8th International Conference on Water Resources and Arid Environments (ICWRAE 8): 01-11
22-24 January 2019*, Riyadh, Saudi Arabia*

Occurrences of Droughts in the Semi-Arid and Sub-Humid Areas of Northwestern Nigeria and Their Implications for Rural Livelihoods

[1]Abdullahi Umar and [2]Ismail Alfa Adamu

[1]Department of Geography Federal University Birnin Kebbi, Kebbi State, Nigeria
[2]Department of Geography Usmanu Danfodiyo University, Sokoto, Nigeria

Abstract: The droughts of 1970s and 1980s and those of 1990s and 2000s have seriously impacted the rural livelihoods of the communities of drylands of Northwestern Nigeria. Significant researches have been conducted on these droughts most of which are confined to inter-annual analysis of rainfall trends, drought occurrences and very few related them with rural livelihoods. This research aims to examine droughts focusing on both their inter-annual and intra-annual analysis of rainfall trends and drought occurrences in addition to assessing their implications on the rural livelihoods. Rainfall data of seven (7) synoptic weather stations (Birnin Kebbi, Gusau, Kano, Katsina, Sokoto, Yelwa and Zaria) in Northwestern Nigeria collected from Nigeria Meteorological Agency was subjected to analyses to obtain the rainfall trends of the various stations and Rainfall Anomaly Index (RAI) and Standardized Rainfall Index (SPI) were generated to determine drought occurrences (in various intensities and duration) at both inter-annual and intra-annual dimensions. A review of studies was conducted to assess the implications of droughts on rural livelihoods. The findings reveal that time of occurrence of longest duration (decadal) drought in most of the stations has corresponded with time of the widespread 30 year drought cycle. Severe and extreme droughts were associated with growing season drought persistence of all season round (JJASO) type. This is a very good indicator of hardship that farmers and livestock rearers had been engulfed in during these droughts. Finally the study suggests formulation of drought contingency plan by governments at all levels as a strategy of tackling droughts.

Key words: Drought · Drylands · Northern Nigeria · Rural Livelihoods

INTRODUCTION

The central theme in documented literature on drought lies behind the context of water deficiency [1]. Drought causes significant decline in biological productivity which seriously affects rural livelihoods such as crop production, animal husbandry and artisan fishing. The three major impacts of drought on rural livelihoods are: crop failure, depletion of water resources which affects fishing and lack of pasture for livestock. Historically, losses from drought events across the world significantly increased with: (a) an increase in number of droughts; or (b) drought severity [2]. Severe drought is one of the greatest recurring natural disasters in North America [1]. The recurrence of severe drought is also a cause of human suffering and a major blockage topro-poor livestock development in sub-Saharan Africa, particularly in pastoral and agro-pastoralsystems. Drought kills millions of animals and reduces millions of people todestitution and reliance on food relief.

Rural households in the semi-arid and dry sub-humid areas of Northwestern Nigeria had been exposed to a variety of risks that include harvest failure and death of livestockas a result of drought. It is documented that the dry-lands Sudano-Sahelian Zone (SSZ) of Nigeria has experienced frequent drought and famine from 1883, to the beginning of the 20th Century.Droughts were reported in 1903-1905, 1913-1914, 1923-1924, 1931-1932, 1940-1941, 1956, 1972-1973 and 1982-1983 and 1986-1987 [3-6]. The extremedroughts of 1972–1973, 1983–1984 and 1991–1992were continental in nature and stand unique in

Corresponding Author: Ismail Alfa Adamu, Department of Geography Usmanu Danfodiyo University, Sokoto, Nigeria.
E-mail: adanmalam@yahoo.com.

the availablerecords [7]. These 30 year cycle droughts are usually regional and cover the entire Sudano-Sahelian belt. The 10 year cycle droughts are usually localized, even in areas lying along the same latitude [8-11].

Long- term rainfall analyses for most of the droughts that occur in dryland areas of north-western Nigeria have been found to be associated with a late start of the rainyseason and early cessation of the rains, resulting in drastic reductions of the length of the rainy seasons. A number of studies [12-17] have shown a significant trend towards false onset, creating a dry periodsituation where the expected start of the rainy season is delayed; and early cessation of the wet season rains over a 30-year period from 1969 to 1998 as well as decrease in annual rainfall. Groove [33] confirmed severe droughts of 1913and that of 1940-1945 in Sudan zonewhich had adverse effects on waterlevels in Lake Chad and River Nigerincluding crops and livestock.

It is reported that during the drought periods of 1972-1973 crop yields in Nigeria dropped to between 12% and 40% of the annual averages and in the drought year of 1987 crop yields ranged between 56% and 75% of the 1986 totals. This led to death of numerous human lives and of millions of livestock. It was estimated that during the 1972-1973 droughts about 300,000 (or 13%) of the livestock population of north-eastern Nigeria, were estimated to have died [18]. Saulawa [10] also reported that the drought years (1972-1974) and (1983-1984) were time of grave hardship, close observation of the land indicated that it became increasingly barren and grass did not grow in most of the grazing areas which lead to reduction of productive pastoral land by 52%. Failure in fodder growth was roughly estimated to be in the order 60% and 80% in Katsina.

Though, the drylands (semi-arid and dry sub-humid areas) of Northwestern Nigeria have been the focus of substantial drought research as a result of an extended period of desiccation commencing in the late 1960s and continuing into the 1990s [19-22], however, bulk of drought studies [3, 4, 22-32] have focused their researches on either: analysis of rainfall distribution and anomaly, rainfall variability and or drought occurrences. Very few researches [10, 33-36] focus on implication of drought on rural livelihood most of which are outdated and need to be updated or some of this few researches need to be replicated in other areas or their temporal scope need to be extended to certain time in-order to establish trend of the nexus of drought and rural livelihoods. There is therefore the need to undertake a comprehensive study of drought that will establish the trend in drought occurrences and implications on rural livelihoods.

