemic in limiting farm productivity is common knowledge. Hands that could have been employed in production are either lost though death or immobilised by sickness. Statistics on morbidity and mortality due to HIV/AIDS are not yet in the public domain. Estimates supplied through the news media are largely unreliable. The rates of losses in man days of farm work due to the disease are probably now as high as those reported for the traditional human ailments. The contributions of the other diseases to morbidity and mortality are depicted in Table 10. However, most of the reported cases of death and morbidity are children under the age of 5. (Infant mortality rate is depicted in Fig 10.) This does not seriously reduce the impact on labour supply because the women who have primary responsibility for the care of the children are also the ones that supply a disproportionately higher percentage of agricultural labour.

Climate is one of the major factors influencing the incidence of diseases in Nigeria (Adejuwon, 1978). In general, disease agents do better when the temperature is high, under conditions of optimum water supply. The climate has long been identified as the fundamental cause of the low state of human health in the Tropical World. With ample justification, Gourou (1961) contended that: “The steady, high temperatures, the high humidity of the air, the many water surfaces fed by rains, are necessary for the maintenance of pathogenetic complexes in which man, insect and a microbe are closely associated”

For instance, heavy rainfall quickly fills small surface depressions and abandoned containers with water in which mosquitoes find suitable conditions for breeding. About forty different types of human diseases are known to be transmissible by
mosquitoes (Brown, 1955). The most widespread include malaria, filariasis and yellow fever. Malaria is transmitted by Anopheles spp. From 1991 to 1995, cases of malaria reported throughout the country averaged one million annually. These figures make malaria the most widespread disease among Nigerians (FMH, 1992/93). There is no part of the country free from the disease. In the coastal belt, as a result of high year-round humidity, and abundant water surfaces, continuous transmission of the disease is possible (Brown, 1955). In the rain forest belt, the period of transmission is as long as 9 months, dropping to 7 months in the Guinea savannas and 5 months in the Sudan and Sahel. Projected higher humidity and rainfall are likely to result in higher rates of transmission. Probably because of the association of mosquitoes with wet surfaces, the disease is more prevalent in the wetter parts of the year. From 1965 to 1970, the northernmost states had the lowest rates of incidence. However the figures for 1991 to 1995 indicated no such difference. The most seriously affected states now include Plateau, Sokoto and Kaduna in the north as well as Lagos in the south (FOS, 1996a).

There are other diseases such as measles, chicken pox, small pox, pneumonia and meningitis whose incidences attain epidemic proportions during particular parts of the year. One cannot avoid the conclusion that the occurrences of these diseases are related to the changing seasonal weather. Incidences of measles, chicken pox and small pox tend to be high during the hot and dry seasons. On the other hand, pneumonia, which ranks third after malaria and diarrhoea, with respect to mortality rates, is significantly associated with the middle of the rainy season in Southern Nigeria.

Cerebro-spinal meningitis is a virus killer-disease, well known in the drier, northern parts of the country. It is an endemic disease but incidence mounts to epidemic proportions in certain years during the dry season, that is, from November to March. It is suggested that high temperatures associated with the change of seasons might be the direct predisposing factor (Brown, 1955). If this proves to be the truth, the high temperatures projected for the country could mean a higher rate of incidence of the disease. Cerebro-spinal meningitis quickly spreads through the population as the conditions of the victims quickly deteriorate to an acute state. The mortality rate among affected individuals is probably higher than that of any other common disease including small pox before it was eradicated. This is one disease whose ravages have not abated in recent years notwithstanding the general improvement in medical facilities. Epidemics of serious proportions have been reported as far back as 1885, and at intervals of about five years ever since (Brown, 1955). The number of reported cases which stood at 2,511 in 1964, rose to 7,623 in 1965, declined to 1,879 in 1969, rose again to nearly 10,000 in 1970 and declined rapidly thereafter to 1719 in 1973. The most recent statistics gave a figure of 7,375 for 1995 indicating another upsurge. From the data on reported cases in recent years, it can be observed that the main areas of occurrence are in the northernmost states of Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Yobe, Bornu, Bauchi and Plateau.

