VULNERABILITY ANALYSIS OF THE EFFECTS OF CLIMATE CHANGE IN SOME PARTS OF SUDANO-SAHELIAN NIGERIA

By

***Mansur Bako Matazu**
and
Tayo Iyanda
Department of Geography
Federal University of Technology
e-mail: mbmatazu@yahoo.com

Abstract
The effects of the impact of climate change will in no doubt affect the ability of the third world countries to achieve poverty reduction and sustainable development strategies. The focus of the vulnerability considered in this paper, is vulnerability to drought and desertification. The degree of wetness/dryness, mean annual rainfall, specific water consumption and the shortest length of the rainy season were examined and used as indices for the vulnerability ranking. In doing this, the states are ranked in terms of each index of vulnerability, then the rank each state achieved for the four indices were averaged to derive a mean rank score. The average rank score was used to derive the overall rank. Sokoto state is found to be the most vulnerable state to the drying effect of climate change. Sokoto is followed by Jigawa, Zamfara, Kano, Katsina, Kebbi, and Kaduna , in that order, making Kaduna the least Vulnerable of all the north-western States of the country. However, by incorporating climate change adaptation will better manage the risks, adapt to changing future risks management into development strategies.

1.0 Background

During the 20th century, particularly in the period following World war II, level of industrialization, changes in land use and the number of vehicles on the world's roads have risen dramatically. The socio-economic benefits of these events are plainly verifiable in an increasing number of countries. The environmental consequences are equally recognizable with many polluted water ways and lakes and acid rain damaged forests, smog over many of the world's cities and public health advisories concerning health hazards of pollution and the dangers of sun exposures.

Other more insidious effects of industrialization may yet overshadow the obvious "local" pollution problems and these concern the build-up of green house gases in the earth's atmosphere that have resulted in ever increasing global warming with unprecedented consequences for humanity and ecosystems. The evidence though not universally accepted, is Climate Change.

The effects of the impact of climate change will no doubt affect the ability of third developing countries to achieve the Millennium Development Goals (MDGs) with respect to poverty reduction and sustainable development strategies. However, by incorporating

climate change adaptation, it is possible to reduce and manage present risks, adjust to potential future risks and develop management strategies.

2.0 Drought and Water Resources Problems in Nigeria:

Drought and aridity have intensified in Nigeria since 1950s, mostly in the dry lands of the country. A perpetual decrease of rainfall north of latitude 11° N has been observed. Also, analysis of climatic data collected at Mallam Aminu Kano International Airport, have shown that since 1962, no year has recorded up to 1000mm. before then, a high rainfall of over 1000mm was normal in most except drought years.

In fact, about 30% of area in the country is prone to severe desertification. The Lake Chad is fast diminishing by almost 90% of its original size in 1963 of about 23,000km^2 (Olofi n, 2006).

Closely related to climate is the issue of water which all life forms depends upon, and water issues pose many challengers of environmental security in Nigeria. These relate to water availability and quality. In many areas, it is not possible to obtain a ready source of sufficient drinking water. Rapid population growth and urbanization pose threats to water resource utilization. Surface water that is used for food production and other domestic purposes is often medium of pollution and transmission of disease. Ground water is not easily accessible and technologies for underground water detection, acquisition and monitoring are underdeveloped in Nigeria.

3.0 Eco-Climatic Characteristics of The Region:

The seven States to be considered in the Sudano-Sahelian belt are: Jigawa, Kaduna, Kano, Kebbi, Sokoto and Zamfara States. The States span the climate vegetation ecological zones known as the Sahel, Sudan and Guinea Savana.

The level of vulnerability of each state in the sub region to ecological problem has been appraised based on the analysis of the spatial patterns of the:

a) Characteristics of the onset and cessation of the rains. These are normal and extreme onset and cessation dates of rainfall including length of the rainy season.
b) Rainfall intensity
c) Mean annual rainfall
d) Degree of wetness or dryness known as the hydrologic ration ( )
e) Specific water consumption or rainfall equivalent to be available in order to avert drought.

