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CONTENTS

VULNERABILITY ASSESSMENT OF CLIMATE CHANGE IMPACTS IN PARTS OF THE SUDANO-SAHELIAN ZONE OF NIGERIA

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Abstract

Exposure to climate variability, change and extremes, most particularly drought and desertification poses substantial risks to communities in the sudano sahelian region of Nigeria. The study aimed to assess adaptation strategies for reducing the vulnerability of communities to climate change in the zone. In doing this, precipitation effectiveness parameters such as degree of wetness/dryness (hydrologic-ratio), specific water consumption (SWC), shortest and mean length of rainy season as well as rainfall intensity and mean annual rainfall amount for the five (5) selected States in the zone between 1940 and 2010 were computed and used as indices for vulnerability ranking of the States. The parameters were: A community-based Focus Group Discussion (FGD) and semi-structured interview were also conducted to ascertain the local climate change adaptive strategies in the communities. The results of the study shows that for the overall vulnerability ranking, Sokoto State is highly vulnerable to the drying effects of climate change, followed by Zamfara, Katsina, Kebbi and Niger respectively, in that order. Result from the study presents an interesting eco-climatic scenario, which shows that even under normal condition rains may not start until the third quarter of May and may end by the first week of September, giving barely 120 days of rainy days. There is also the possibility of rain starting as late as mid-July and stopping by the middle of August to give barely 30 rainy days, as occurred during the 1972 droughts in parts of the zone. The direct implication of these findings is that there may be shortage of water for the use of man, animal crop production. The analysis further reviewed poor adaptation techniques within the communities, while problem of desertification *in the region can be traced to physical factors such as climate and weak resilience of land in these States as a result of drought, human factors such as inappropriate land uses and deforestation seem to be the most important cause. The study suggests the need for integrating adaptation measures with development planning towards achieving developmental goods of the region. To be effective, ministries and parastatals that are responsible for development, finance, economic planning, land and water management, and public health institutions needs to be integrated. This is because it is within these Agencies that adaptation strategies resides.*

Keywords: Adaptation, Climate Change, Climate Variability, Drought Severity, Hydrologic Ratio

Introduction

There is an emerging global scientific and political consensus that rising concentrations of greenhouse gas in the atmosphere, which are largely induced by industrial and other human-related activities, are having significant impact on global climate. The marked change in awareness and convergence of views appear to hinge on the increasingly more definitive scientific evidence on climate change and its current and future impact on sustainable human development. This development has helped to make concerns about climate change a leading global environmental and development issue in recent years.

In the last few decades, the scientific evidence of climate change has become more prominent than ever before. The awareness of climate change has spread at an unprecedented pace and it is now accepted as a major threat to human survival and sustainable development. Its increased adverse impact is expected on the environment, human health, food security, economic activities, natural resources and physical infrastructure. The Stern report as pre by presented IPCC (2007) on the economics of climate change presents a most comprehensive review of the likely impact of climate change over the coming decades. According to the report, climate change could create risks of a major disruption to economic and social activities, on a scale similar to the great wars and the economic depression of the first half of the 20th century. The report further estimates that investment of two percent of the world GDP would be required to avoid the worst effects of climate change (Stern, 2006).

Africa has been portrayed as one of the most vulnerable regions to the impacts of global climate change due to her low human adaptive capacity to anticipated increases in extreme events, resulting from widespread poverty, heavy reliance on rain-fed agriculture, lack of economic and technological resources, insufficient safety nets and educational progress (IPCC, 2001; Reid and Vogel, 2006). Some studies have observed that Africa is already close to the limits of her coping ability, (Sokona and Denton, 2001; Davidson *et al.*, 2003, Mortimore and Adams, 2001).

Available meteorological data in the sudano-sahelian belts of Nigeria show evidence of increasing air temperatures over the past 90 years (NEST, 2003), in addition to recurring droughts since 1960s. There are clear indications that other climate variables especially rainfall (both magnitude and distribution), and atmospheric circulation patterns are changing, while extreme weather events and incidences of climate-related disasters are increasing (Adefolalu, 2006). The projections of the IPCC Working Group-I predict that Africa's warming trend will become 1½ times more than the global trend and the sudano-sahelian zone will be about 3-5°C hotter by the close of this century. By this prediction, sudano-sahelian zone of Nigeria will develop the following characteristics:

(i) Warmer and more frequent hot days over most land areas.
(ii) Warm spells as heat waves frequency increases.
(iii) Heavy precipitation (rainfall) events increase over most areas.
(iv) Areas affected by drought increase.

The extent of drought and desertification in Nigeria shows that areas of north of latitude 10°N are more prone to drought and desertification process. This region includes the sudano-sahelian zone of Nigeria which covers substantial part of Northern Nigeria. The total land area currently covered by this zone is about 326,000 km^2, which when compared with the 140,000 km^2 estimated from the World Desertification Map by FAO, WMO and UNESCO in 1977, shows significant southward migration of desertification process.

Drought is recurrent phenomenon in the sudan-sahelian zone of the country. Following the early season, the first showers usually signal the time of planting. In turn, an unexpected break may result in the withering of emerging plants, even though subsequent rainfall may be favourable for good crops. Similarly, if the total rainfall is inadequate, or it terminates early, the crops may not mature and yields will be low. Thus, it is often the distribution rather than the total amount of rainfall that is a more significant factor for agricultural productivity.

Adapting to climate change in the study area is important for two reasons: first, some climate change impact as evident in the zone are inevitable and, indeed, are already being observed in myriad sectors. Second, even if all GHGs emissions were to stop completely now, average temperatures would continue to rise and climate change will continue to impact on all systems for possibly decades, because of lags in the earth's natural processes. Hence, assessing local adaptation strategies will be of great importance in dealing with the inevitable impact of climate change in the sudano-sahelian belts of Nigeria.

Study Area

The sudan-sahel zone is located between longitudes 3° and 15° East of Greenwich Meridian and between latitudes 9° and 14° North of the Equator (Figure

1.). This zone stretches from the Sokoto plains through the northern section of Hausa plain land to the Chad Basin. The extreme North position of the belt approaches the desert fringes, sharing boundaries with the semi-arid and arid zones of the Niger Republic. The States in this zone in Nigeria that are selected for this investigation includes: Sokoto, Kebbi, Katsina, and Zamfara. The climate of the zone is savannah type with alternating wet and dry seasons. Rainfall amount in the region is slightly above 1000 mm per annum and is usually expressed between the month May and October. The rainfall is highly variable and its onset is erratic. The intensity is very high between the months of July and August. There is intra-zonal difference in the amount of rainfall received in the region as the southern part receives more rain and is less variable compared to the northern section.

