



Review Article

An Overview of the Changing Pattern of Rainfall and its Implications for Environmental and Agricultural Development: Akwa Ibom State, Nigeria—A Case Study

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ABSTRACT

This paper examined the changing pattern of rainfall in Akwa Ibom State and discussed the implications thereof for environmental development. Using annual rainfall total from 1977 to 2006 obtained as secondary data from University of Uyo meteorological service, inter-annual variability was examined. The trend of variability over the years was computed using regression model. The result of the analysis indicated coefficient (R) value of .196 and R² value of .039 implying that the temporal relationship of rainfall is positively low. This showed that the pattern of rainfall is changing positively in terms of annual rainfall totals and intensity. The analysis also shows that 52%, 37% and 11% annual rainfall totals fell as light rains of less than 25.4 mm, moderate rainstorms of more than 25.4 mm and heavy rainstorms of more than 100 mm, respectively. While the light rainstorm is declining over the years, the moderate and heavy rainstorms are increasing. On the basis of the findings, the study discussed the implications of the changing pattern of rainfall for environmental and agricultural development and made useful recommendations. © 2010 Friends Science Publishers

Key Words: Rainfall; Environment; Agriculture; Nigeria

INTRODUCTION

Rainfall is an element of weather. Other elements of weather include temperature, humidity, wind, cloud and sunshine. It is the collective pattern of expression of these elements overtime that becomes described as the climate of a place. Climate is the synthesis of the weather in a given place over a period of at least 30 years. Thus climate is the “average weather” together with the variability from the average. Climate change is a change in the collective pattern of expression of weather elements. Obioh (2002) stated that climate change is the permanent departure of climate pattern from mean values of observed climate indices. Accordingly climate change differs from climate variability in the sense that the latter means annual variations in temperature and rainfall and their spatial distribution, while the former refers to long term changes in weather patterns resulting from changes in composition of the atmospheric gases (UNEP, 2002; World Bank, 2008).

It is important to note that all the greenhouse gases have strong human sources. For instance, it is estimated that Nigeria is the largest contributor of global emissions of Carbon dioxide and other greenhouse gases in the sub-region, accounting for 11% of Africa's total emissions in 1996 (ADB, 2001; UNEP, 2002). According to United

Nations (1999), Nigeria has gas reserves estimated to be sufficient to provide power to the whole of West Africa but gas flaring in Nigeria consumes large amounts of natural gas daily during oil extraction activities thereby contributes to atmospheric pollution. This produced the uncomfortable realization that climate change is human-induced attributable to human activities undertaken on daily basis in the course of ordinary living or while pursuing development e.g., generating energy for driving machines, transportation, cooking, heating, cooling and manufacturing; producing food by farming, applying fertilizer, livestock production, using halo carbon containing propellants for spraying or refrigerants for cooling (NEST, 2004a). In Nigeria in general and Akwa Ibom State in particular, the changing pattern of rainfall is noticeable in the form of rainfall variability, which result in unpredictable changes in the frequency and intensity of extreme weather events such as floods, erosion and landslides. While the number of geophysical disasters has remained fairly steady, the number of hydro-meteorological disasters since 1996 has more than doubled. During the past decade over 90% of those affected by natural disasters are linked to hydro-meteorological events such as windstorms, floods and droughts (IFRCRCs, 2001).

The analysis of changing pattern of rainfall is of

serious concern in Akwa Ibom State for a number of reasons. Every part of Nigeria will be affected by climate change but the degree of impact will vary depending on the geography of the area. The coastal regions will be more threatened by sea-level rise than inland regions. Also events like tropical storms will be exacerbated by climate change and as such, coastal regions are at greater risk of such events than inland regions. Thus, Akwa Ibom State being a coastal region is one of the most vulnerable regions due to its geographical location. Nigeria has a coast line that is more than 800 km long. Calculations showed that 0.2 m rise in sea level will inundate 3,400 km² of our coast land and a 1.0 m rise will cover 18,400 km² (Onofeghara, 1990; Adejuwon, 2002). The problem of coastal erosion, which already is a menace in the region will worsen, flood hazards will increase and intrusion of sea water into fresh water sources will increase, while mangroves, agriculture and fisheries will be destroyed. There will be changes in water level and volume of streams, rivers and ponds as well as frequency of storms. The general livelihoods will be destabilized population displaced and social conflict already prevalent in the region will be heightened.