This paper is aimed at evaluation of occurrences of droughts in Semi-arid and Dry Sub-humid areas of Northwestern Nigeria and their implication on rural livelihoods. The following objectives are set to achieve this aim namely:

- To analyze the historical rainfall trends in theregion;
- To quantify intensities and durations of droughts in the study area;
- To identify hotspots and determine the implications for rural livelihoods;
- To provide recommendations for improving drought and rural livelihoods adaptationplanning, investments and policies across thestudy area.

MATERIALS AND METHODS

Description of Study Areas: Figure 1 shows the location of the study area which is situated at the cross-road of Lat 10° 02^{i}N and 13° 22^{i} N and Long 4° 20^{i} E and 9° 20^{i} E covers a landmass of 113200 km^2 [37]. The climate of the study area is tropical wet and dry type coded A_W by Koppen [28, 38]. The area from its southern parts is situated along the dry sub-humid with annual rainfall totals of over 1000mm; while in its northern part is semi-arid with annual rainfall of range of 600 – 800mm. The extreme northern part is arid zones with annual rainfall of between 400mm to 600mm [39-41]. The pattern of rainfall is unpredictable unreliability and highly variable in spatial and temporal dimensions that frequently culminates into dry spells, severe and widespread droughts [3, 4, 42-44].

Somany rivers either originated from or traverse the study area.Vegetation in the study area comprises of the vast tropical grasslands of the Sahel and Sudan Savanna from the north through most of the south. Trees and numerous grass species co-exist. Agriculture, the predominant economic activity in the study area, is mostly rain fed. Crops produced include millet, sorghum, rice, cowpea, soy beans, wheat, groundnut, maize, cotton and sesame [45]. While the animals reared include cow, sheep, goats, rams and poultry. There are also vegetables cultivated such as tomatoes, pepper, onion, garlic, lettuce, cabbage and etc.

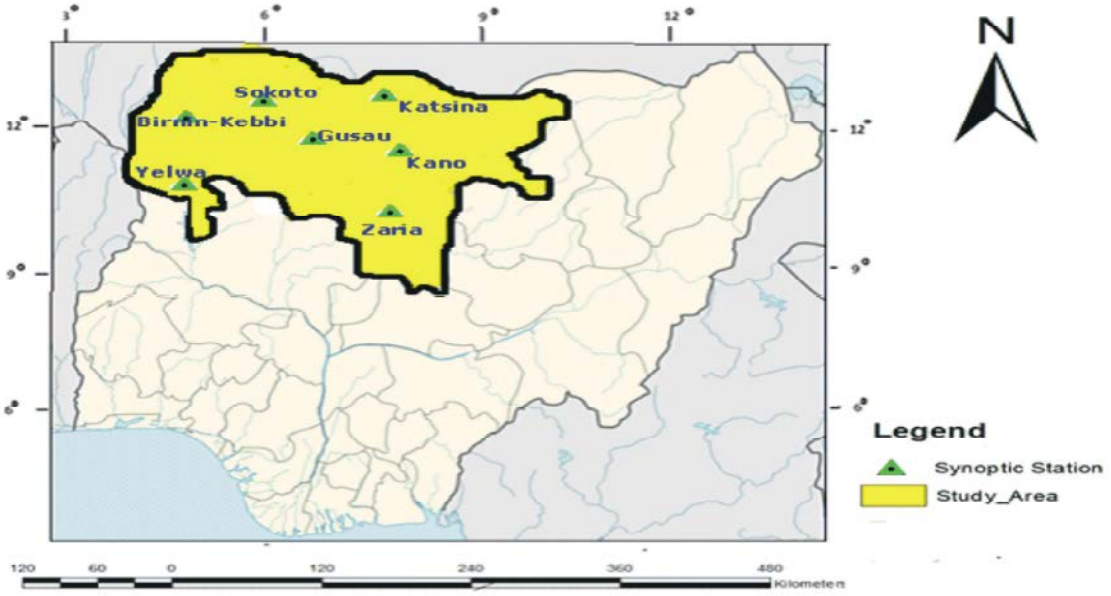

Fig. 1: Map of Nigeria showing the Study area and Synoptic Stations

Sampling Technique: Purposive sampling procedure was adopted in this research and as a result of that a total of seven synoptic stations (Birnin Kebbi, Gusau, Kano, Katsina, Sokoto, Yelwa and Zaria) were selected out of about ten (10) of such stations in Northwestern Nigeria. This is done while giving consideration to stations with longer consistent rainfall records and those stations more prone to drought.

Procedure for Data Collection

Field Data Collection: Rainfall data of varying temporal resolutions from 1915 to 2013 in case of Sokoto, 1915 to 2007 in case of Birnin Kebbi and from 1952-2013 in case of Kano, Katsina, Gusau, Yelwa and Zaria were sourced from Nigerian Meteorological Archives.

Review and Synthesis: Review and synthesis of literature onimplications of drought on rural livelihoods in the study area has been conducted. This has been done while keeping in mind that "virtually any topic you can name, there is a vast body of past research that may have some continuing value but mostly remains ignored" [46].

Procedure for Data Analysis

Determination of Rainfall Pattern and Trend: MS Excel data analysis tool box has been used in evaluating rainfall patters and trends through simple linear (least square) analysis which uses the equation $\Sigma \{[(at + b) - Yt]\}^2$ where at + b = trend line.