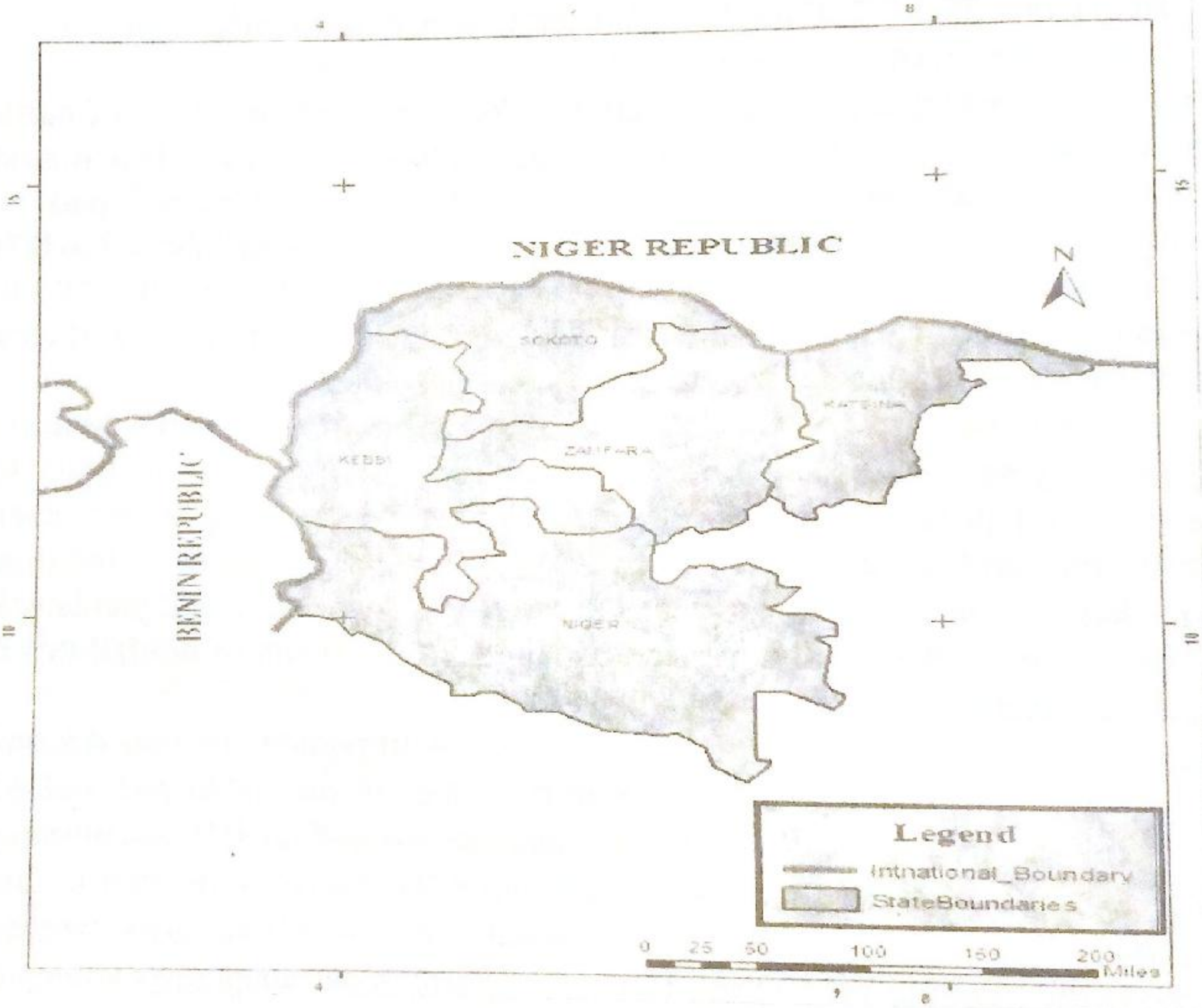

Figure 1: Study Area
Source: Department of Geography, FUT Minna (2011)

The gross features of rainfall pattern in this region, as in other parts of the country are usually in association with what is often called- the Inter- Tropical Discontinuity (ITD) (Ojonigu *et al.* 2007). The movement of the ITD northwards across the country between January and August, and its retreat from the southern fringe of the Sahara desert after August, cause much of Nigeria to experience seasonal rainfall. The ITD itself is the boundary at the ground between the dry tropical continental (cT) air mass of northern origin and the moist Tropical Maritime (mT) air mass of southern origin. Within the mT air-mass is enclosed a number of rainfall producing systems, such as the disturbance lines (especially the easterly waves), squall lines and the two tropospheric jet streams. It is the magnitude of these systems that influences the amount and seasonal distribution of rainfall over the region.

Methodology

In pursuance of the study objectives, two sets of data, namely: primary and secondary data were generated. The primary data include observed and derived parameters of precipitation effectiveness which was used to determine level of vulnerability of each state to the drying effects of climate change. The data were collected from the Centre for Climate Change and Freshwater Resources (CCCFR) FUT Minna for the study period. In like manner copies of a questionnaire was used in obtaining information from respondents on level of vulnerability to climate change. Precipitation effectiveness parameters were derived in Kebbi, Katsina, Sokoto, Niger and Zamfara States. These data were used to compute:

(i) Onset, cessation and LRS
(ii) Hydrologic ratio (λ), and
(iii) Specific water consumption

The onset (Ø) and cessation (⊄) dates of rains were estimated from graphs of pentad rainfall values. The Pentad Rainfall each year were computed from the formula:

$$PR(s, p-n) = PR(s, p=n-1) + \; t = a(n-1)+a$$
$$\sum_{t=a(n-1)+1}^{t=a(n-1)+a} RR(t, s)$$

Where:

RR (s,t)= recorded rainfall for a particular day (t) at location S

PR = cumulative rainfall for a period interval a, ascribed 5, 7, 10 etc.

T = values depending on range preferred 5 for 5 day pentad, a is 5

Cessation (⊄) refers to the end of a rainy season. It is marked by the last inflexion point on the 'Ogive' before it becomes parallel for the second and last time to the abscissa. Thus, it usually lies somewhere before the last rain is received. It is the effective end of the rainy season.

Having determined the onset (Ø) and the cessation (⊄) dates of the rains for the pentad numbers, the effective length of the rainy season (LRS) calculated thus:

$$LRS = (\not\subset - \emptyset)$$

A total of 70 Local Government Areas (LGAs) were systematically selected for the administration of the questionnaire; Sokoto (11), Kebbi (15), Katsina (17), Niger (10) and Zamfara (13). A total of 7000 questionnaire were administered; in each Local Government Area. A Focus Group Discussion (FGD) was undertaken in the studied communities. This provides a good complement to the semi-structured interview (SSI).

The computed derived parameters: mean, onset and cessation dates, shortest length of rainy season as well as specific water consumption are presented with appropriate comment for each States. This was used to determine the vulnerability of each State to the drying effects of climate change. Numerical scores were assigned to the vulnerability ranks as follows:

Very high = 1 High = 2 Medium = 3 Low = 4

Scores were summed down columns to derive a weight or measures of vulnerability; the four indices were averaged to derive a mean rank score. The response of the questionnaires was analyzed using SPSS 13.0 software and results were presented in charts to ascertain the past and present traditional adaptation strategies and expertise in the communities.