Of all the sustainable development challenges facing Nigeria, few are critical and daunting as the deepening level of poverty. While only 28% was considered poor in 1980, 70% of all Nigerians survive on 1 US Dollar a day at present (NPC, 2004; Amina, 2005, 2006). With a GDP per capita figure comparable to South Korea and Malaysia 20 years ago, Nigeria today falls below sub-Saharan Africa average in a wide range of human development indicators. There is high poverty profile in Akwa Ibom State (Atser, 2008). This implies that climate change will further threaten poverty reduction programs of the government. Agriculture being dependent on rainfall will be adversely impacted by increased variability in timing and amount of rainfall, while areas that rely heavily on fishing may also be hit. The production of crops also can be depressed by the variability in rainfall pattern. The variability in the onset and cessation of rainfall and rainfall amount undermines the age-long ability of farmers to predict when to plant their crops. Unpredictable changes in the onset of rain in the last 20 years have led to situations where crops planted with the arrival of early rains get smothered in the soil by an unexpected dry spell that can follow early planting. Thus rainfall variability may result in harvest failures especially, where rain fed agriculture is practiced. According to OFEDI (2009), increased disruption of agricultural calendar wrecks havoc on agricultural planning.

Against the background of the vulnerability of Akwa Ibom State to climate change impact, it is expedient to attempt an overview of the changing pattern of rainfall as a measurable indicator of climate change. Such an overview is expected to reveal the direction and magnitude of change in the rainfall pattern and discuss the implication thereof for the sustainability of environmental development.

The study area and data sources: Akwa Ibom State is the study area. It is one of the oil rich states in the Niger Delta Region of Nigeria. Located in the southeastern coast of Nigeria, Akwa Ibom State was created on September 23, 1987 from the former Cross River State of Nigeria. The State is wedged in between Rivers, Abia and Cross river States and the Republic of Cameroon to the Southwest, North, East and Southeast, respectively while the Bight of Bonny bordered the State to the South. It lies between latitudes 4°32' and 5°32' North of the Equator and longitudes 7°28' and 8° 25' East of the Greenwich Meridian. According to NPC (1998), Akwa Ibom State has a total land area of 6,187 km², which represents 0.67% of the total land mass of Nigeria. The State has 31 Local Government Areas with Uyo, Eket, Ikot Ekpene, Abak, Etinan, Ikot Abasi and Oron being the most developed urban centres. According to the 2006 National Population Census result, Akwa Ibom State had a total population of 3920208 persons out of which 87.89% constituted rural population, while 12.11% formed the urban population (NPC, 2007), thereby accounted for 2.7% of the over all national population. The most striking characteristic of the population of Akwa Ibom State is its crude density. When compared with other states in the south-south and southeast, the region is one of most densely settled state. In fact, apart from Imo and Anambra States, Akwa Ibom State is the most densely populated state with densities as high as 634 persons per square kilometer in Nigeria (NPC, 2007). The state is virtually surrounded by water with Atlantic Ocean flanking the southern part, Cross River to the east and Imo River to the west. As a coastal state, it is characterized by many streams and creeks. This scenario has created an illusion of abundance of water for domestic uses and thus, eclipsed the reality that adequate water is an increasingly scarce commodity in the region. Investigation has shown that streams, which are the major sources of domestic water supply in rural areas are drying up (Abasiiodiong, 2003). In the urban areas the ugly situation has led to desperate resort to indiscriminate underground water extraction through borehole drilling. The implications of this development are obvious. Beside characteristically long queues of water boreholes, water supply from most boreholes is not safe due to contaminants loading in them as a result of non-treatment. Thus the increasing waves of water borne diseases in our society are due to consumption of water from untreated sources (Bassey, 2003). Data on rainfall, number of rain days per month and frequency and intensity of rainfall were acquired from secondary sources for analysis using regression models.

Pattern of rainfall in Akwa Ibom State: Rainfall in the coastal areas of Nigeria follows the typical tropical rain forest climate. There is rainfall during each month of the year. Table I shows the mean monthly rainfall and number of rain days over time. However there is relatively dry part of the year from December to February, when monthly rainfall is low.

Table I: Mean Monthly Rainfall and Number of Rain Days (1977-2006)

Months	J	F	M	A	M	J	J	A	S	O	N	D	Total	Mean
Rainfall (mm)	15.4	44.3	141.2	214.2	268.8	291.1	364.0	350.4	351.3	274.5	104.0	13.8	2430.0	202.5
Rain days	2	2	8	11	14	17	19	18	16	15	8	1	131	10.9

Source: University of Uyo Meteorological Records (2008), Udosen (2008)

Usually there is a 'little dry season', which occurs from the middle of July to the end of August. There is no clear indication from our findings that this pattern will change in the near future. The findings however, indicate a probability of an increase in rainfall during the rainy season and a decrease during the dry season months. Thus there is the probability of dry season becoming drier and rainy season becoming wetter. In Akwa Ibom State, the annual cycle of rainfall pattern shows that the July, August and September months have the highest precipitation. In the past years, a double rainfall peak was usually observed in the months of July and September with the month of August experiencing a dry spell called 'August break'.

