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Climate Change and Soil Conditions in the Tropical Rainforest of Southeastern Nigeria

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Abstract

There is often the tendency for the component of a system to respond to perturbation whether from within or outside. Climate, itself a system, is never static because of some internal and external perturbations. Similarly, the bigger earth-atmosphere system to which climate belongs is never stable due to its components that are ever changing. As climate is affected by changes, other components of the earth-atmosphere system (Vegetation and Soil, for example) might respond to influences exerted on them by the change. Presently, climate change is one of the most actively investigated scientific issues because of its potentially far-reaching consequences. The recent climate change and its consequences on soil conditions in relation to the rainforest vegetation of Southeastern Nigeria have not been given their deserved attention. Consequently, this paper examines the relationship existing between the changing climate and soil conditions in the tropical rainforest of southeastern Nigeria and its implication for agriculture.

Keywords: Climate Change; Soil Conditions; Southeastern Nigeria and Tropical Rainforest

Introduction

Climate was once considered to be static possibly because of the long period of time it takes for a change to occur in it. Sometimes generations come and go without any marked change in climate. This notion of climate being static has equally been attributed to some authoritative works on the climate of various regions that were written without allusion to the possibility of change, sometimes without mention of the period to which the quoted observation referred (Lamb, 1966).

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Today, climate is well known to vary from time to time and from place to place consequently, some variation terms are commonly associated with climate such as variability, fluctuations, trends, cycles and change (Ayoade, 1983). Climate change is most easily accepted when evidences of it start manifesting in the environment. For example in the present change, droughts are becoming more frequent and prolonged and by extension, the expansion of desertification and its concomitant effects on vegetation, famine, drying –up and/or shrinking of water bodies and increased dust loading (Alpert *et al*., 1998; Miller and Tegen, 1998; Dube, 2002; and Obioha, 2005) Also, there has been increased frequency and magnitude of coastal flooding emanating from powerful and destructive hurricane propelled by strengthened storm systems (Ayres and Walter, 1991and IPPC, 1996), and the melting of glacier and frozen sea water (Ayres and Walter 1991; and Meyer, 1996). Similarly, the survival ability of some very sensitive organisms such as algae and corals has been altered. The increasing global temperatures (the driver of the present change) are translating into increased agricultural productivity and better vegetation conditions for some regions as they are becoming warmer and wetter; and enlarged habitable areas for some once frozen regions they get melted and warmer (Meyer 1996).

Danielson *et al*. (1998) and Obioha (2005) have noted changes in climate to be either naturally induced or induced by man's activities. The latter has been generally accepted as the major source of the present rapid change in climate. For instance, Kellogg and Schneider (1974), Kellogg (1978), Obasi (1992), Barry and Chorley (1992), IPCC (2001) and Goudie (2002) observed that, though climate changes had occurred in the past, the present is rapid. This is due to the inadvertent change man has made on the face of the land and the composition of the atmosphere which are of such magnitude that they should now be taken into account in any equation describing the global balance of nature. Probably because of this magnitude of change in climate and some of the recent destructive and life-threatening climatic events, the interest of many researchers, organizations, nations and governments have been aroused to research into the subjects. Soil conditions in the rainforest vegetable of southeastern Nigeria vis-à-vis climate change is therefore investigated in this paper as soils, vegetations and climate are components of the earth-atmosphere system. Perturbations in one affect the other.

Materials and Methods

Study Area

The study area, Southeastern Nigeria shown in Fig. 1, lies roughly between latitudes 4° and 7° North of the Equator and between longitudes 5° and 10° East of Greenwich (Nwagbara, 1997). It possesses about 37, 845Km^2 in land mass (Udo 1970) with 60 percent of this area covered by the tropical rainforest (Njoku, 2006). Being that most of southeastern Nigeria is within the tropical rainforest, the soils are largely a combination of hydromorphic soils, vertisols and ferrasol (Areola, 1983). Air temperatures over Southeastern Nigeria are generally high all year round. Current mean maximum temperature of the area is 32°C while the mean minimum is 21°C, and a relatively very wet coastal area with an annual rainfall total exceeding 3500mm (Njoku, 2006) Also its north is relatively drier with an annual rainfall total of about 1800mm within Enugu and Ogoja areas (Nwagbara, 1997).