Computation of Rainfall Anomaly Index (RAI): Rainfall Anomaly Index by von Roy [47] was generated and employed to quantify occurrences, intensities and duration of drought in Sokoto (1915 -2013) and Birnin Kebbi (1915 – 2007). This is due to the fact that the available rainfall data of the two areas is in total annual format. RAI Values and interpretation used in the analysis are:

- -1.00 to -1.99 mild drought
- -2.00 to -2.99 moderate drought
- -3.00 or less severe drought

Computation of Standardized Precipitation Index (SPI): SPI, developed by McKee *et al*. [48], an index that quantify droughton various timescales (say 6, 12 months, etc) was generated. SPI standardize and normalize rainfall data into a Gausian Distribution. The computation was done with the National Drought Mitigation Centre's (NDMC) Program for Calculating SPI. The program is SPI_SL_6.exe_file is downloadable. The program is already complete and all libraries are included it was compiled in C^{++} for PC and it is user friendly. SPI Values and interpretation used in the analysis are:

-1.0 to -1.49	moderate drought,
-1.5 to -1.99	severe drought
-2 and less	extreme drought

RESULTS AND DISCUSSION

Results and Discussions

Rainfall Patterns and Trends of Sokoto and Birnin Kebbi 1915 - 2013: The patterns and trends of rainfall in Sokoto and Birnin Kebbiare almost the same. The rainfall pattern of Birnin Kebbi as depicted in Figure 2 is that: between 1915 and 1946 there was a moderate increasing trend while between 1947 and 1977 there were sharp upward trends before a final downward trends of the rainfall from 1978 to 2007. The overall picture shows that from 1915 to 2007 there has been a decreeing trend of rainfall in Birnin Kebbi. With regard to Sokoto between 1915 and 1946 there was a moderate increasing trend while between 1947 and 1960 there were sharp upward trends before a final downward trends of the rainfall from 1961 to 1989. Rainfall then started ameliorating from 1990 to 2013 though with minor fluctuations.

Rainfall Patterns and Trends of Kano, Katsina and Gusau 1952 - 2013: From 1952 to 2013only Kano station shows an upward trend in rainfall as shown in Figure 3. Though there are some oscilliations but generally the decades 1971-1980 and 1981-1990 are decades of decrease in rainfall in all the stations. The decade 1991-2000 also witnessed some decreases in rainfall in all the station with the exception of Kano and Gusau around the close of the decade.

Rainfall Patterns and Trends in Yelwa and Zaria 1952 – 2010: The rainfall started from decline in rainfall around 1960 up to around 1968 when the least rainfall was recorded (Figure 4). The rainfall then moderately increased a little bit before regressing back again from 1973 to 1982 in a fluctuating manner. But the rains ameliorated from 1990 to 2000. The rainfall of Zaria is unique in the sense that it experienced increasing trend of rainfall through out the time with exception of 1967 to 1972 and 1980 to 1985. However, the general picture of the rainfall trend is that of increasing one (from 1959 to 2012 there has been a positive trend in rainfall).

Inter-Annual Droughts

Inter-Annual Droughts in Sokoto and Birnin Kebbi: Figure 5 an outcome of Rainfall Anomaly Index generated from rainfall data of the two stations shows rainfall anomalies in Birnin Kebbi.As can be seen from Figure 5 drought years are in the 1924, 1925 (the driest years in the station), 1968, 1970s, 1980s and 1990s (decadal droughts). 1980s experienced the highest intensity drought conditions after 1924 -1925. However, rainfall has ameliorated in the years 1921 and 1946. The decades mid-1940s, 1950 and 1960s are time of rainfall amelioration generally.

Figure 6 reveals that drought years are in Sokoto are 1916, 1925, (the driest years in the station just like 1987), 1943, 1968, 1970s, 1980s and 1990s (decadal droughts). 1980s experienced the highest intensity drought conditions. The decades mid-1940s and 1950s are time of rainfall amelioration generally.

Inter-Annual Droughts in Yelwa and Zaria: Figure 7 shows the years of drought occurrences in Yelwa. The years of extreme drought are 1967, 1968, (these are the driest years in the station), But the longestdrought period (decadal droughts) is from 1976 to 1987. Though the intensity of drought in this station was not as severe and extreme like in the above two stations. The decades 1950s to mid 1960s and 1990s are time of rainfall amelioration generally.