Results and Discussion

Precipitation effectiveness in Katsina State

These sets of data, consists of analysed information on rainfall intensity, mean annual rainfall, degree of wetness/dryness and specific water consumption. The breakdown of precipitation characteristics for Katsina State is shown on Figures 2-7 below. It indicates 'that the earliest mean cessation is around September 27, occasionally rains persist until November 05 around Ingawa and Kankiya. The mean onset is earlier in the south around Funtua and Danja, which has over 150 rainy days. The rest of the state has between 90 and 120 days. Only a small section in the north of MaiAdua axis has less than 90 rainy days whereas the southwest area around Funtua and Danja has over 150 rainy days. The central west area around Jibia in the north and Kankia in the east has 120 to 150 rainy days.Only the southern tip records a ratio of 00 to +200; all other areas record positive ratio with areas in the central part of the state around Dutsin-ma and Safana recording over +1000 of specific water consumption.

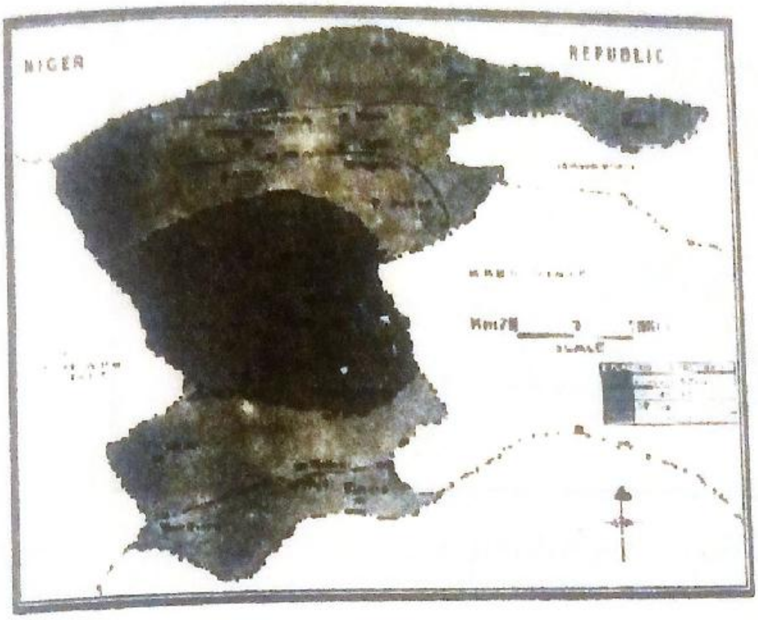

Figure 2: Katsina State Rainfall Intensity

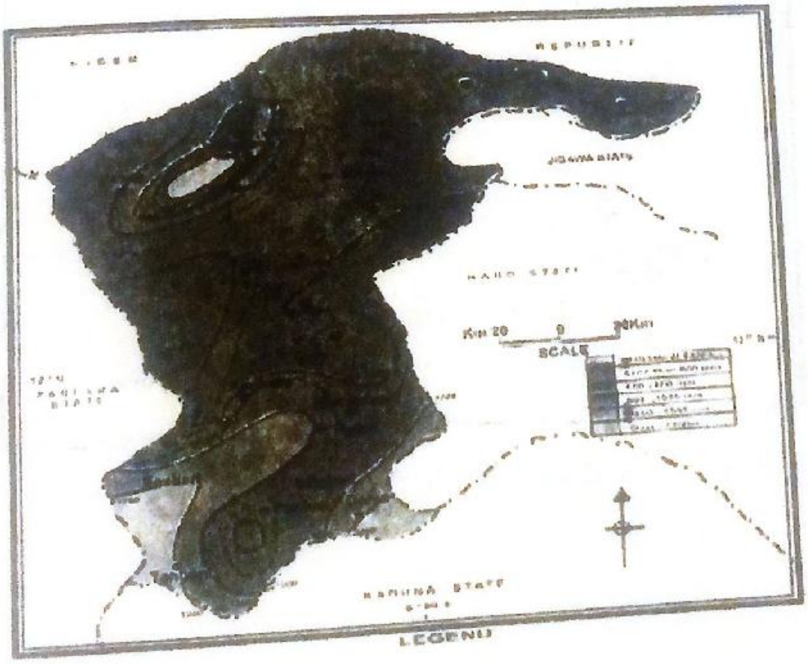

Figure 3: Katsina State Mean Annual Rainfall

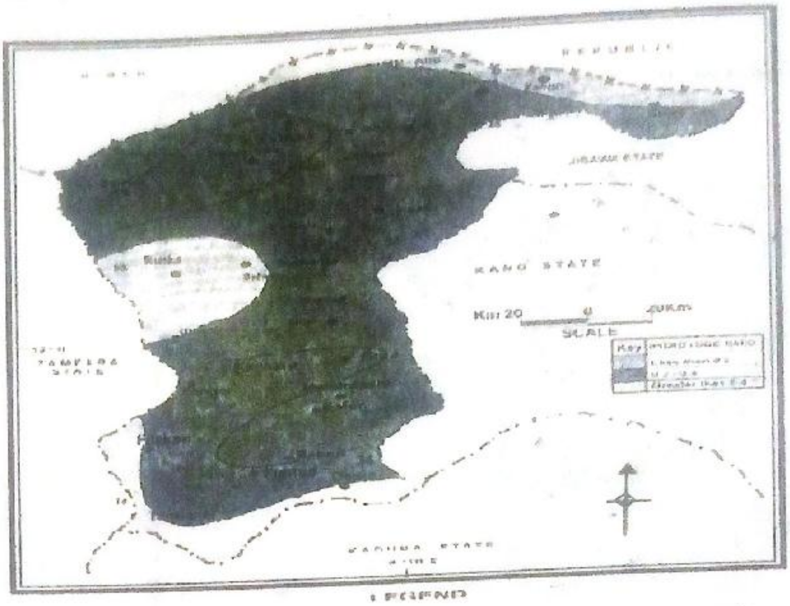

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Figure 4: Katsina State Hydrologic Ratio Consumption (mm/Area)