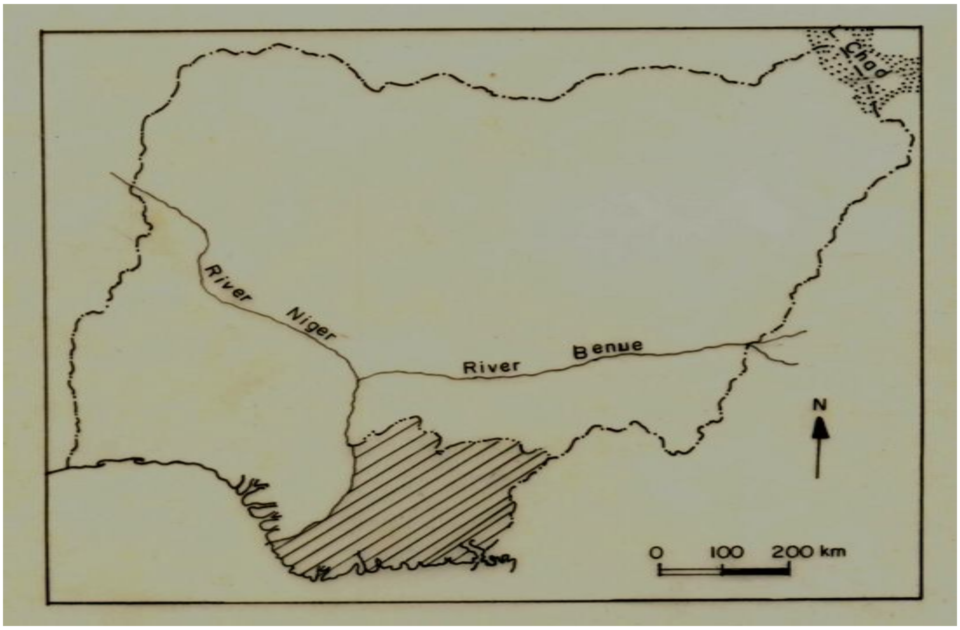

Fig. 1: Southeastern Nigeria: Study Area (Shaded)

Data Collection

Data used for the study are as follows:

(1) Rainfall amounts for Enugu (39 years) and Umuahia (35years)
(2)Maximum and minimum temperatures for Enugu (39 years) and Umuahia (35 years) .

These data were collected from the Nigeria Meteorological Agency (NIMET), Oshodi, Lagos, and analyzed using the linear regression statistical technique (Nwagbara *et al*., 2013). It is expressed in form:

y = a + bx - - - - - - - - - - - - - - - - - - - (1)

Where b = $\frac{n\sum xy-(\sum x)(\sum y)}{n\sum x^2-(\sum x)^2}$ - - - - - - - - - - (2)

$$a = \frac{\sum y}{n} - \frac{b\sum x}{n} = \bar{y} - b\bar{x}$$ - - - - - - -- (3)

a is the intercept; b the regression coefficient or slope; y the temperature/rainfall values; x the time in years; $\bar{x}$ the mean time; and $\bar{y}$ the mean temperature/rainfall values.

Results and Discussion

Climate Change in Southeastern Nigeria

Temperature and rainfall are good indicators of climate change (Nwagbara, 2008 and Uguru *et al*., 2011). Their trends describe a general increase or decrease in climatic variables over time. The annual mean temperatures of Enugu and Umuahia are increasing by 0.02 and 0.03^{o}C respectively per annum (Table 1). This implies a warming trend for Southeastern Nigeria, and this is in agreement with the global trend (IPCC, 2001, United States National Climatic Data Centre (USNCDC), 2001 and Ahlenius, 2007).

Table 1: Prediction Models for Mean Annual Temperatures of Southeastern Nigeria

S/N	Station	Period	a(Intercept)	b(Slope)	Regression Line Equation
1	Enugu	1970-2009	31.84	0.02	Y = 31.84 + 0.02 x
2	Umuahia	1977-2011	26.37	0.03	Y = 26.37 +0.03 x

Source: Nwagbara *et al*. (2013)

Generally, an increasing temperature implies that water molecules will be leaving wet surfaces by way of evaporation and transpiration. There is thus the tendency for rain to fall (Meyer, 1996, Chima *et al*., 2009). These implied that more luxuriant vegetation will be encouraged. And if a more luxuriant is encouraged thus enriching the soil. For annual rainfall totals, Enugu is getting wetter by 5.84 mm while Umuahia is doing so by 5.25 mm per annual (Table 2). It is not a surprise to find rainfall for the two sampled stations having an upward trend, just like their mean annual temperatures, which encourages evapo-transpiration and might result in rainfall.