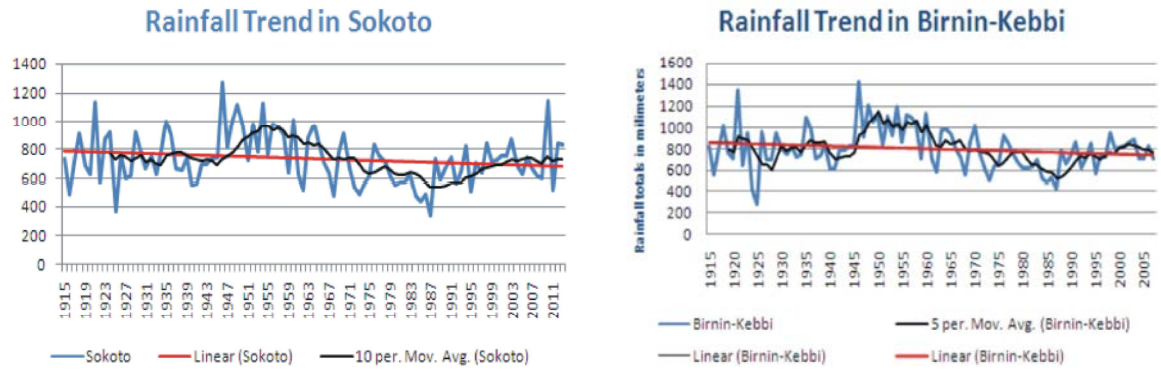

Fig. 2: Rainfall Trends in Sokoto and Birnin Kebbi

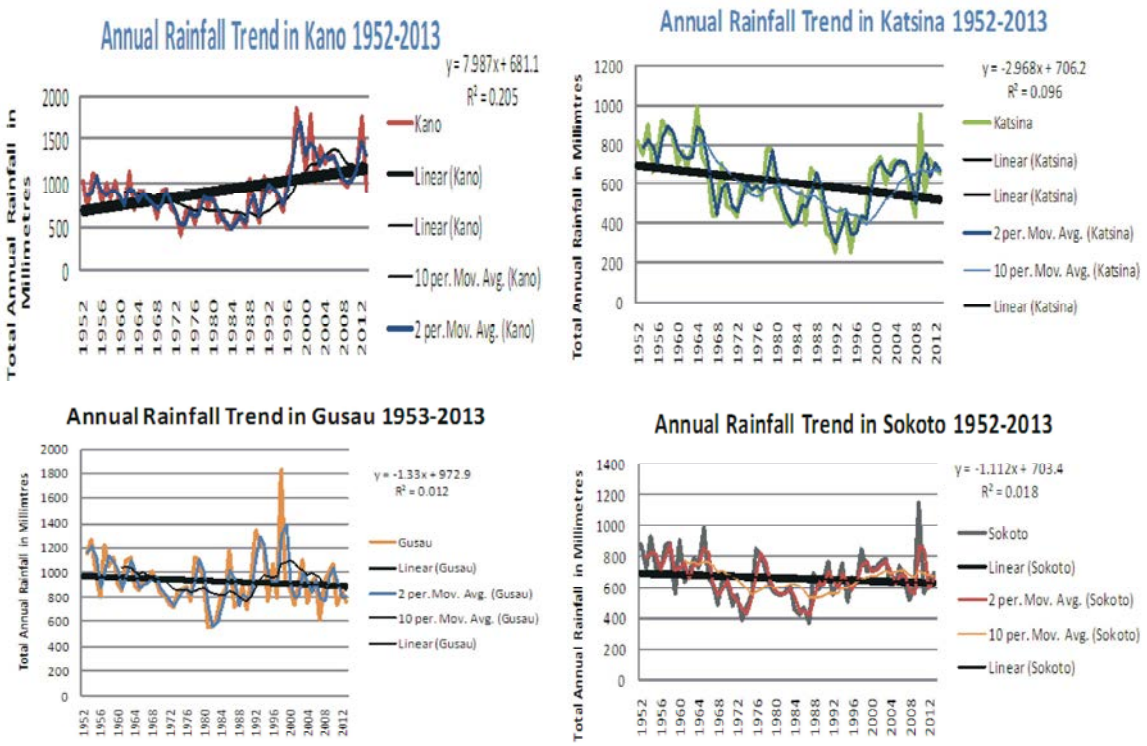

Fig. 3: Rainfall Trends in Kano, Katsina and Gusau

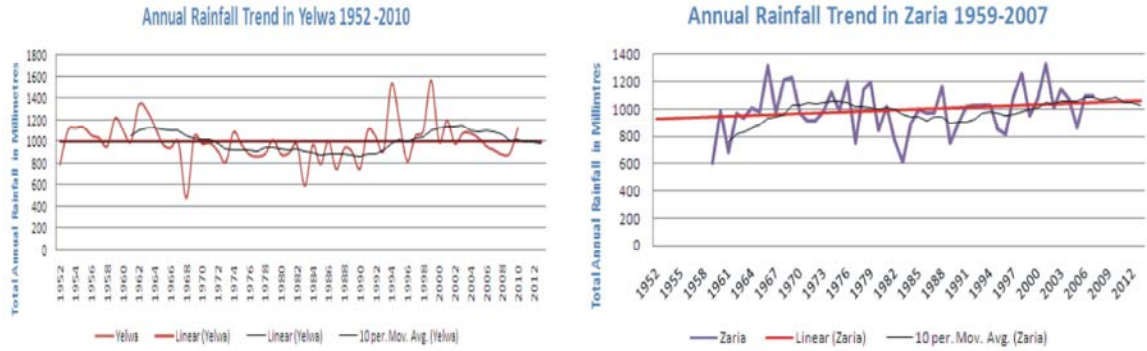

Fig. 4: Rainfall Trends in Yelwa and Zaria

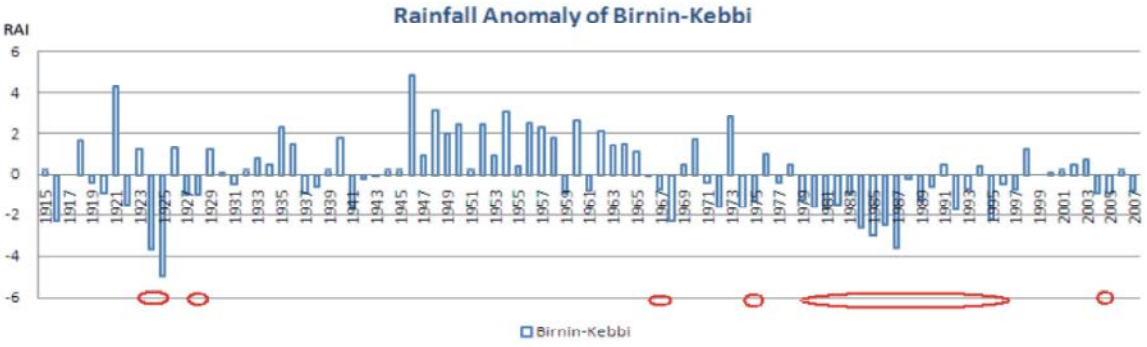

Fig. 5: Rainfall Anomaly of Birnin Kebbi

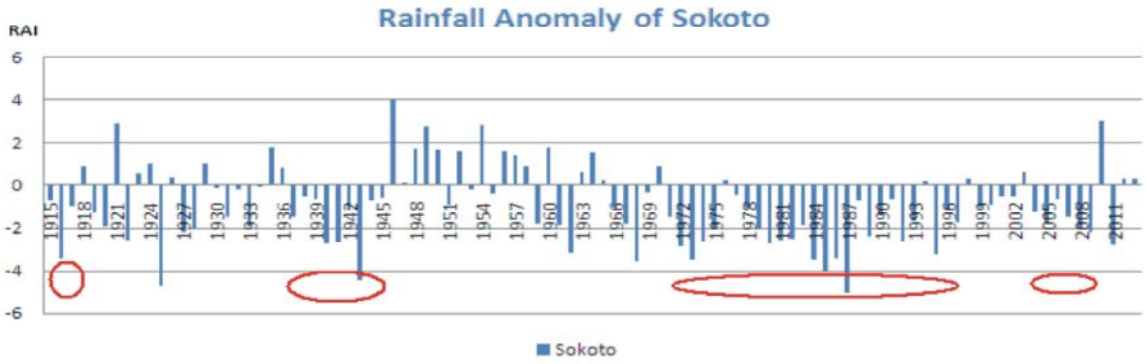

Fig. 6: Rainfall Anomaly of Sokoto

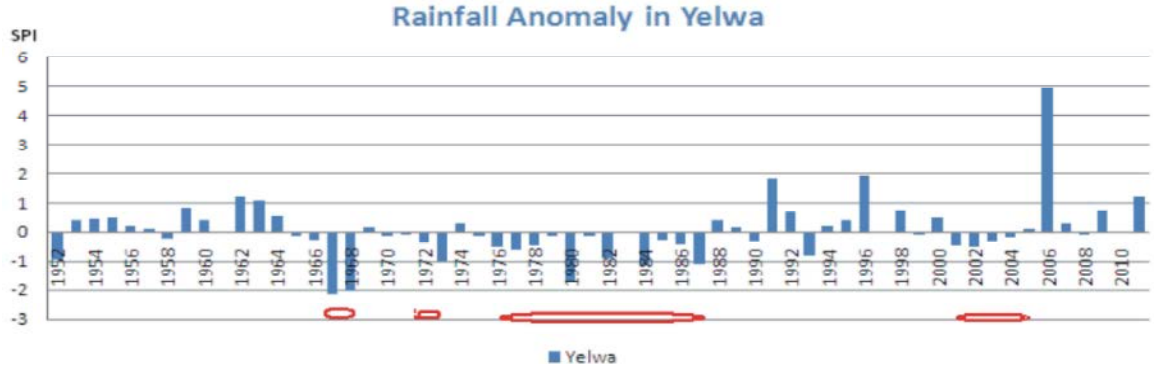

Fig. 7: Rainfall Anomaly of Yelwa

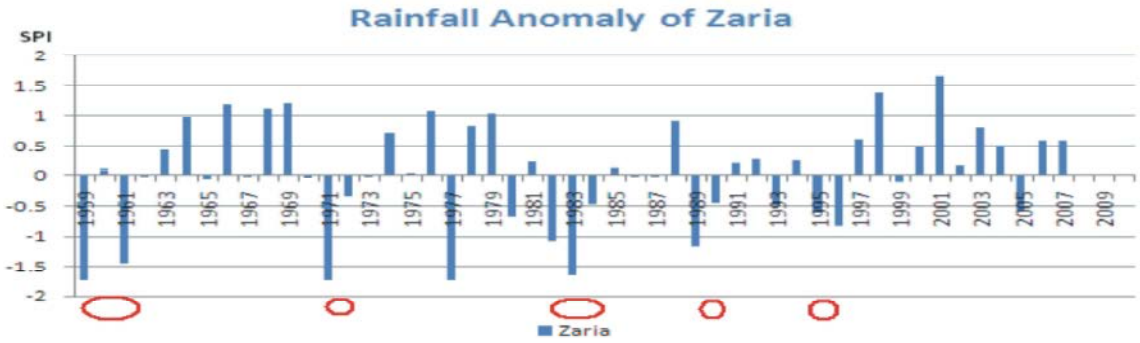

Fig. 8: Rainfall Anomaly of Zaria

Figure 5-7 show that the time of longest duration drought in Birnin Kebbi, Sokoto and Yelw has corresponded with time of the Sahelian widespread 30 year drought cycle that has been well reported in the literature such as IPCC [3] and Abaje *et al.* [49]. Figure 8 shows the year of drought occurrences in Zaria. There are no years of extreme droughts but as per years of severe drought they include: 1959 (the driest year in the station), 1961, 1971, 1877 and 1983. There is no also occurrence of decadal droughts in this station.. The period 1960s and 1997-2000s are time of rainfall amelioration generally.

Intra-Annual Drought Persistence in Kano, Katsina, Gusau and Sokoto: Drought is less experienced in Zaria and Yelwa as a result analyse the intra-annual (within the growing season) drought persistence is done in all the areas except these two. As the pattern of drought within the growing seasons determine the kind of hardship that farmers and livestock rearers are exposed to. An analysis of intra-annual (within the growing season) drought persistence show that the commonnest drought persistence that occur in all the areas is that of the whole growing season (*June-July-August-September-October*) which had occurred six times (6 or 60%) in Kano, Katsina

