Perspectives on Nation-Building and Development in Nigeria

Environmental and Economic Issues

Edited by:
Hassan A. Saliu
Adeyemo Aderinto
Isah H. Jimoh
Godwin T. Arosanyin

Dedication

The book is dedicated to
Professor Ifeyori I. Ihimodu, former Dean,
for his contributions to the growth and development
of the Faculty of Business and Social Sciences,
University of Ilorin, Nigeria.

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Chapter 4

Methods of Assessing the Impacts of Climatic Change on Agricultural Land Use

*Rhoda Olanrewaju

Introduction

CLIMATIC change has been defined as the fluctuation in weather average over a relatively short period of about one hundred years; while climate change connotes any form of long term climatic inconsistency (Adeyemi, 2000). Both long and short-term changes in climate bring unpleasant repercussions on agricultural industries of the world as they manifest in vulnerability of food production. Nigeria has been described as most vulnerable to effects of climate change because of its geographical location, among other factors. The impact of severe flooding in Nigeria calls for serious attention. For instance, in 1999, about 65 deaths were recorded, over 12 billion hectare of farmlands washed away resulting in an estimated farm produce loss of 100 million tons. Similarly, Nigeria has experienced severe drought during the normal rainy season, which attracted international attention and assistance (Adefolalu, 1999).

The decimation inflicted by climate directly through weather extremes such as flood, drought and indirectly through the infestation of pests and diseases has almost cancelled the positive roles agriculture would have played in the food economy of Nigerians. Thus, efforts should be directed towards mitigating the negative climatic impact on agriculture. Such efforts require

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close monitoring of climatic parameters and their vagaries, especially as it affects agriculture. This chapter, therefore, examines the appropriate techniques for research into climatic change and agricultural land use types; with the following areas under focus:

(a) Climate change, greenhouse gases and man;
(b) Interactions in the climate system and the consequences on man;
(c) Climate change and agricultural land use; and
(d) Assessment of agricultural impact on climatic change.

Climate Change, Greenhouse Gases and Man

Recent changes in climate have been linked to the increasing concentration of green-house gases in earth's atmosphere. Naturally, some trace gases such as carbon dioxide (CO_2), nitrous oxide (N_2O), tropospheric ozone (O_3) and methane (CH_4) do occur in the atmosphere. Various anthropogenic activities have only increased the level of these gases in the atmosphere and, in addition, support emission of other artificial gases such as chlorofluorocarbons. These gases affect the earth's climate through their influence on radiation balance. In fact, the transparency of the atmosphere to short wavelength from the sun and its opacity to long wave radiation from the earth is termed greenhouse effect. This has been the major cause of global warming.

Growing awareness and increasing concern about the accumulation of man-made green- house gases has resulted in a series of initiatives such as the United Nation Framework Convention on Climate Change (FCCC) and the Rio de Janeiro Conference in 1992. The aim of these programmes is to avoid or at least reduce the undesirable impacts of global climatic change on man's environment and socio-economic activities, mostly agriculture. Models of atmospheric general circulation (GCMS) have been used in some experiments designed to reflect the climatic changes that are likely to result from increased levels of CO_2 (Gates, 1985) and hence the level of warming expected in future. These are:

(a) Changes in average CO_2 levels have been studied by many researchers, for instance Schneider and Chem (1980).
(b) Changes in average sea level, Titus (1986), Warrick and Oerlemans (1990).
(c) Changes in rainfall characteristics and temperature trends – Sahsamanoglou and Makrogionis (1992), Ati (2003), among others.

Man is vulnerable to climate change induced by him, the awareness that prompted the World Meteorological Organization in 1992 to suggest for a better understanding of the climate system of human impacts and its impacts on man's activities too.

Interactions in Climate System and the Consequence on Man

The components of the climate system are the atmosphere, biosphere, cryosphere and hydrosphere and are driven by solar energy. A complex web of interactions exists within and among components. Gowon and Ononiwu (1999) emphasize the interactions between atmosphere and other subsystems such as water and vegetation of the earth, among others.

Responses from these interactions vary over space. For instance, Aina and Adejuwon (1994) observe that a low trend of rainfall, except in Benin, and erratic rainfall onset and cessation occur over Nigeria. Again, a shift in climate towards aridity over northwest Nigeria and a reduction of the northward migration of ITD (Inter-Tropical Discontinuity) have been noticed by Adedoyin (1989). The entire issues above correlate with changes in both natural terrestrial biomes and agricultural land use.

Climatic Change and Agricultural Land Use

One of man's activities that suffer the repercussion of climatic change most is agriculture. Climate determines the types of agricultural land use engaged in by man, e.g. arable farming, plantation agriculture, livestock grazing, fishery, etc. In arable farming for instance, climatic change may bring about the following, among others.