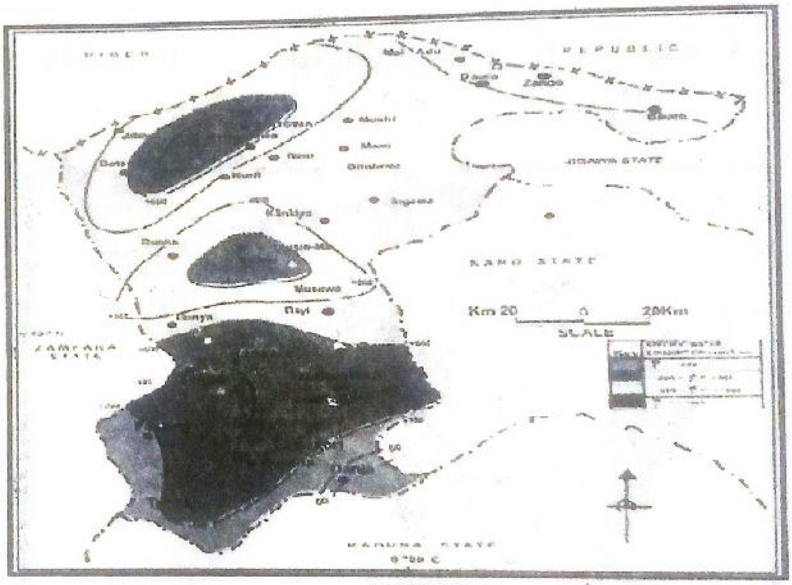

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Figure 4.5: Katsina State Specific Water

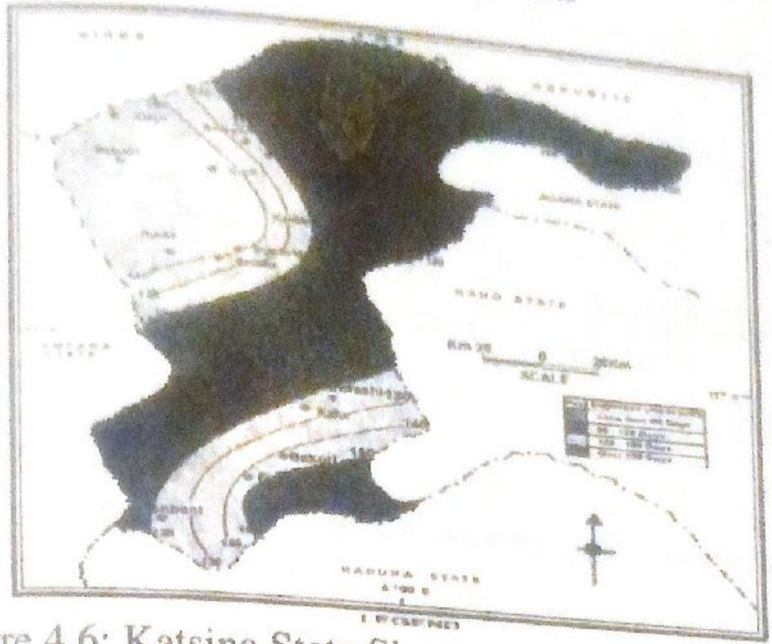


Figure 4.6: Katsina State Shortest Length of Rainy Season

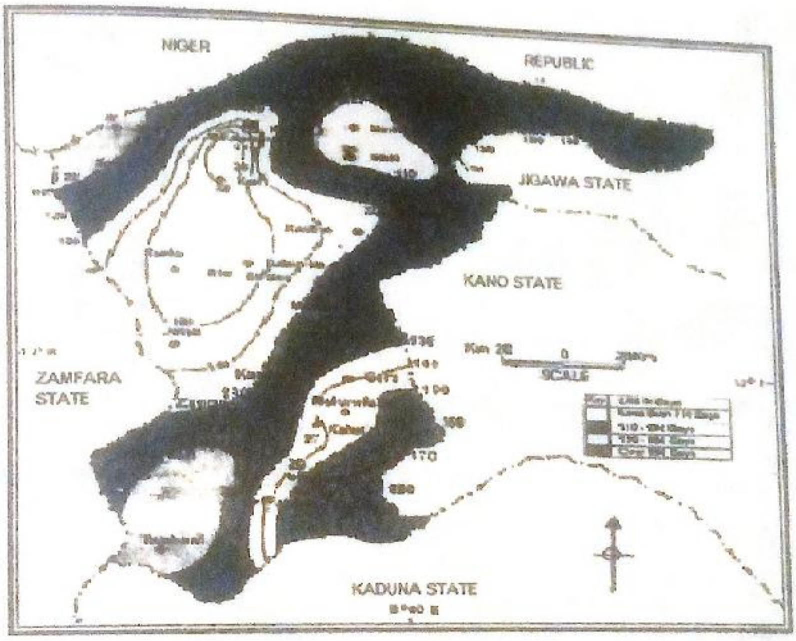
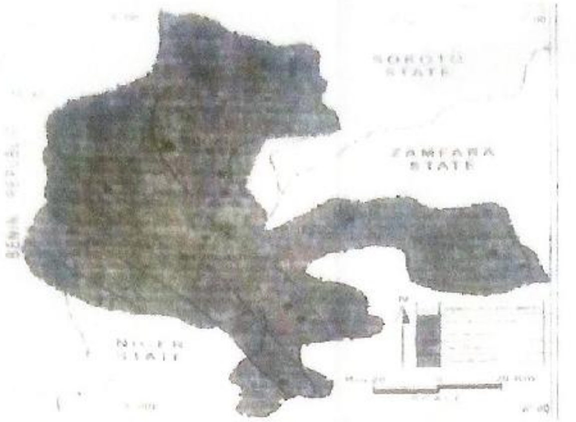


Figure 4.7: Katsina State Mean Length of Rainy Season

Precipitation effectiveness in Kebbi State

Figures 8-13 depicts precipitation effectiveness characteristics at district level in Kebbi state. On the average, rains last until October in the state. Only small areas around Bena and Kande have their rainy season stopped by September 27. Rains last until 27 October in the southern tip of the state. The average onset date of the rains is May. Only a small area in the West around Bunga has less than 90 days while limited areas east of Zuru and around Tunga have over 140 rainy days.



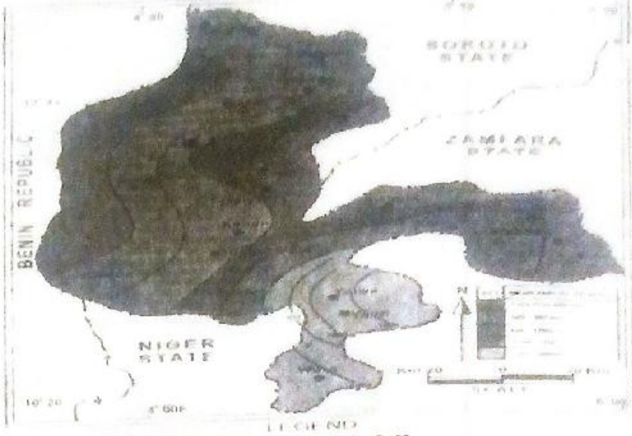
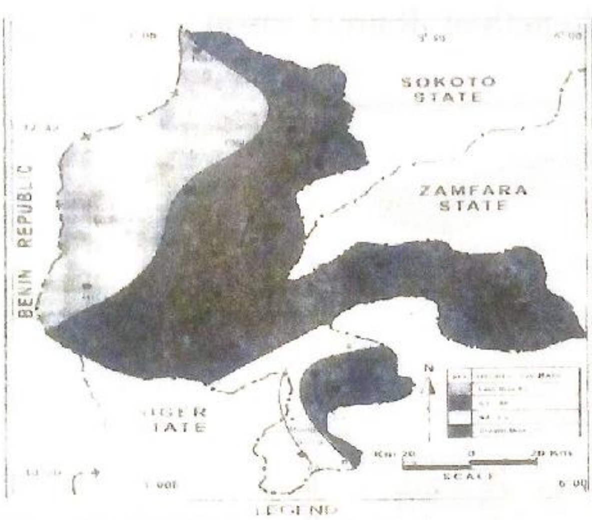