The mean monthly distribution of rainfall shows that December, January and February months do not record heavy rainfall. This period indicates water deficit situation during the short dry season. High concentration of rainfall occurs in the months of May to October with July, August and September months having the highest rainfall total. It is observed that between 1977 and 2006, the study area had a cumulative mean monthly rainfall total of 2430 mm, out of which 1065.7 mm representing 43.9% occurred in the months of July, August and September. This gives an average value of 355.2 mm for the three months. While August and September months rainfall have values below the mean, the amount of rainfall recorded in July implies that the month of July is still outstanding in the frequency and intensity of rainfall in the region.

Table II shows data on total annual rainfall from 1977 to 2006. From the data, the yearly variability in rainfall reflects a marginal upward trend over the years as indicated by low positive R-value of .196, which explains about 3.9% (R-square value of 0.039) of temporal variations. Table III and Figure I highlight the nature and magnitude of the relationship existing between annual rainfalls over the years. However a number of sharp peaks of relatively higher annual totals are observed, while the driest period occurred in the year 1983 when the total annual rainfall of 1599.4 mm was recorded. Using the mean or average value of the 30 years total annual rainfall data, it is possible to examine the inter-annual variability of rainfall around the mean. Generally the pattern of rainfall variability in the region closely reflects the mean annual rainfall, being greatest in absolute figures between 1977 and 1979. This is followed by a concentration of dry years with values being below the mean value. The yearly variability in rainfall totals depicts a 10 year cycle of dry years as indicated by the year 1983, 1993 and 2003, respectively.

Table IV shows that the first 10 years (1977-1986) has a total rainfall of 26196.2 mm with a mean value of 2619.62

mm and a standard deviation of 807.64 mm. The mean value for this decade is above the overall mean of 2453.76 mm for 30 years. Although subsequent decades reflect a general trend of decreasing rainfall total in the region, the rainfall total in the last decade (1997-2006) indicates impressive amount over the previous decade (1987-1996). The observed increase in rainfall total from 2004-2006 points to the fact that the increase in total rainfall observed in the last decade (1997-2006) may continue to the next decade (2007-2016). In terms of frequency and rainfall intensity, the data on Table II shows yearly percentage of rainfall less than 25.4 mm (light rain), rainfall more than 25.4 mm (moderate rain) and rainfall more than 100 mm (heavy rain). A summary of rainfall intensity is presented in Table V.

Table V shows that showers of less than 25.4 mm accounted for about 52% of total annual rainfall. This is light rainfall and it is declining (Table V). The highest concentration of light rain occurs in 1997, where about 84.1% of total annual rainfall occurs as light showers. Rainfall of moderate intensity on the average accounts for 37.0% of annual total and occurred in showers of more than 25.4 mm, while rainfall of heavy intensity coming as showers of more than 100 mm averagely accounted for 11.0% of annual rainfall total and this category is experiencing an increasing trend over the years and thus, reflects the changing pattern of rainfall in the region.

The implications for environmental and agricultural development: The changing pattern of rainfall in Akwa Ibom State has a number of implications for environmental development planning. The data in Table II, which indicated the frequency of intense rainfall has implications for the design of structures such as bridges, dams, culverts, roads construction, drains and agriculture development in terms of soil conservation and protection. These environmental infrastructures must be designed based on predicted magnitude of floods, which the structures have to withstand during their estimated life span. A latest report on climate change has started that the consequences of climate change for human beings are unclear and unpredictable (Etuonovbe, 2008), arguing that in 1990, the Intergovernmental Panel on Climate Change (IPCC) noted that the greatest single impact of climate change could be on human migration with millions of people displaced by shoreline erosion, coastal flooding and agricultural disruption (IPCC, 2001). OFEDI (2009) observed that the changing pattern of rainfall experienced in almost all the West African Countries is an important indicator of significant climate change, which in consequence has serious adverse effects on agriculture and food security.