(a) Regional shift in cropping pattern
(b) Determination of the size and configuration of farmland
(c) Determination of the type, status and magnitude of crop pests and diseases.

For example, the regional shift in livestock grazing currently experienced in Niger Republic has a lot of bearing on the shift in climate towards severe aridity. Also, animal pests and diseases are climatically controlled. Changes in the marine ecosystem on a global scale are less documented but it is evident that artificial pollutants have invaded both the inland water systems and deep seas. Variations exhibited by rainfall pattern over Nigeria's coastal area have been a critical factor affecting agricultural production in general and fishing in particular (Edafienene, 2003). These changes represent a threat to agricultural resources. Thus, efforts are geared towards assessing the agricultural impacts of climatic change for efficient planning and decisions towards global food security in general and Nigeria in particular.

Assessment of Agricultural Impact on Climatic Change

Any research work seeking a better understanding of impact of climatic change on agriculture tends to examine the relationship that exists between climate and agriculture. Various approaches to doing this have been put forward by different scholars but none has gained universal acceptance.

Smit, et al. (1988) recognize three approaches of assessing the impacts of climatic change on agriculture. To these three, Bolin, et al. (1991) add a fourth as follows:

(a) Crop Impact Analysis
(b) Marginal-Spatial Analysis
(c) Agricultural-Sector Analysis
(d) Historical Case Study.

Crop Impact Analysis

This examines the possible effects of climatic change on crop productivity level. It focuses on estimating the direct influence of environmental variables (precipitation, temperature, relative humidity, sunshine hour, etc.) on crop yield. This approach has been employed by many researchers such as Adefolalu (1986), Olaniran and Summer (1990), Bello (1996), Owolabi and Adebayo (2003), among others.

Marginal-Spatial Analysis

This approach examines the repercussion of altered climates on the location of agricultural boundaries. It investigates the possible spatial shifts in cropping pattern or other characteristics of agriculture that resulted from climatic change. Spatial shifts in cropping patterns occur to compensate for climatic change. When this happens, two things may result:

(a) Expansion or contraction of farm size, which leads to alteration of farmland configuration.
(b) Mismatch of environment and agriculture, leading to mal-adapted agriculture.

In order to eradicate or at least limit crop-climate maladjustment, it is necessary to:

(i) Identify and estimate the effects of climatic change on agri cultural land use. This will involve identification and qualification of environmental indices that limit spatial extent of crop region. Olanrewaju (2004) employed this method to explain the spatial shift observed in melon production in the Guinea Savannah Zone of Nigeria.
(ii) Select the scenarios of science of climatic change and the modification of meteorological records accordingly. Williams, et al. (1980) used this method to investigate the effect of climatic warming on farm income and profitability.
(iii) Calculate the effects of the key climatic constraints and the resultant spatial shift in crop region. Newman (1980) and Blasting and Solomon (1983) used the approach to identify climatic warming as the key constraint that would displace North American Corn Belt 175 kilometres per degree Centigrade in a north-northeast direction.

Agricultural-Sector Analysis

Agricultural-sector analysis concentrates on estimating the range of impacts within and between agricultural regions. It goes beyond assessment based on crop yield and spatial analyses but provides information on many agricultural sectors for total production, prices, trade patterns and employment.

Historical Case Study

Historical case study seeks to know what past experience says about the agricultural impacts of climatic change. It involves historical analogues that use responses to previous climatic changes as a means of suggesting potential adjustments to future climates. For instance, an attempt can be made by researchers to gain an insight into the possible implications of a climatic warming on agriculture (Rosenberg, 1982).

Research Techniques

Sampling Framework

The sampling framework describes the database and represents the pattern of data collection within a study area. The selection of the sampling points must cut across all ecological zones in such a way that each of the climatic regions within such zones is adequately represented for the collection of both climatic and agricultural data which will be analyzed for valid conclusions. Importantly, delimitation of the study area denotes the geographical extent of the study area (i.e., both the latitudinal and longitudinal locations) as well as location relative to political boundaries. Here, detailed information of relief structure, drainage system, climate, soil and present agricultural land use practices are required. However, discussions should point towards exposition and proffering of solution to the research problem.

Types of Data Required for the Study

Two major categories of data required for such investigation are climatic and crop yield database. The source of these data is a function of the method of investigation adopted. The methods can be grouped into two classes:

(i) *Experimental Research:* This represents the type of research in which the growth and development of crop is based on the phytotron method with various combinations of temperature, air humidity, radiation and the length of the day (Bello, 1996). In this method, the source of data is primary because measurements and recordings of both thermal and moisture indices values are carried out by the researcher on a daily basis. However, some observations are also made in greenhouse, in which case many of the factors such as water, fertilizer, etc., are held optimum.

(ii) *Statistical Methods:* Under this method, data are extracted from documented information and hence, described as secondary source. Statistical methods used are obtained from climatological, phenological and crop data archives.