The level of vulnerability to drought of each state depends on the deviation of the critical hydro meteorological parameters from normal condition as presented in the tables below:

Table 1: Kaduna State: Precipitation Characteristics

Parametre	Lowest Value	Highest Value	Remark
Rainfall intensity (mm/hr)	34	48	Low to fairly moderate rainfall intensity
Degree of wetness or dryness (n – ratio)	0.3	0.8	Low hydrological ratio in the semi-arid improving to fairly high hydrologic ration in the south.
Mean annual rain fall (mm)	800	1800	Moderate to high rainfall in the middle belt
Specific water consumption (w/f)	-600	+600	Very high to poor conditional w/f from south-northern part of the state.

Source: (Eco-climatic Atlas, CCCFR, Nigeria 2006).

* Mean **Cessation Dates**:

The pattern is complex. The earliest dates of mean cessation are before October in the north-east and between Shika and Sabon-Bimi. Mean cessation dates at varying times in October affect the major areas of the state with the latest dates put after October 27 occurring north of Yelwa and around Zango.

Length of rainy season in Days:

Spots in the north (pink) have between 110 and 120 days, while a portion in the southeast and around Kwoi and Kagoro axis has over 160 rainy days, making Kaduna the wettest of the selected states.

*** Specific water consumption ratio (w/f):**

The Kurmi – Biri, Kachia, Kwoi and Kafanchan area has negative ratios of -200 to $<$-600 showing surplus balance naturally. Most of the other areas has positive ratios with the highest (yellow) around Ku-daku at +600. A large zone in the central part (Birnin-Gwari and Yelwa including Kaduna city) has ratios of -200 to 00.

Table 2: Kano State: Precicipitation Characteristics

Parameter	Lowest Value	Highest Value	Remark
Rainfall intensity (mm/hr-1)	30	40	Low to moderate rainfall intensify dropping to moderate rain shower
Mean Annual rainfall (mm)	600	1100	Low to moderate rainfall
Degree of wetness or dryness (n) ratio	0.2	0.4	Pure Sahel in all ramifications with severity of drought towards the northern- tip
Specific water consumption (w/f)	+200	+700	In the southern boundary were +20 to +400 deficit water equivalent prevails

Source: (Eco-climatic Atlas, CCCFR, Nigeria 2006).

*** Mean Cessation Dates:**
By September, 17 it is all over for Gwarzo and Rano areas in the central west, while the rain cease for the entire state by the end of September, except for a section of the south-east and south (Sumaila and Riruwai), when rains persist until October.

*** Length of the Rainy season in Days:**
The western periphery of Kano State has less than 90 rainy days, followed by a ribbon of 90-120 rainy days belt, while the central portion (yellow) has 120-130 days and the south east having over 130 days.

*** Specific water consumption (w/f):**
Only a small area west of Bebeji and areas near Riruwai record 00 to +200 the middle, south and west have +120 to +600 while the northern half (yellow) has over +600.

Table 3: Jigawa State:Precipitation Characteristics

Parameter	Lowest Value	Highest Value	Remark
Rainfall intensity (mm/hr-1)	34	40	Moderate to high suggesting the packing of isopinic lines to be due major rain storms that can generate flood.
Mean Annual rainfall (mm)	400	900	Low to moderate rainfalls flash flood under rainstorms responsible for moderate rainfall in the western sector.
Degree of wetness or dryness (n) ratio	0.2	0.4	High run-off and poor soil moisture retention under sahelian condition.
Specific water consumption (w/f)	+200	+1000	High deficit of water equivalent to avert drought most severe to the east and decline in the western periphery of the state.

Source: (Eco-climatic Atlas, CCCFR, Nigeria 2006).

*** Mean Cessation Dates:**
Mean cessation of rains is as early as first week of September in the north-west section where mean onset could be as late as end of May. Mean cessation occurs in the central part around early October, where onset is around mid-June. The real wet season is therefore between June and August.