Table II: Inter-annual variability of rainfall in Akwa Ibom State (1977–2006)

Year	Rainfall Total	Light Rain (>25.4 mm)	Moderate Rain (<25.4 mm)
1977	3855.5	15.9	84.1
1978	3270.7	30.6	69.4
1979	3825.4	19.2	80.8
1980	2860.4	44.2	55.8
1981	2426.8	49.2	50.1
1982	2442.5	48.9	51.1
1983	1599.4	55.1	44.9
1984	1878.7	43.7	56.3
1985	2132.6	39.1	60.9
1986	1904.2	40.4	59.6
1987	2251.4	48.5	51.5
1988	2115	34.2	65.8
1989	2588.5	37.2	62.8
1990	2032.8	53.3	46.7
1991	2246.7	52.4	47.6
1992	2256.8	32.6	67.4
1993	2229.5	43.8	56.2
1994	2668.7	41.1	51
1995	2282	44.6	46.8
1996	2378.4	55.2	44.8
1997	2004	58.6	41.4
1998	2033.8	47.6	52.4
1999	2945.4	57	43
2000	1904.5	54.4	45.7
2001	2317.2	38.1	62
2002	2341.5	32.1	67.9
2003	2194.8	48.7	51.3
2004	2221.6	33.6	66.5
2005	3030.5	39.6	60.4
2006	3373.7	34.1	65.9

Source: University of Uyo Meteorological Records

Table III: Regression statistics

Parameters	R	R-square	Adj.R-square	Std. error	F	Sig.
Linear	.196	.039	.004	554.8	1.122	.299
Growth	.151	.023	-.012	.212	.655	.425

Table IV: Summary statistics of rainfall total in Akwa Ibom State (1977-2006)

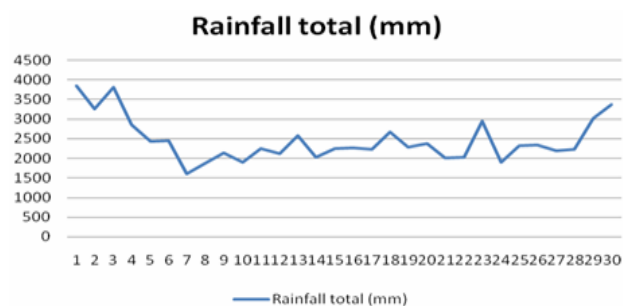
Period	1977-1986	1987-1996	1997-2006	1977-2006
Total	26196.2	23049.8	24367.0	73613
Mean	2619.62	2304.98	2436.7	2453.76
SD	807.64	195.24	500.03	555.94
Minimum	1599.4	2032.8	1904.5	1599.4
Maximum	3855.5	2668.7	3373.7	3855.5

Table V: Summary statistics of rainfall intensity in Akwa Ibom State

% rainfall	Sum	Mean	SD	Min	Max	Status	Trend
>25.4 mm	1560	52.0	9.5	41.1	84.1	Light	Declining
<25.4 mm	1110	37.0	10.3	15.9	58.6	Moderate	Increasing
<100.0 mm	330	11.0	10.3	3.8	50.7	Heavy	Increasing

As a coastal region, the changing pattern of rainfall and its frequency is indicative of the vulnerability of the region to erosion and flood disaster. Against the background that a 0.2 m rise in sea level will inundate 3,400 km² of our coastland (NEST, 2004b), there is need to plan the coastal environment in order to prevent the fragile environment

Fig. 1: Annual Rainfall over the years (Derived using Table II)



from impending disaster. This may be achieved through integrated coastal area planning approach. This is necessary, because the future economic development in the coastal areas in large measures depends on how the coastal ecosystem is utilized and managed sustainably in such a way that the resource base of the coastal area is not willfully degraded. Activities in the coastal environment should be guided by planning legislations. Policies on set back for instance must be implemented in order to conserve the coastal zone and therefore conserve development. Thus the integrated coastal area plan (ICAP) would focus basically on issues of erosion/flood management, degradation of coastal area natural habitats and protection of scenic areas and cultural sites. The usefulness of the analysis of changing pattern of rainfall and the frequency of intense rainfall in Akwa Ibom State lies in predicting both the severity of erosion/flood events. The years with severe soil erosion and flood menace would coincide roughly with exceptionally high rainfall totals. According to Udosen (2008), intense soil erosion and flood hazards occurred in Akwa Ibom State in 1977. The same year contrast remarkably with other years in terms of its high rainfall total of 3855 mm.

The changing pattern of rainfall in terms of annual rainfall total and rainfall intensity in the study area is consistent with the predictions for climate change. Since the climate change has the potentials to affect all natural and human systems and a threat to system development and human survival, it is important that all segments of the society have adequate information on the trend and magnitude of change so as to create a common zeal to pull resources together to manage the effects of climate change.