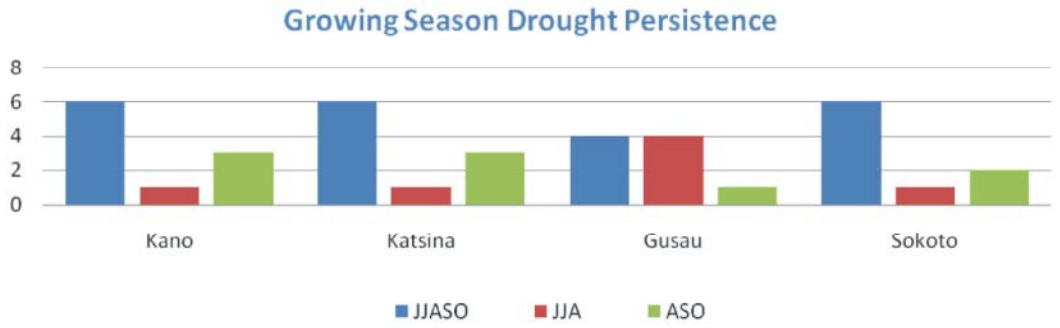

Fig. 9: Growing Season Drought Persistence

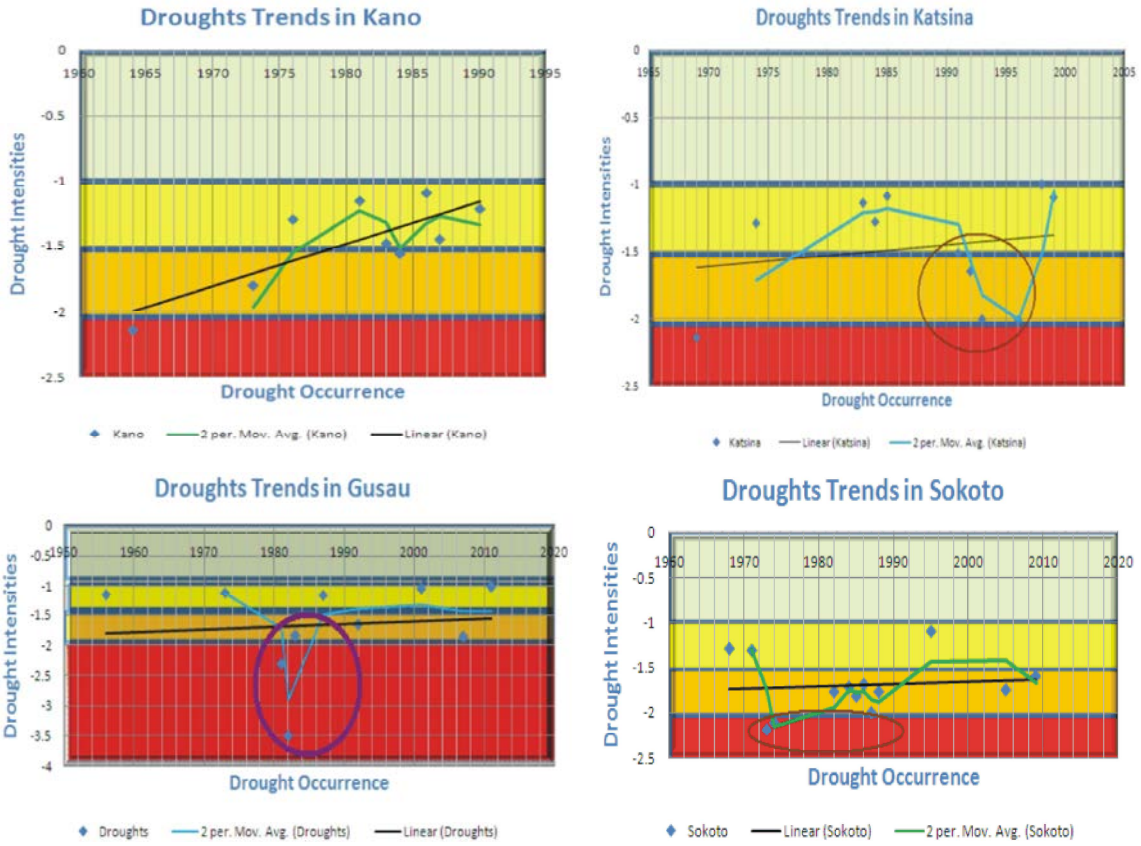

Fig. 10: Drought Trends in Kano, Katsina, Gusau and Sokoto

(6 or 60%) and Sokoto (6 or 67%) and four times in Gusau (4 or 44%) while the beginning of growing season drought persistence (*June-July-August*) occurred only once in Kano, Katsina and Sokoto but four (4) times in Gusau. While the end of growing season Drought persistence (*August-September-October*) occurred only once in Gusau, twice in Sokoto and three times in both Kano and Katsina.

From Figure 9 it would be observed most periods of severe and extreme droughts are associated with growing season drought persistence of all the season (*JJASO*) type. This is a very good indicator of hardship that farmers and livestock rearers had been engulfed in especially during the decadal drought occurrences.

Inter-Annual Drought Persistence in Kano, Katsina, Gusau and Sokoto: With regards to inter-annual drought persisntence Figure 10 shows that some of multi and mega years at the same time also the widespread droughts were experienced in the decades 1971-1980, 1981-1990. There are howver localized droughts that occurred in: Kano, Katsina, Gusau and Sokoto at varying time in

1960s, 1990s and in 2000s. Decade of common drought of higher intensity was 1981 to 1990 were drought occurred in all the stations. Likewise these droughts almost persisted through out the decade from 1981 in Kano and Sokoto, 1982 in Gusau, 1983 in Kano, Sokoto and Katsina and 1984 in Kano, Katsina, Sokoto and Gusau. This must have been a severe hardship decade.

Implication of Intra/Inter-Annual Droughts Persistence on Rural Livelihoods: Mortimore and Adam [50] observed that the years 1972-1974, thedreadful culmination of several years of low rainfall, evenbefore they were over, became known in northern Nigeria as *kakaduba,* a word that conveys acute shortage. According to them, granaries were empty for months or years. People atethe leaves of trees and herbs, or sold livestock, valuedpossessions or productive capital in order to struggle tomarket to bid for tiny portions of ground cassava, thecheapest food on sale. Whole villages appeared abandoned;whole families went to the towns to beg, especiallythose of pastoral people whose starving herds had died.In an analysis of annual water storage and its impacts on agriculture in the Sudano-Sahelian Zone (SSZ), Adeaga [34] observed that the periods 1980-1990 as well as the two 4-year periods of 1970-1973 and 1992-1995 were times with low annual water storage which greatly affected agricultural practices in the region. Implications ofdrought on livelihoods are: loss of flood plains, widespread crop failures, loss of livestock and over-cultivation of flood plains; and declining groundwater levels. In the 1970s 1980s and 1990sdrought resulted in bio-diversity loss due to clearing for farming and river dam construction for irrigation as a drought mitigation measures as for example construction of Tiga, Challawa, Zobe, Ajiwa dams and river impoundment in Kano and Katsina States. This resulted in loss of woodlands, repeated logging of the primary and secondary vegetation and depletion of large volume of species, drastic lowering of the water table which led todrying of wells and water bodies [35, 36].