*** Length of Rainy Season in Days:**
In the north-eastern part, the shortest length is less than 50 days and less than 100 days in the north-west and south-east. The area with the longest LRS of over 130 days particularly around Dutse and Birnin-Kudu.

*** Specific Water Consumption:**
It should be remembered that positive ratios mean water deficit indicating the amount needed to avert drought conditions and negative ratios mean amount to be drained to prevent natural floods. There are no negative ratios in any part of Jigawa State. Indeed, the least prone place to drought is in the south-west corner with less than +200 but over 00, while the north and east have ratios of over +600.

Table 4: Katsina State: Precipitation Characteristics

Parameter	Lowest Value	Highest Value	Remark
Rainfall intensity (mm/hr-1)	32	36	Rainstorms strongest to the north built of moderate intensity.
Mean Annual rainfall (mm)	600	1400	Highest rainfall to the north west. Lower rainfall in the south in anomalous especially around Funtua.
Degree of wetness or dryness (n) ratio	0.2	0.4	Pure Sahel to sub-sahel in a narrow band south of Funtua where rainfall (>800mm) is only moderate.
Specific water consumption (w/f)	+00	+1000	Driest part in the middle and northern tip of the state with marginally surplus water in areas south-east of Funtua.

Source: (CCCFR, Nigeria 2006).

*** Mean Cessation Dates:**
The earliest mean cessation is around September 27, and rains persist until October 13, around Funtua.

*** Length of Rainy Season in Days:**
Only a small section in the northern tip of Mai-Adua and Mani has less than 90 rainy days whereas the southwest corner around Funtua and Danja has over 150 rainy days. The entral west near Kankia, Matazu and Malumfashi has 120-150 rainy days. The rest of the state has between 90-120 days.

*** Specific Water Consumption:**
Only the southern tip records a ratio of 00 - +200, all other areas record positive ratios with areas around Safana recording over +1000.

Table 5: Kebbi State:Precipitation Characteristics

Parameter	Lowest Value	Highest Value	Remark
Rainfall intensity (mm/hr-1)	30	40	Moderate but heavy rain storm occurrence is prevalent to the southern half of the state.
Mean Annual rainfall (mm)	600	1800	Moderate to high rainfall especially in Yelwa / Yauri (proximity Kainji Lake)
Degree of wetness or dryness (n) ratio	0.2	0.7	Dryness of Sahelian to Guinea Sudan condition. Orientation is NW - SE .
Specific water consumption (w/f)	-200	+1000	Hydrologically stable in the southeast. But pure Sahel condition is to the northern line SW/NE through Yelwa and Wasagu.

Source: (CCCFR, Nigeria 2006).

*** Mean Cessation Dates:**

On the average, rain lasts until October in Kebbi State, only a small areas around Bena in the east and Kande and Illela in the west have rains stopping by September 27. Rains last until October 27 in the southern tip of the state. On the average, the onset of rains is May.

*** Shortest Length of Rainy Season in Days:**

Only a small portion in the west around Bunza has less than 90 days while limited areas east of Zuru around Tunga-Illela have over 140 rainy days.

Table 6: Zamfara State: Precipitation characteristics

Parameter	Lowest Value	Highest Value	Remark
Rainfall intensity (mm/hr-1)	30	36	Moderate with more storms to be expected in the northeast
Mean Annual rainfall (mm)	500	1400	Rainfall is from low to high in the north/south direction
Degree of wetness or dryness (n) ratio	0.1	0.5	(n) ratio of dryness is high, in line slightly with vegetation belt south of the state.
Specific water consumption (w/f)	+00	+1000	No appreciable water surplus hence the dryness is of the pure sahel.

Source: (CCCFR, Nigeria 2006).

*** Mean Cessation Dates:**

Mean dates run in semi-latitudinal belts in the state, strangely starting from the south before September 17 and moving northwards, reaching October 17 in the middle and some portion in the northwest. The mean onset of rains also behaves in the same manner with the area around Binki and Bawa receiving rains before April 17.