The major climatic data crucial for crop growth and development and hence spatial shifts in cropping pattern are thermal and moisture indices. The thermal indices are temperatures (minimum and maximum) °C, soil temperature and photo period (i.e. length of day). Rainfall, relative humidity, soil moisture content, evaporation, etc., represent moisture indices. Phenological data represent information collected from the first stage of plant development through its last stage of harvesting. For instance, most cereals have five phenological stages of establishment, vegetativon, flowering, grain filing and ripening.

Crop yield can be viewed from two perspectives of biomass and yield per hectare (Bello, 1989). Biomass denotes plant dry weight and is obtained by subtracting the oven-dried value from the fresh weight. On the other hand, measurement of crop it yield varies, based on the type and part of crop being emphasized. For instance, in cereal grain it is measured; in vegetable it is the total fresh weight; and tuber is emphasized for root crop. Yield component is measured in kilogram per hectare.

Methods of Data Collection

The two types of data described above should be collected for at least thirty years, for which consistent records of yield, meteorological data are available simultaneously at all stations. However, for experimental research, the period of data collection may be limited to two years of constant and accurate measurements and recording of both agro-climatological indices and crop growth on daily basis.

Thermal indices such as temperatures (air and soil) are collected in degree centigrade. Soil temperature is collected from various depths, depending on root penetration extent of different crops. The range can be between 10cm and 50cm. Photo period is recorded on hourly basis. For moisture indices, rainfall amount, frequency, etc., are measured in millimetre (mm) while relative humidity is measured in percentage. Soil moisture content is also obtained from various depths of between 5cm and 100cm. Some of the moisture indices that cannot be measured directly are derived from the measured values of other indices. For instance, actual evaporation from crop surfaces is determined by lysimeter studies followed by the procedures of Kowal and Stockinger (1973). Also, open surface water evaporation is determined according to Penman's (1948) formula. Others include Actual Water Availability (AWA) which is equivalent to the available rainfall plus the change in stored soil water. Consumptive water by Crop is another index and has been defined as:

$$ETcrop = K_{co} \times E_o,$$

where,

$ETcrop$ = Crop Consumptive Water Use

K_{co} = Crop Coefficient

E_o = Open Surface Water Evaporation

Doorenbus and Pruit (1984) in Bello (1996).

There is need to relate the climatic attributes of the study area to the climatic requirements of such crop from planting to harvesting period. Thus, agro-climatological indices for crop growth described above are measured according to phenological stages of the crop with the aim of identifying which climatic indices are responsible for a displacement of one crop type by another.

Analytical Framework

Researchers examine the dependency of the crop yield on meteorological factors. Various quantitative methods are used for estimating and predicting the yield and cropping pattern. The common statistical analyses employed are correlation and regression (Bello, 1993), among others. For instance, a correlation analysis shows which climatic variable is significant at different levels, while multiple regression reveals critical climatological variables that account for variation in yield over space. Both correlation and regression methods are statistical tools used for measuring strength of association between variables which may lead to prediction of the values of dependent variables. For an investigation of this nature, crop yield forms the dependent variables while meteorological factors are the independent variables. Another similar method, the chi-square, exists for the same operation.

Cluster analysis can also be used to classify critical climatological variables according to sampling points (stations). Finally, a linkage tree for the agro-climatic stations of the study area can be drawn to illustrate the relationship between station points. From this, spatial pattern of the different homogeneous regions for each crop type can be prepared. However, for marginal spatial analysis, the use of spatial analysis is employed. The techniques involves identifying analogue regions that are in another region given a future climatic condition of such region, e.g. climatic warming (Newman 1980, Blasting and Solomon 1984).

Furthermore, to specify with greater precision the connections between climates, climatic risks, yields and farm decisions, the crop-climate model may be simulated. The simulation model is developed by combining a set of mathematical equations based on experiments or knowledge of specific plant processes such as photosynthesis, respiration and transpiration and their interactions with the environment (Williams, et al. 1998) as cited in Smit, et al. 1988).

The conclusion of the study, which is expected to summarize the main findings, must be emphasized. Also, suggestions are made for further research on the issue(s) researched into.

Summary and Conclusion

The climate of Nigeria has not only changed but Nigeria is vulnerable to its impact. Agricultural land use of Nigeria is climate-determined and, therefore, subject to climate vagaries of different scales. Hence, the appropriate methods of investigating the relationship between climatic change and agricultural land use type were discussed under major approaches in this chapter. However, it is glaring from most agro-climatological researches carried out in Nigeria that the use of the marginal-spatial analysis and the historical case study techniques are the most unpopular of all the methods listed. Nigerian researchers in agro-climatology are, therefore, encouraged to adopt all methods available in seeking to combat the negative roles climate plays on agricultural industries of Nigeria. This will guarantee food security in the country.