Since the close of the 2009 United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen, about 35 developing countries including Nigeria have communicated information on the nationally appropriate mitigation actions they have planned to take (United Nations, 2009). There is need to put in place effective mechanisms capable of bringing about significant acceleration of such actions to prepare for the inevitable impact of climate change. The reality of climate change is that our environment is failing to cope with the sudden upsurge of flooding that is aggravated by narrow bridges, drains and the blocking of water courses by developmental

structures. Changes in timing and length of growing seasons may lead to planning problems for agriculture. For instance, the changing pattern of distribution of forest and other natural habitats may place more animals and plant species under the threat of extinction and inland fisheries may be threatened by the changing rainfall and flood regimes. For instance, brackish water is the home of several species of fishes and changes in the ecology of the brackish water will affect the fish population. Cline (2008) posited that climate change can affect agriculture in a variety of ways. Agricultural effect of sea level rise is increased salinity of both surface and underground water due to the intrusion of sea water. This will have serious impacts on food security, because of its impact on coastal agriculture. The salinity of underground water will lead to shortage of fresh water for domestic uses. Climate change exacerbates the challenges of growth and development. According to Kirk and Marianne (2009), growth and development challenges of climate change are already harming developing countries by introducing new threats, worsening old ones, diverting resources from development programs and making it more difficult to escape poverty. Climate change disasters affect lives, livelihoods, economies, political systems belief systems and in short, everything that makes society works. Thus socio-economic cost of climate change impact is often enormous involving physical losses of buildings, infrastructure, crops and materials. Our policy makers in government therefore must be ready to appropriate more funds than ever before to massively develop and expand infrastructures to cope with the new realities. This is because greater climate resilience measures involves more financial commitment to make communities become stronger in terms of development so as to promote macroeconomic stability and alleviate poverty (Jones & Keen, 2009). Climate change hazards cannot be prevented but early warning systems and sustainable development, which has proved beyond doubt to save lives and reduce economic losses at all levels should be instituted.

CONCLUSION

The analysis of annual rainfall data showed remarkable increase between 2004 and 2006. However on decadal basis, the last decade (1997-2006) recorded rainfall total of 2436.7 mm, which is less than the amount recorded from 1977-1986. The observed increase in rainfall total between 2004 and 2006 implies that in the current decade (2007-2016), the region may experience tremendous increase in total rainfall. While rainfall in showers of less than 25.4 mm is declining, rainfall of moderate and high intensities occurring in showers of more than 25.4 mm and 100.0 mm, respectively are increasing. On the basis of the findings this paper recommends the following. The government authorities in charge of climate data need detailed record of rainfall data from year to year and pre-inform farmers on the time to start planting working with

the rainfall data from previous year. This will help to strengthen this strategy for adapting to variation in rainfall pattern. Planning plays a major role in the protection of natural resources, of habitats and biodiversity. Closer attention should be focused on detailed research, proactive environmental planning, impact assessment and management. For instance preparing master plans for the control of land, coastal and marine based activities to minimize pollution and protect coastal and marine resources. The value of the coast should be emphasized, ways of facilitating sustainable coastal development, promotion of coordinated and integrated coastal management as well as the style of management should all be adequately considered. In order to achieve this, extensive use of professionals (Urban Planners, Surveyors, Environmentalist, Engineers, Builders & Agricultural Experts etc.) who have a good knowledge of practical options should be used. Finally, the three tiers of government must respond to climate change and other environmental challenges now, while the cost is low or else pay a stiffer price later for lack of concern. In order to achieve sustainability in the study area, there is a need for research on how societal driving forces (social & demographic, political & institutional, economic & commercial, cultural & technological) affect the nature and distribution of human activities in the state and their impacts on ecosystems. Development agencies such as the World Bank, UN and others should work more closely with grassroots organization in the region that are privileged to have good knowledge of the communities. An integrated coastal resource management approach with the objective of promoting sustainable utilization of coastal resources as well as restoring and maintaining the integrity of coastal ecosystems, needs to be adopted to address a wide range of social and environmental issues and move coastal areas towards sustainable development. Sound policies and decision making with information systems especially the geographic information system (GIS) needs to be adopted for information collection, analysis, management and dissemination of technical data relevant to various coastal communities planning needs. Above all people need information as much as water, food, medicine and shelter. Information can save lives, livelihoods and resources. The right kind of information, which could be the most affordable form of disaster preparedness for the vulnerable communities, can lead to deeper understanding of needs and ways to respond (IFRCRCS, 2005, 2009). This study emphasizes that wrong information can lead to inappropriate interventions while lack of it can make people victims of climate change impact.

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(Received 12 April 2010; Accepted 08 May 2010)