Length of Rainy Season in Days:
Only a small area around Isa and Galadi in the north has less than 90 rainy days. The bulk of the start has between 90 to 120 rainy days with parts of the east and west having over 120 rainy days.

*** Specific Water Consumption ratio:**
Some areas in the south around Mutumi Dogo and Kwiambara record 00 to +200 within which a small area between Marafa and Maraba records less than 00. The other areas of the state show ratios of +200 to +600, +600 to +1000 with the northern tip north of Isa displaying a ratio of +1000.

Table 7: Sokoto State: Precipitation Characteristics

Parameter	Lowest Value	Highest Value	Remark
Rainfall intensity (mm/hr-1)	32	36	Low to moderate with isopicnic liens oriental NW/SE suggesting severe storms spring-up from the north.
Mean Annual rainfall (mm hr-1)	500	1000	Low to moderate secondary and maximum of 800mm to the west of Sokoto
Degree of wetness or dryness (n) ratio	01.	0.3	Pure shael confirmed by very low X- values
Specific water consumption (w/f)	+400	+1000	Level of high deficit confirms Sokoto State as well within the Sahel.

Source: (CCCFR, Nigeria 2006).

*** Mean Cessation Dates:**
Only a section in the west has mean cessation before September 17 and this is around Gota, Katin-Chana area. Rains last later than October 17 in a small corner in the east. Indeed, the pattern of mean cessation of rains is very interesting because it starts from the west and moves eastward. The onset rains follow the same pattern running between May and June.

*** Shortest Length of Rainy Season in Days:**
Small portions of the north around Gada and soth-west around Shagari have 80 to 90 rainy days, enclosing areas having less than 80 days – the lowest for any in all the states. Indeed, no area in Sokoto records up to 130 rainy days.

*** Specific Water Consumption:S**
The ratio is over +400 everywhere in Sokoto State and the builk of the State lies in the range +600 to +1000, with the northern tip recording > +1000.

4.0 Ranking the ates For Impact Vulnerability:

Because of the belief that the main impact of climate change in tropical and dry sub tropical area would be increasing aridity and increasing drought severity (Olofin 2006), the focus of the vulnerability considered in this paper is vulnerability to drought and desertification. To this end, the Degree of wetness/dryness, Mean Annual Rainfall, Specific water consumption and the length of the rainy season were examined in the previous tables and used as the indices for the vulnerability ranking. In doing this, the states are ranked interms of each index of vulnerability, then the ranks each state achieve for the four indices were averaged to derive a mean rank score. The average rank score was used to derive the overall rank. The result is presented in the table below:

Vulnerability Rating of the States

Indices rank	(n) ratio	Mean Ann. Rain Fall	(w/f)	LRS	Overall (Mean Rank Score)
1. Most	Sokoto	Jigawa	Sokoto	Jigawa	Sokoto (1.5)
2.	Zamfara	Sokoto	Jigawa	Sokoto	Jigawa (2.0)
3.	Katsina	Zamfara	Kano	Kano	Zamfara (3.5)
4.	Jigawa	Kano	Katsina	Zamfara	Kano (3.75)
5.	Kano	Katsina	Zamfara	Katsina	Katsina (4.25)
6.	Kebbi	Kebbi	Kebbi	Kebbi	Kebbi (6.0)
7. Least	Kaduna	Kaduna	Kaduna	Kaduna	Kaduna (7.0)

Sokoto State is found to be the most vulnerable state to the drying effect of climate change. Sokoto is followed by Jigawa, Zamfara, Kano, Katsina, Kebbi and Kaduna, in that order, making Kaduna the least vulnerable of all the north-western States of the country.

5.0 Implications for Water Resources Management in the Zone:

The climatic conditions and vulnerability to drought examined above relate to current condition. However, the specific effects of climate change in the zone include increasing incidents of drought and aridity, the decline in agricultural productivity and the incursion of desert-like conditions, other others.