References

Adefolalu, D. O. (1999). "Climate Change and Natural Disaster in Nigeria during the 1999 Rainy Season." *Resume* pp. 1-8.

Adeyemi, A. S. (2000). "Climate Change and Environmental Threat." In Jimoh, H. I and I. P. Ifabiyi (eds.) *Contemporary Issues in Environmental Studies.* Ilorin: Haytee Press pp. 158 – 164

Aina, E. O. and S. A. Adejuwon, (1994). "Regional Climate Change: Implication on Energy Production in the Tropical Environment." *Proceedings of the Regional Conference on Global Climate Change: Impacts on Energy Development.*

Ati, F. O. (2003). "Trends and Changes in Rainfall and its Onset Series for Kano." Proceedings of the Regional Conference on Global Climate Change and Food Sustainability in Africa, held at Oshodi, Lagos.

Bello, N. J. (1989). "An Agroclimatological Study of the Savanna Belt of Nigeria for the Growth of Maize (zea mays)" A Ph. D. Thesis submitted to the Department of Geography, University of Ilorin.

—— (1993). "Hydrometeorological Zoning of the Savanna Belt of Nigeria for the Growth of Maize (zea mays)" *Climatological Bulletin*27 (3).

—— (1996) "An Investigation of the Agroclimatic Potential of the Forest Savanna Transition Zone of Nigeria for the Cultivation of Sorghum." *Expl. Agric.* Vol. 33 C PP. 157 – 171.

—— (1999). "Investigating the Optimum Planting Date for Sorghum in the Forest Savanna Transition Zone of Nigeria for the Cultivation of Sorghum" *Expl. Agric* Vol. 35 PP. 1-10.

Blasting, T. J. and A. M. Solomon, (1993). "Response of North American Corn Belt to Climatic Warming" Doe/NBB – 004".

Bolin, B, B. Doos, J. Jagger and R. Warrick, (1991). The Greenhouse *Effect, Climatic Change and the Ecosystem.* Brisbane: John Wiley and Sons, pp. 151 – 197, 271 – 311.

Doorenbos, J and W. Pruit, (1984). Guidelines for Predicting Crop Water Requirements, *Food and Agriculture Organisation Irrigation and Drainage Paper* No. 24, Rome: FAO.

Edafienene, L. B. (2003). "Coastal Climate Variability and its Implication on Food Sustainability in Nigeria". *A Paper presented at the Regional Conference on Climate Change and Food Sustainability in the 21st Century,* Oshodi, Lagos...

Gowon, D. T. & N. U. Ononiwu, (1999). "Impacts of Climate Change on Soil Erosion Activities in Nigeria" *A Paper presented at the International Conference on Climate Change, Oshodi, Lagos.* pp. 1-11.

Kowal, J. and K.R. Stockinger, (1973). Construction and Performance of Weighing Lysimeter. Samaru Misc. papa. 44:1-8.

Newman, J. B. (1980). "Climate Change Impacts on the Growing Season of the North American Corn Belt". *Biometeorology* (2): 128 – 142.

Olaniran, O.J. and G.N. Summer (1990). Long-term Variation of Annual and Growing Season Rainfall in Nigeria, *Theoretical and Applied Climatology* 41: 41-53.

Olanrewaju, R.M (2005). The Preliminary Study of the Impact of Climatic Variables on the Growth of Melon in Kwara State. *Journal of Nigerian Meterological Society,* 5(1)

Owolabi, J.T and W. Adebayo, (2003). The Impact of Changes in the Growing Season on Crop Yield in Ekiti State. A Paper presented at the Regional Conference on Climate Changes and Food Sustainability in the 21st Century, Oshodi, Lagos.

Peman, H. L. (1948). "Natural Evaporation from Open Water, Bare Ground and Grass Surfaces" R. Soc. London. Ser. A. 193: 120 – 145.

Sahsamaoglou, H. S. and T.J. Makrogionis (1992). "Temperature Trends over the Mediterranean Region. 1950 – 1988" *Theory Application Climatological.* 45:183 – 192.

Schneider, S. H. and R. S. Chem (1980). "Carbon Dioxide Warming and Coastline Flooding: Physical Factors and Climate Impact" *Ann. Rev. Energy,* 5, 107 – 140.

Titus, J. G. (1986). "The Basis for Expecting a Rise in Sea Level." In Greenhouse Effect, Sea Level Rice, and Salinity in the Dalawa Estuary." EPA Publication.

Warrick, R. and J. Oerlemans (1990). "Sea Level Rise" in Houghton, J. T., G. J. Jenkins and Ephraums. J. J. (eds.) *Climate Change: The IPCC Scientific Assessment* 257 – 281.

WMO (1992), GCOS: Responding to the need for climate observations. WMO No. 777 PP. 1- 11.