Figure 4.8:Kebbi State Rainfall Intensity (mm/hr) **Figure 4.9: Kebbi State Mean Annual Rainfall**



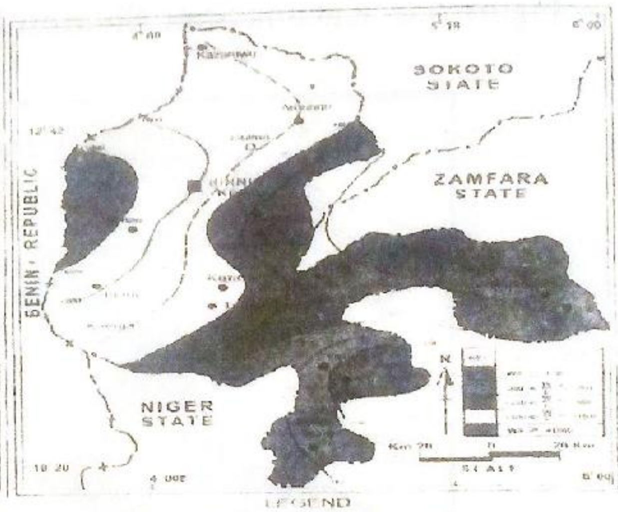
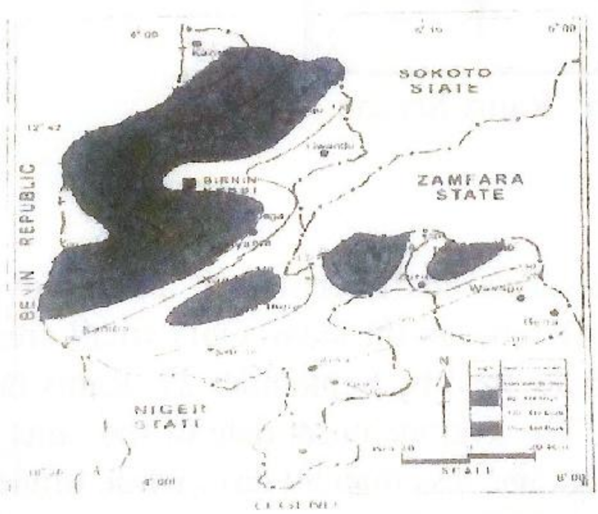


Figure 4.10: Kebbi State Hydrological Ratio (mm/Area)

Figure 4.11: Kebbi State Specific Water Consumption



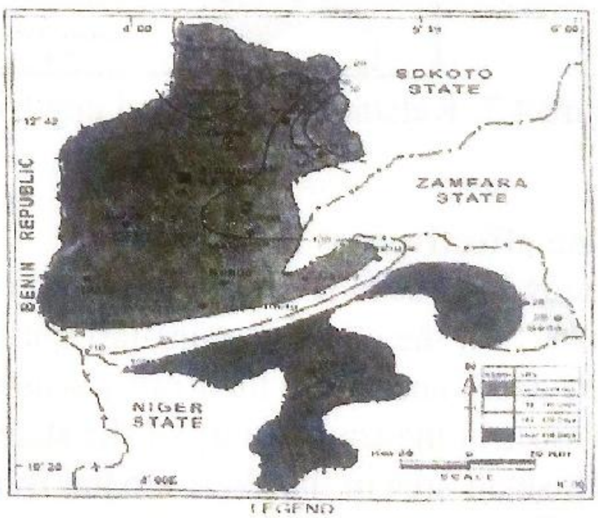


Figure 18:Kebbi State Shortest Length of Rainy Season

Figure 19: Kebbi State Mean Length of Rainy Season

Precipitation effectiveness in of Zamfara State

Figures 14-19 shows that in Zamfara, mean cessation dates run in semi-latitudinal belts around 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 follows the same pattern with the area around Binji and Bawa receiving rains before April 17. Only a small area around Isa Galaudu in the north has less than 90 rainy days. The bulk area of the state have between 90 to 120 rainy days with parts of the east and west having over 120 days. On SWC, some areas in the south around Mutumi, Dogo, and Kwimbara record 00 to +200 within which a small area between Marafa and Mararaba records less than 00. The other areas of the state show ratios of +200 to +600; +600 to +1000 with northern tip north of Isa displaying a ratio of +1000.

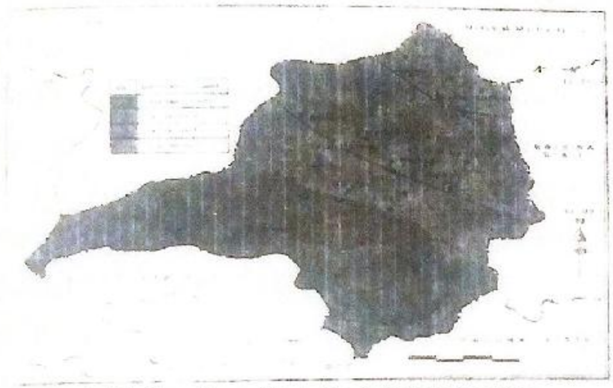


Figure 4.14: Zamfara State Rainfall Intensity (mm/hr)