Okunola and Ikuomola [51] also reported that agriculture in the Sokoto, Zamfara and Kano is becoming less lucrative because of the low farming yields of food and cash cropssuch as: millet, guinea corn, sugar cane, rice andbeans (cowpea). Oluwasemire, *et al.* [52] revealed that drought in the dry-lands of Northern Nigeria resulted in poor yield, low prices of crop/livestock, low dowry for their daughters, high cost of labor as a result of migration to urban centers, inadequate water for dry season farming, low income, low standard of living and high level of poverty. Although drought in the study area has altered cropping pattern, through elimination/reduction in the level of producing some crops or introduction of new crop varieties that are drought resistant and early maturing and diversification of source of livelihood which may be positive impact.

Summary, Conclusion and Recommendations

Summary: This paper is aimed at evaluation of occurrences of droughts in Semi-arid and Dry Sub-humid areas of Northwestern Nigeria and their implication on rural livelihoods. The research through adopting purposive sampling procedure selected seven synoptic stations (Birnin Kebbi, Gusau, Kano, Katsina, Sokoto, Yelwa and Zaria) out of about ten (10) of such stations in Northwestern Nigeria. Rainfall data of varying temporal resolutions from 1915 to 2013 in case of Sokoto, 1915 to 2007 in case of Birnin Kebbi and from 1952-2013 in case of Kano, Katsina, Gusau, Yelwa and Zaria were sourced from Nigerian Meteorological Archives and subjected to analysis to obtain rainfall trends. Rainfall Anomaly Index and Standardized Precipitation Index were generated to quantify droughts.

CONCLUSION

The patterns and trends of rainfall in Sokoto and Birnin Kebbi are almost the sameThe times of decline and amelioration of rainfall are almost common in both of the stationsFrom 1952 to 2013 only Kano station shows an upward trend in rainfall.The rainfall of Zaria is also unique in the sense that it experienced increasing trend of rainfall through out the time with exception of 1967 to 1972 and 1980 to 1985. The time of occurrence of longest duration (decadal) drought in Birnin Kebbi, Sokoto, Katsina, Kano and to some extent Yelwa has corresponded with time of the Sahelian widespread 30 year drought cycle that has been well reported in the literature though the intensity of drought in Yelwa was not as severe and extreme like as in other stations.There are no years of extreme drought ordecadal droughts of 1970s, 1980s and 1990s in Zaria. The decades 1950s to mid 1960s and 1990s are time of rainfall amelioration generally inmost of the stations. Periods of severe and extreme droughts are associated with growing season drought persistence of all the season (*JJASO*) type. This is a very good indicator of hardship that farmers and livestock rearers had been engulfed in especially during the decadal drought occurences.

Implication of drought on rural livelihoods included: loss of flood plains, widespread crop failures, loss of livestock and over-cultivation of flood plains; poor yield, low prices of crop/livestock, low dowry for daughters, high cost of labor as a result of migration to urban centers, inadequate water for dry season farming, low income, low standard of living and high level of poverty. Other implications are that farmingbecoming less lucrative because of the low farming yields of food and cash crops such as: millet, guinea corn, sugar cane, rice and cowpea. People resorted to eating the leaves of trees and herbs, or sold livestock, valued possessions or productive capital in order to struggle to market to bid for tiny portions of ground cassava, the cheapest food on sale. Whole villages appeared abandoned; whole families went to the towns to beg, especially those of pastoral people whose starving herds had died.

Recommendations: In view of the daintiness of drought and its effects onrural livelihoods the following suggestions have been proffered to be implemented by the stakeholders concerned:

- Governments at all level should prepare drought contingency plan that will effectively mainstream activities to provide early warning for drought, constitute task force that will proactively mitigate the effect of drought and enhance drought coping and adaptation of rural resources users. Where this plan is existing it should be updated and its implementation be enhanced.
- Community bases storage facilities should be evolved so that farmers and other rural resources users such as artisan fisher men can effectively store their surplus produce to the favourable market time or as a precautionary measure to un-rainy drought times;
- Also ecological problem of vegetal resources depletion should be given utmost priority as the farmers resort to consumption of wild fruits, vegetables and other hunger foods during drought so as not to make these vital resources extinct.
- Smallholder farmers, livestock rearers and fisher men should be assisted with interest free micro- loan that requires no collateral. As securing of collateral for a loan has persistently been a militating factor against rural dwellers access to agricultural finance.
- Non-Governmental Organizations (NGOs) and human right organization should champion the cause of empowering rural resources users and safeguarding their ecological environment;
- There is need to invest more in research and development on drought early warning, crop improvement and farm extension services;
- Dry season farming through the use of small and medium irrigation scheme should be encouraged by governments, private sector, donor organizations, research community in the study area;