Similarly, Olofin (2006) contends that while the effects of global warming may be flooding and humid condition in some temperate areas, "the predicted global warming will cause ....." Further drying up" in the arid and semi arid middle east. The same effect (further drying up) is expected for tropical arid and semi-arid areas such as the Sudano-Sahelian states of Nigeria.

The direct implications of these effects include that fact that there would be less water availability in the area for human and animal use and crop production. The drier the condition and decreasing land space would force people to overuse the resources of affected areas drive them into marginal, delicately balanced ecosystem, thereby compounding the problems of deforestation and soil erosion due to the pressure of people on the fragile ecosystem as evident in many parts of the zone.

More and more desert - like land that is not capable of supporting any meaningful sustainable development would emerge, except precautionary measures are taken right now.

Besides the expected increasing water deficit in the zone, evaporation from the surface of water bodies would continue at the rate dictated by climatic conditions (Bako 2002). Consequently, water management steps should be taken to ameliorate the effects of these natural hazards. There is therefore, the need to adopt methods that ensure optimum use of water with less wastage as well as to embark on water resource management strategy that encourages conservation (including sustainable dam construction, controlled ground water extraction, rain harvesting, etc), reuse and recycling in the area, if the millennium development goals are to be achieved.

6.0 The Need for Capacity Building to Support Climate Change Adaptation Measures in the Zone:

The severe drought of 1969 to 1973 which came to a climax in 1972/73 seemed to have posed a challenging question in relation to the relative weighing of the different aspects of services that Meteorological Department and other Government agencies can and should offer.

Meetings of Heads of Governments, especially in the Sahel since that catastrophic episode (which still lingers on) have culminated in a call for a better understanding of the weather and climate and its variabilities as they affect the livelihood of the people in the zone in particular and West Africa in general. That drought caused hundred of thousands of death of man and livestock but perhaps did not 'draw' as much attention as one or two plane crashes (Adefolalu 2006).

There is no doubt of the paramount importance of research and information on climate change, its causes and its impacts to guide policy makers at senior governmental, industrial and institutional levels on the need for and nature of mitigative and adaptive responses. This will also help to improve capacities, infrastructure, knowledge and partnership related to climatic risks management and adapts to changing future risks and integrates climate risk management and adapt to chancing future risks and integrate climate risk management strategies into develping programmes.

The ACCCA Pilot Action Project proposed in some developing nations is a welcome development with the following specific objectives:

a) To identify and priorities climate risks and climate influenced decision the stakeholders will face.
b) To assess existing risk knowledge and adaptation opportunities and synthesize the knowledge based on stakeholder decision making needs.
c) To develop, test and disseminate risk communication materials (information kits).

A participatory communication development approach has been suggested to generate, communicate and apply climate adaptation decisions. This would help in raising capacity in adapting to threats (e.g. food security in the various target regions through improved capacity in soil and water conservation) and to increase awareness on the need for adequate application of climatic parameters in planning development projects.

Table 9: Benefits of Actions to Adapt to Climate Change:

IMPACT ON	REGION	SAVING
Agriculture	U.S.A. (mid west)	30% reduction in agricultural losses through changed planting date, cultivation type and irrigation
Agriculture	Global	Welfare losses due to lower cereal production reduced by $7-24B globally per annum
Coastal zones	U.K. (East Anglia)	Damaged costs (all sectors) of sea level rise reduced by £1 Billion by up-grading sea defenses.
Coastal zones	Global	Global expenditure of $1 Billion per annum to cope with ½ meter sea-level rise could achieve $ 45 Billion income saving on land services

Source: (WMO 1996)

Conclusion

The paper epitomized on community's vulnerability to hydrometeological hazards in the Sudano – Sahelian part of Nigeria through assessment of the local risk from potential hazards of climate change through developing adaptation capabilities. Reduction of vulnerability requires that there is assessment of risks, formulation of strategies for mitigation, adaptation and coordination of emergency response plans.

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