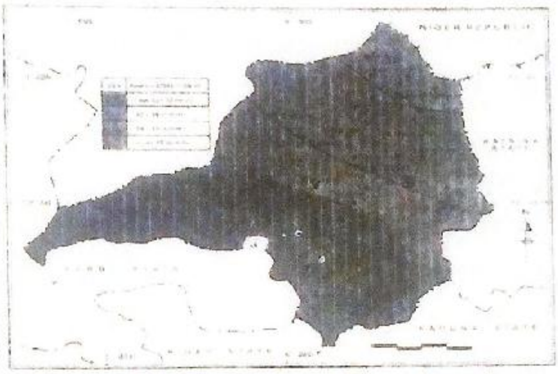


Figure 4.15: Zamfara State Mean Annual Rainfall

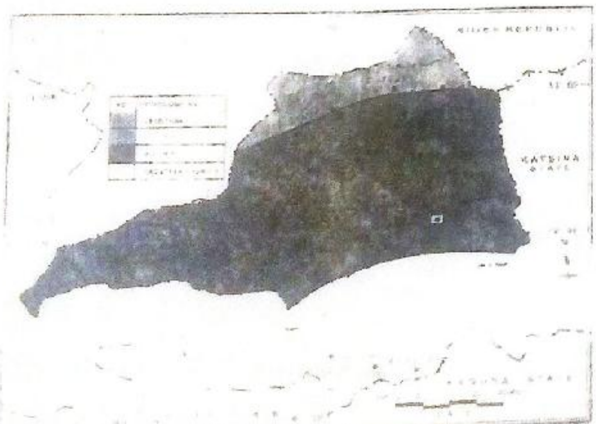


Figure 4.16: Zamfara State Hydrologic Ratio

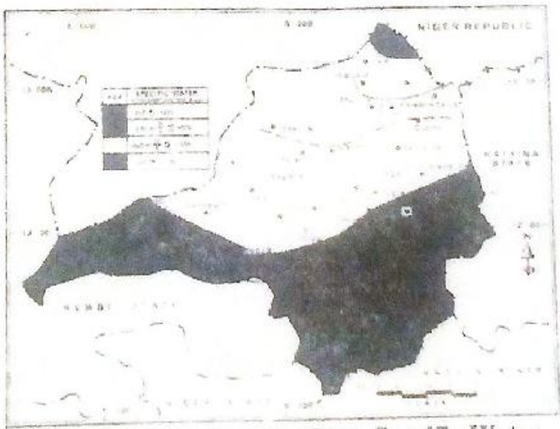


Figure 4.17: Zamfara State Specific Water Consumption (mm/Area)

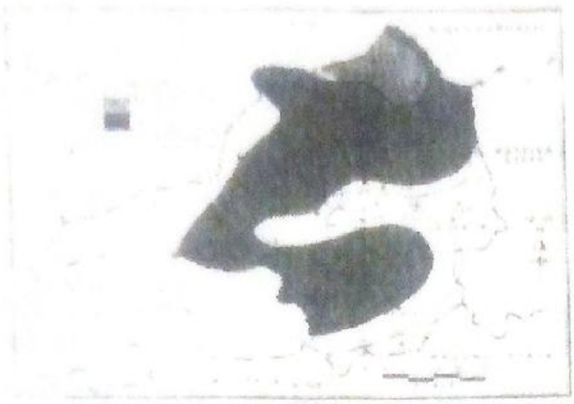


Figure 18: Zamfara State Shortest Length of Rainy Season

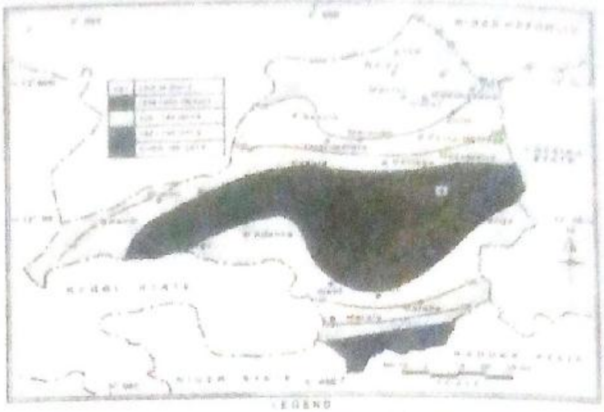


Figure19: Zamfara State Mean Length of Rainfall

Precipitation effectiveness in of Sokoto State

Figures 20 - illustrates that only a section in the western part of the state has mean cessation before September 17, this is around Gota, Kantin Chana area. Rains last later than October 17 in the eastern area corner. Indeed, the pattern of mean cessation of rains is very interesting because it starts from the west and moves eastward. The onset of rains follows the same pattern running between May and June. Some areas in the northern fringes of the state around Gada and in the southwest around Shagari record between 80 and 90 rainy days, enclosing areas having less than 80 days- the lowest for any area in all the states under study. In fact, no area in Sokoto records up to 130 rainy days.

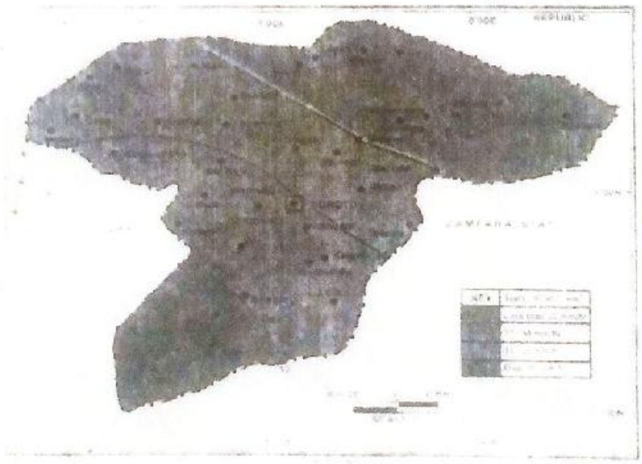


Figure 4.20: Sokoto State Rainfall Intensity (mm/hr)

Figure 4.21:Sokoto State Mean Annual Rainfall

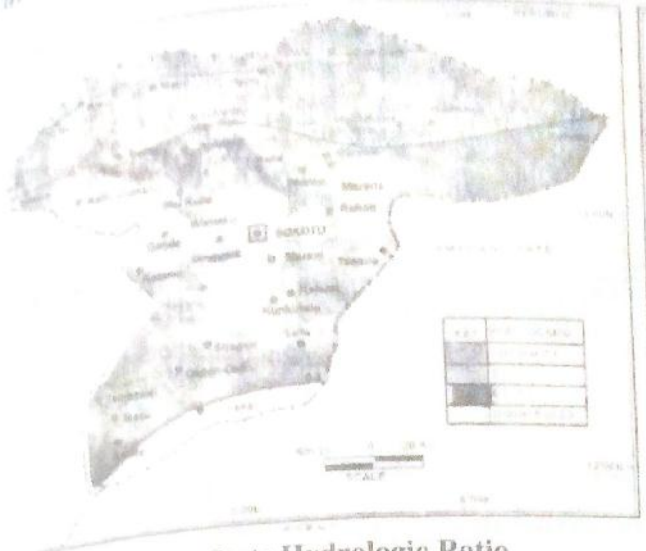


Figure 4.22: Sokoto State Hydrologic Ratio

Figure 4.23:Sokoto State Specific Water Consumption (mm/Area)