11 INDICATORS OF VULNERABILITY

Fig 11 is a map depicting the spatial pattern of vulnerability in the country based on the 30-state structure and attributes indicating: sensitivity to climate variability, sensitivity to climate change, and inherent capacity or lack of capacity to respond to,
in the sense of cope with, recover from, or adapt to climate change. The attribute representing climate variability is the index of variability of onset month rainfall between 1961 and 1990. The attribute representing climate change is the projected average temperature for the growing season for the 2070 – 2099 period. The attribute connecting the peasant household through agriculture to climate is the percentage of the households employed in agriculture. The attributes indicating adaptive capacity include economic, health, education and demographic conditions of the households. The economic attributes at household level include poverty head count and access to electricity. Internally generated revenue is adopted as a measure of poverty at state level. The environment attribute included was access to potable water. Among the health attributes are population per medical personnel and under-five mortality. Education-related attributes include adult literacy, primary school enrolment, secondary school enrolment and tertiary institution enrolment. Demographic attributes included are child dependency burden ratio and the use of modern contraceptive methods. Each state was assigned a rank for each attribute depending on their positive indication of adaptive capacity. The ranks were added and the results used to determine a composite value of relative vulnerability to each state. These were the data used in preparing the map. The mean rankings show clearly that the peasant households in the southern states are the least vulnerable to climate change, followed by those in the Middle Belt, while the households in the extreme northern states were the most vulnerable.

12 SUMMARY AND CONCLUSIONS

Exposure of crop production to contemporary climate variability, especially to droughts of varying severity is a major source of existent vulnerability of the Nigerian peasant household. Climate change during the 21st Century in Nigeria will be manifested with a higher degree of confidence with regards to temperature than any other climatic element. The higher temperatures projected will be associated with significant increases in atmospheric humidity and marginal to significant increases in precipitation. As a result of the increases in precipitation and atmospheric humidity, crop yield will increase substantially during the first half of the century. This will tend to relieve contemporary vulnerability. However, during the second half of the century, whatever benefits are due from the increases in precipitation and atmospheric humidity will be masked by the negative consequences of the higher temperatures. The net result of these is that climate change will pose considerable risks to peasant household health, crop production and food security. The risks will be intensified towards the end of the century. The risks will be greater in the north than in the southern parts of the country. Peasant households in the country will be vulnerable to the potential climate change mainly because they are dependent on agriculture, which will be subject to the negative impacts of the change in the second half of the century. Also because of existent poverty, the households will be vulnerable to the changes in climate because they lack the resources required for coping. Vulnerability will also result from the potential compounding consequences of the changes in climate on some of the current household inadequacies. Such inadequacies include: scarcity of water, food insecurity and poor health. Part of the vulnerability will derive from the predisposition to further damage by some of the current negative attributes including explosive growth in human population, low levels of educational attainment and inadequate social and economic infrastructure. There are indications that the climate
projected may present opportunities for improving the quality of human life in the coastal and high altitude regions.

REFERENCES

5) Burton, I, (1997)”Vulnerability and adaptive response in the context of climate and climate change” Climate Change 36 185 - 196
26) Hulme, M; (1996) Climate Change and Southern Africa, Climate Research Unit University of East Anglia
27) Hulme, M; Doherty, R; Ngara, T; New, M; Lister, D; (2001) “Africa climate change: 1900-2100) Climate Research 17 145 -168
32) IPCC-DDC (1999) The IPCC Data Distribution Centre: Providing Climate Change and Related Scenarios for Impact Assessment;CD-ROM Version 1.0 Climate Research Unit, University of East Anglia, Norwich, United Kingdom; Available online at http??ipcc-ddc.cru.uea.ac.uk.
33) Johnston, B.F; (1958): The Staple Food Economies of Western Tropical Africa Stanford University Press Stanford, California pp 305
38) Nicholson, S.E “Climatic and environmental change in Africa during the last two centuries” Climate Research 17 124 - 144
42) WMO (2000), Coping with the Climate: A way Forward New York. IRI