Table 2: Prediction Models for Annual Rainfall Totals of Southeastern Nigeria

S/N	Station	Period	a(Intercept)	b(Slope)	Regression Line Equation
1	Enugu	1970-2009	1657.7	5.84	Y = 1657.7 + 5.84 x
2	Umuahia	1977-2011	2052.3	5.25	Y = 2052.3 + 5.25 x

Source: Nwagbara *et al*. (2013)

Soil Conditions of the Rainforest of Southeastern Nigeria

The tropical rainforest is particularly attracting interests because it is undoubtedly one of the most fascinating interactions between climate, vegetation, organisms, and soil that exist in the world. Tropical soils are among the deepest in the world because the soils are often several metres deep, and because they are often washed out or strongly leached with large amounts of nutrients and mineral being removed from the subsoil and considerable thickness of rock broken down to produce soil. Over millions of years this leaching has depleted many of the fundamental nutrients needed by the above ground vegetation (Brady and Weil, 2005). Many tropical soils are acidic and depleted in weather able minerals such as calcium, potassium and magnesium, essential for plants. Many lowland forests are limited by low level of phosphorus, or sometimes calcium and magnesium (Akamigbo, 2000). Plant growth is dependent upon the presence and interactions of many nutrients. To add to the intricacy of the situation, the presence or limitation of one mineral may affect the uptake and metabolism of others. For instance, the ability of leguminous trees to fix atmospheric nitrogen and convert it to nitrates and nitrites may be compromised by deficiencies in iron, molybdenum and/or calcium. Because there are so many types of tropical soils, their mineral profiles are so complex.

There are few nutrients more than 5cm below the surface of the soil in tropical rainforests (Keks, 2009). This poverty of soils has the consequence that the forest is dependent on the recycling of nutrients, most of which are contained within the vegetation and not in the soil, unlike temperate forests (Mbagwu and Scott, 2000). Many rainforest trees are evergreen and drop their leaves infrequently, thus there is relatively little “litter fall” in comparison with temperate forest. Leaves and dead plants and animal which fall on the forest floor are rapidly decomposed by fungi and bacteria, and the resulting chemical compounds are quickly reabsorbed by the living plants. Plants on tropical soils typically recycle 60% to 80% of minerals, and in the case of calcium and phosphorus, more than 99% of these minerals appear to be recaptured from the soil by the roots of forest trees (Brady and Weil, 2005). The remainder of necessary nutrients must come from soil or from rainfall. Under this stringent condition of the tropical soil of the rainforest, plants retain their nutrients because many have adaptations which allow them to exploit the limited quantities of nutrients in tropical soils. Root biome is very high where soils are infertile, so that plants can locate whatever nutrients might be available (Speergeren, 2005).

Forest trees grow on a mat of fungi (*mycorrhizae*) and absorb phosphorus and other minerals, and transfer them to roots. Many soil fungi, bacteria and other detritivores rapidly decompose organic material on the forest floor, and these compounds become part of the soils nutrient supply. High quality soil may have as much as 4000 kilograms of fungi per square meter, and 3000 kilograms of bacteria in the same volume (Ibanga, 2006). Trees form associations with nitrogen fixing bacteria and fungi, which can extract gaseous nitrogen from the air and convert it to compounds usable by plants. In addition, forests contain large number of arthropods earthworms (which aerate the soil and increase water infiltration), nematodes and many other organisms. Forests by means of their roots stabilize the soil and thereby reduce run off into rivers and lakes, and eventually, into oceans (Lal, 2006). Where soils are stable, balanced nutrients relationship between fresh water bodies and land are maintained (Fasina *et al*., 2007). Since many tropical soils are already heavily weathered, they are highly vulnerable to nutrient loss and this is why many tropical soils are difficult arenas for the establishment of agriculture. Only 209, of tropical soils are suitable for conventional agriculture, and many of these are found in alluvial plains and volcanic highlands (Keks, 2009). Disruptions of the nutrient cycle by clearing or burning (usually for agriculture or pasture) can be catastrophic for the soil, as nutrients will be rapidly lost and often the soil cannot support the same species as before, only an impoverished flora (Voroney, 2006).

Conclusion

Increased rainfall in the tropical rainforest has resultant effects. It encourages the vegetation. More vegetation will result in increased plant litter on the soil surface and this equally lead to increased soil nutrients. If the vegetation is destroyed by man, then the soil will be left bare. In this case, the resultant effects are loss of nutrients by leaching and loss of soil particles and nutrients by erosion.

References

Ahlenius, H. (2007): Climate Feedbacks. United Nations Environmental Programme/GRID –Arendal.

Akamigbo, F.O.R. (2000): The role of soil conservation in Nigeria agriculture in the 21 century. Being guest lecture delivered at the occasion of the 6th matriculation ceremony of the Federal Soil Conversation School, Owerri.

Alpert, P., Kaufman, Y. J, Shay-El, Y., Tanve, D., da Silva, A., Schubert, S. and Joseph, J.H. (1998): Qualification of dust forced heating of the lower troposphere. Nature, 395: 367 - 370.

Areola, O. (1983): Soil and Vegetal Resources. In: J.S Oguntoyinbo, O.O Areola and M. Filani (eds); A Geography of Nigeria Development. Ibadan: Heinemann Education Books, pp. 105 -126.