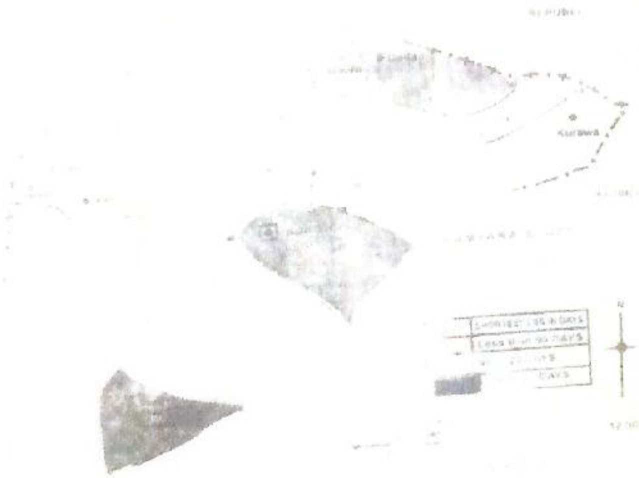


Figure 4.24:Sokoto State Shortest Length of Rainy Season

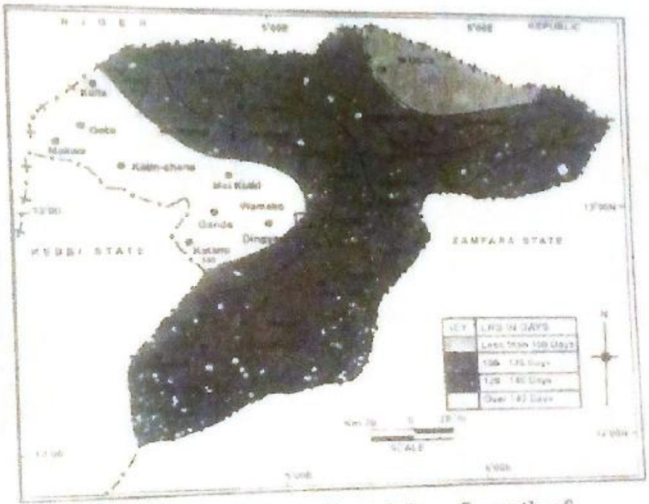


Figure 4.25: Sokoto State Mean Length of Rainy Days

Precipitation effectiveness in Niger State

Figures 26-28 reveals that the earliest dates of mean cessation are before October 07. Central parts of the state, around Wushishi, Tegina and Maikunkele has late onset date of rains around 10-20 May. Kontagora, Saho Rami and Gawu has hydrologic ratio of 0.4 - 0.6.

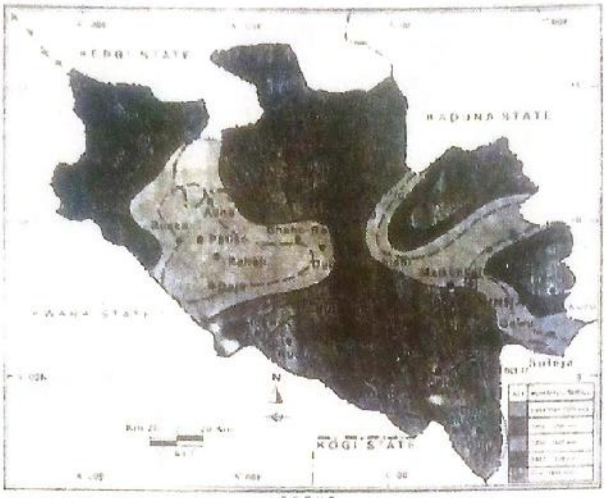


Figure 27: Niger State Mean Annual Rainfall

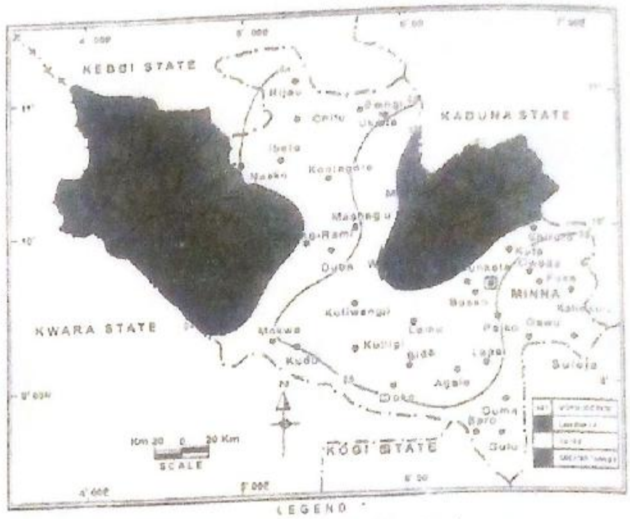


Figure 4.28: Niger State Hydrologic Ratio

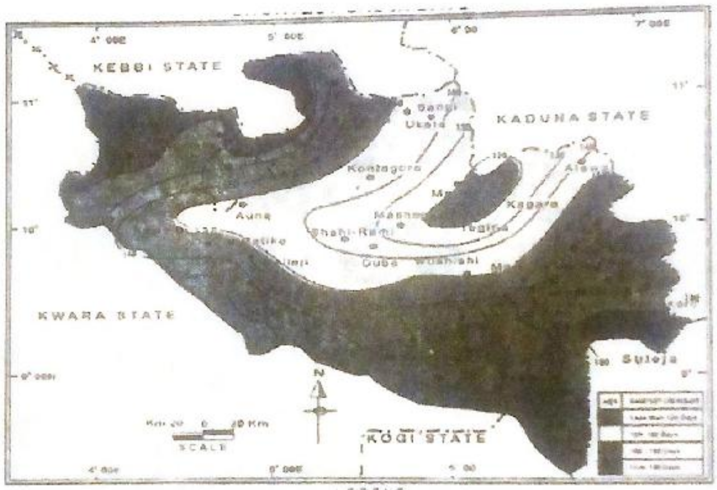


Figure 28: Niger State Shortest LRS in Days

Impact Vulnerability Ranking of the Study Area

Because of the belief that the main impact of climate change in tropical and dry sub-tropical areas would be increasing aridity (Issar, 1998) and increasing drought severity (Olofin, 2003), the focus of the study is vulnerability to drought and desertification. To this end, the Degree of Dryness/Wetness (λratio), Mean Annual Rainfall (MAR), Specific Water Consumption (SWC) and the Shortest Length of the Rainy season (SLR) were examined and used as the indices for the vulnerability ranking. In doing this, the states were ranked in terms of each index of vulnerability. then the ranks each state obtain 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 of the ranking is as presented on Table 1.

Table 1: Vulnerability Rating of the Studied States

Ranking	Indices Rank	Degree of Wetness or Dryness	Mean Annual Rainfall	Specific Water Consumption	Shortest Rainy Days	Overall Mean Score
1 (Most)	Sokoto	Sokoto	Sokoto	Sokoto	Sokoto	**Sokoto (1.0)**
2	Zamfara	Zamfara	Zamfara	Zamfara	Zamfara	**Zamfara (2.0)**
3	Katsina	Katsina	Katsina	Katsina	Katsina	**Katsina (3.0)**
3	Kebbi	Kebbi	Kebbi	Kebbi	Kebbi	**Kebbi (3.0)**
4(Least)	Niger	Niger	Niger	Niger	Niger	**Niger (4.0)**

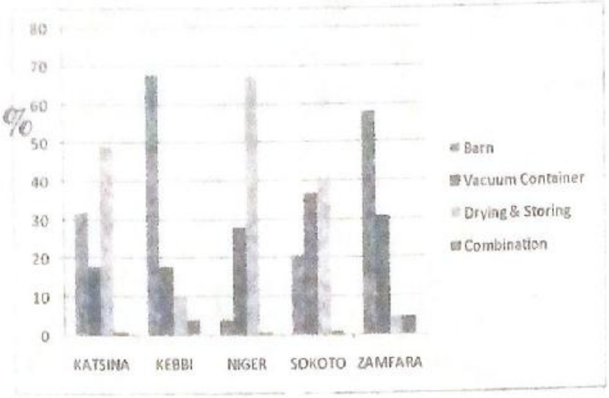
Source (Authors' Field work 2011)

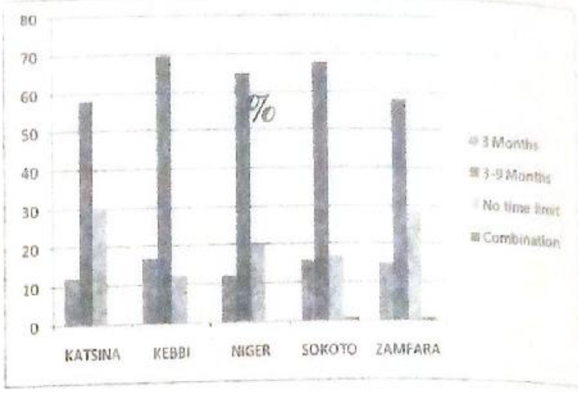
As illustrated on Table 1 above, the overall vulnerability ranking indicates that Sokoto State is most vulnerable to the drying effects of climate change. Sokoto is followed by Zamfara, Katsina, Kebbi and Niger in that order. Niger state is thus the least vulnerable of all the five (5) states in this study. This result presents an interesting eco-climatic scenario; it shows that even under normal conditions, rains may not start until the third quarter of May and may end by the first week of September, giving barely 120 days of rainy days. There is the possibility of rain starting as late as mid-July and stopping by the middle of August to give barely 30 rainy days as occurred during the 1972 drought in some parts of the zone. The direct implication of this is that there may be induction in water supply in the area for human, animal and crop production. The drier conditions and decreasing land space would force people to overuse the resources of the affected areas and drive them into marginal, delicately balanced ecosystems, thereby compounding the problems of deforestation and soil erosion due to the pressure of people on the fragile ecosystem. More and more desert-like land that is not capable of supporting sustainable development would emerge, except precaution any measures are taken.

Besides the expected increasing water deficit in the study area, evaporation from the surface water bodies would continue at the rate dictated by climatic conditions (Olofin, 1985). Consequently, water management steps should be taken to ameliorate the effects of these natural hazards. There is, also 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 exploitation, and rain harvesting), if the Millennium Development Goals are to be achieved in the zone.

Climate Change Adaptive Strategies in the Studied States

The result of the questionnaire administered as indicated shows that the major occupation of the respondent in the five state is agriculture. Over 70% of the respondents are farmers while those engage in agricultural activities 25%. These sets of activities are most affected by drought and famine. In all the five states, the art of food storage is historically sound and respondents highest priority and crop for storage is grain (55-75%) Tuber (10-25%) is next while vegetables and combination of all farm produce score 5-10%. This signifies the place of grains as the most preferred crop which should be given highest priority in advocacy, support and strategic adaptive plans on drought and famine.





Local Adaptive Technology for Food Storage Shelf-life of Food Stored

On method of storage, the barns vacuum containers and drying are most prominent in all five states examine. These are ageless strategies that have been in use for long. According to the respondent, this forms of storages are done seasonally to last for between 3 and 9 months. Most of the respondent however belief that adaptive capacity of rural dwellers is more efficient than the use of present day silos which is being constructed across all geopolitical zones. According to them, the local technical know-how of the different stakeholder should be consider before embarking on such multi-billion naira facilities which often times get rusted and contract have to be re-awarded. It will be record that silos were first build in the 1980s and different government have continued to re-structured with limited economic benefit.

Result obtained from the field has lends the credence to the earlier findings of Appledora, (1977) on migration during the 1969-1974 drought. Between 50 and 65% of respondents confirmed that migrating to another or settlement is common while 20 -40 indicate that sizeable number of people prefer going to relations during period of harsh climate.

The complete agreement in all the five states suggests that, cultural similarities are high and should be explored and exploited. Cultural ties should be forged further to enhance communal responsibilities in future efforts to curtail negative impacts of climate change. This study is of the view that activities that can bring people together should be encouraged as it is only where there is cordiality that "Book-me-Down" credit strategy to keep body and soul together will thrive and be sustainable. This can only be possible if there is mutual trust between neighbours.

On environmental protection for preservation and conservation, development of shelterbelts, windbreak, early cropping are consciously inherent in environmental management strategies in rural dwellers in the five states examined. Governments agencies that are involve in clearing of country side for public works or destruction of shade trees which serve as shelter belts or wind brakes in urban settings must learn from the community management skills and expertise. It is also wise for authority concerned to consult local dwellers on development of community projects. For example, Tree planting that have no economic or health benefits to the rural dwellers will receive lips-service support.

The present generation of rural dwellers in the study area are making life-saving sacrifices for a stable. This is demonstrated in their pattern of food consumption during drought. In most cases children are fed first and adults eat the remnant, while the adults work less (burn less energy) and rest more. The daily menu is composed of grains (70-90%) in Sokoto, Zamfara and Katsina) while combination of grains and tubers dominates in Niger and Kebbi. The most scientific option to reduce food consumption and increase survival for longer periods is by eating twice a day during droughts. (In fact, it is only in Niger State that people eat twice a day, in other 4 states, it is only once a day. However, most of the respondent in this study (over 90%) depends purely on fuel and their energy source.

Conclusion and Recommendations

Climatic variation and change in the study area has caused substantial damage to households, communities, natural resources and economies. In many of these communities, the damages are increasing, giving evidence of an adaptation deficit. This means that practices in use to manage the climate hazards are falling short of their expected returns. Evidently, climate change threatens to widen this gap in the sudan-sahel zone of Nigeria. Action now, aimed at narrowing the deficit, can yield immediate benefits and also serve as useful first step in a longer-term process of adapting to the changing climate.

Even though drought and desertification are difficult to define, they are at least best identified by land degradation of various types. These phenomena constitute a menace in the extreme sahelian part of the study area, particularly in the shrub and dry-grassland agro-ecological zone. While there are physical factors such as climate and the weak resilience of land in these states as a result of drought, human factors such as inappropriate land uses and deforestation (often the result of physical changes and their concomitant stress) seem to be the most important causes of desertification. Based on the findings of this work, the following recommendations are thus put forward:

- There is need for authority concerned to create room for enabling people to surmount the obstacles of adaptation. Enabling the process of adaptation is the most important step that the public sector can make.

- Integrating adaptation with development planning, an actions which can exploit the complementarities to advance both adaptation and development goals. To be effective, integration needs to engage ministries that are responsible for development such as finance institutions and other services. This is because it is within these agencies and among their stakeholders where much of the sector-specific expertise that must be engaged resides.

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