Ayoade, J. O. (1983): Introduction to Climatology for the Tropics. Ibadan: Spectrum Books.

Ayres R.U. and Walter, J. (1991): The greenhouse effect: damages, costs and abatement. Environmental and Resources Economics, 1:237 - 270

Barry, R.J. and Chorley, R.J. (1992): Atmosphere, Weather and Climate. London: Routledge.

Brady, N.C. and Weil, R.R. (2005): The Nature and Properties of Soils. Delhi: Pearson Education.

Chima, G.N., Nwagbara, M.O. and Ijioma, M.A.(2009): Rainfall response to dam/irrigation projects in northern Nigeria. Global Journal of Social Sciences, 8(1) pp. 41 – 50.

Danielson, E. W., Levin, J and Abram, E. (1998): Meteorology. Boston: WCB/ McGraw-Hill.

Dube, L.T. (2002): Climate of Southern Africa. The South African Geographical Journal, 84 (No. 1): 125 -138.

Fasina, A.S., Omolayo, F.O., Ajayi, O.S. and Falodum, A. A. (2007): Influence of landuse on soil properties of three mapping units in southeastern Nigeria – implication for sustainable soil management. Research Journal of Applied Sciences, 2(8) pp. 879 – 883.

Goudie, A. (2002): The Ever-changing climate. In: Douglass, I., Hugget, R. and Robinson, M. (eds), Comparison Encyclopedia of Geography. London: Routledge, pp. 44-66.

Ibanga, I.J. (2006): Soil Studies: The Pedological Approach. Calabar: Maesot Printing and Computers.

IPCC (Intergovernmental Panel on Climate Change) (1996): Climate Change 1995. New York: Cambridge Univ. Press

IPCC (2001): Climate Change 2001: The Scientific Basis. New York: Cambridge Univ. Press.

Keks, F. (2009): Forest soils. Department of Forestry and Environmental Management, MOUAU Journal, pp. 39 – 43.
Kellogg, W.W. (1978): Global Influences of Mankind on the Climate. In: J. Gribbin (ed). Climate Change. Cambridge: Cambridge University Press.
Kellogg, W.W. and Schneider, S.H. (1974): Climate stabilization for better or for worse? Science, 186: 1163-1172.
Lal, R.U. (2006): Encyclopedia of Soil Science. 1st Edition, Vol. 1. London: Taylor and Francis Group.
Lamb, H.H. and Johnson, A. I. (1966): Secular variation of the atmospheric circulation since 1750. Geographical Memoirs, 14 (No. 110): 125.
Mbagwu, J.L.R. and Scott, T.W. (2000): Physical properties of three soils in southern Nigeria. Journal SSN, pp. 136 – 148.
Meyer, W.B. (1996): Human Impact on Earth. New York: Cambridge University Press.
Michael E.R. (2009): The Physical Environment: An Introduction to Physical Geography. Stevens Point: University of Wisconsin.
Njoku, J.D. (2006): Analysis of the effect of global warming on forest of southeastern Nigeria using remotely sensed data. A Ph.D. Thesis: Imo State University, Owerri, Nigeria.
Nwagbara, M.O. (1997): Temperature characteristics and variability over cities in south-eastern Nigeria (1965 -1994). An M.Sc. Thesis: Department of Geography, University of Port-Harcourt, Port-Harcourt.
Nwagbara, M.O. (2008): Landcover change in relation to climate change in northern Nigeria using GIS techniques. A Ph.D. Thesis: Department of Geography and Planning, Abia State University, Uturu, Nigeria.
Nwagbara, M.O., Chima, G.N. and Ndukwe-Okoye, N. (2013): Climate change and soil erosion in the derived savanna of southeastern Nigeria. Being a paper presented at the 37th Annual Conference of the Soil Science Society of Nigeria held at Lafia, Nasarawa State, 11 – 15 March.
Obasi, G.O.P. (1992): Foreword. In: Anon (ed), Climate Change Environment and Development. Geneva: WMO, No. 722, pp v-ix.
Ronald, A. (2006): Soil Preservation and the Future of Pedology.
Spaargeren, O.C. (2005): Major soils of the world and their physical properties. International Soil Reference and Information Centre (ISRIC). Wageningen, the Netherlands.
Udo, R.K. (1970): "The Geographical Regions of Nigeria. London: Heinemann.
Uguru, M.I., Baiyeri, K.P. and Aba, S.C. (2011): Indicators of climate change in the derived savannah niche of Nsukka, south-eastern Nigeria.
USNCDC (United States National Climatic Data Center) (2001): Global Temperature Changes (1880 – 2000). Washington D.C.
Voroney, R.P. (2006): The Soil Habitat. In: A.P. Eldor (ed), Soil Microbiology, Ecology and Biochemistry.