REFERENCES

1. Cook, E.R., R. Seager, M.A. Cane and D.W. Stahle, 2007. North American drought: Reconstructions, causes, and consequences Earth-Science Reviews., 81: 93-134
2. Wilhite, D.A., 2000. Drought as a natural hazard: Concepts and definitions, Chapter 1. In: Sonmez, F. K., A. U. Komuscu, A. Erkan and E. Turgu, (2005) ed: An Analysis of Spatial and Temporal Dimension of Drought Vulnerability in Turkey Using the Standardized Precipitation Index. Natural Hazards., 35: 243-264
3. Abaje, I.B., O.F. Ati, E.O. Iguisi and G.G. Jidauna, 2013. Droughts in the Sudano-Sahelian Ecological Zone of Nigeria: Implications for Agriculture and Water Resources Development Global Journal of Human Social Science Geography, Geo-Sciences & Environmental Volume 13 Issue 2 Version 1.0 Year 2013 Type: Double Blind Peer Reviewed International Research Journal Publisher: Global Journals Inc. (USA) Online ISSN: 2249-460x & Print ISSN: 0975-587X
4. Oladipo, E.O., 1993. Some Aspects of the Spatial Characteristics of Drought in Northern Nigeria: *Natural Hazards,*8, 171-188, Netherlands: Kluwer Academic Publishers.
5. Odekunle, T.O., 2006. Determining Rainy Season Onset and Retreat over Nigeria from Precipitation Amount and Number of RAINY days; Theor. Appl. Climatol., 83: 193-201, Austria: Springer-Verlag
6. Federal Ministry of Environment, 2008. State of Nigerian Environment Report.
7. Masih, I., S. Maskey, F. Mussa and P. Tranbauer, 2014. A Review of Drought in the African Continent a geospatial and long-term perspective in Hydrol. Earth System Sci. Discuss 6 March 2014 18: 3635-3644/2014 accessed online @ www.hydrol_earth_syst _sci.net/18/3635/2014 doi:10519/hess-18-365-2014.

8. Motimore, M., 1989. Adapting to Drought: farmers, famines, and desertification in West Africa Cambridge: Cambridge University Press.
9. Watts, M., 1983. Silent Violence: Food, Famine and Peasantry in Northern Nigeria. University of California Press, Berkeley, CA, 687, pp: 8
10. Saulawa, A.M., 1989. Impact of Drought on Animal Husbandry in Katsina-Maradi Boarder Divisions in Asiwaju, A.I. and Barkindo, B.M. (1989) ed. The Nigeria-Niger Trans-border Cooperation a proceding of workshop at Bagauda Hotel, Kano, 2-8 July, 1989
11. FGN, 2007. National Drought Preparedness Plan.
12. Ekpoh, I.J., 1999. Rainfall and Peasant Agriculture in Northern Nigeria Global Journal of Pure and Applied Sciences, 5(1): 123-128
13. Camberlin, P. and M. Diop, 2003. Application of daily rainfall principal component analysis to the assessment of the rainy season Characteristics in Senegal. *Climate Research*, 23, 159-169. doi:10. 3354/cr023159, http://dx.doi.org/10.3354/cr023159
14. Nicholson, S.E., 1989. African Drought: Characteristics, Causal Theories and Global Teleconnections IUGG and AGU Publication 79-100
15. Chappell, A. and C.T. Agnew, 2004. Modeling Climate Change in West African Sahel rainfall (1931-90) as an artifact of changing station locations. Int. J. Climatol., 24: 547554.
16. Dai, A., P. Lamb, K.E. Trenberth, M. Hulme, P.D. Jones and P. Xie, 2004. The recent Sahel drought is real Int. J. Climatology, 24: 1323-1331. doi:10.1002/joc.1083, http://dx.doi.org/10.1002/joc.1083.
17. Floyd, B.N. and I.J. Ekpoh, 2007. Transforming traditional agriculture. Global Journal of Social Sciences, 6(2): 97-102.
18. National Committee on the International Decade for Natural Disaster Reduction, 1994. Natural Disaster Reduction in Nigeria A report of the National Committee on the (IDNDR) to the World Conference on Natural Disaster Reduction, Yokohama, Japan, 23-27 May, 1994
19. Hulme, M., 1984. An exceptionally dry year in central Sudan Oxford University Press, UK.
20. Batterbury, S. and A. Warren, 2001. Viewpoint on the African Sahel 25 years after the great drought: assessing progress and moving towards new agendas and approaches Global Environmental Change, 11: 1-8.
21. Hulme, M., 2001. "Climatic perspectives on Sahelian Desiccation: 1973-1998. Global Environmental Change, 11: 19-29.
22. Brooks, N., 2004. Drought in the African Sahel: Long Term Perspectives and Future Prospects Tyndall Centre Working Paper No. 61 October 2004.
23. Ayoade, J.O., 1984. Perspectives on Recent Drought in the Sudansahelian Region of West Africa with particular Reference to Nigeria Arch. Met. Geoph. Biokl. Ser. B., 25: 67-77.
24. Ayoade, J.O., 1988. On Drought and Desertification in Nigeria" In: P.O. Sada and F.O. Odemerho, eds. Environmental Issues and Management in Nigerian Development. Ibadan: Evans Brothers (Nigerian Publishers) Limited, pp: 271-290.
25. Buba, L.F., 2000. "Drought Occurrence and the Utilization of Rainfall for Agriculture in Northern Nigeria" In: Falola A. J., Ahmed K., Liman M. A., and Maiwada A. (ed.) Issues in Land Administration and Development in Northern Nigeria. Department of Geography, Bayero University, Kano Nigeria.
26. Adejuwon, J.O., T.O. Odekunle and S.A. Adejuwon, 2006. Climate Variability in Nigeria In Adejuwon, J.O. and Ogunkoya, O.O. (2006). (Ed.) Climate Change and Food Security in Nigeria. Obafemi Awolowo University Press.
27. Ati, O.F., C.J. Stigter, E.O. Iguisi and J.O. Afolayan, 2009. Profile of Rainfall Change and Variability in the Northern Nigeria, 1953-2002. Research Journal of Environmental and Earth Sciences, 1(2): 58-63, 2009 ISSN: 2041-0492
28. Attia, M.M., 2011. "Recent Rainfall Variability in Northern Nigeria" Katsina Journal of Natural and Applied Sciences, 2(1).
29. Abdulkadir, A., M.T. Uthman and A.H. Shaba, 2013. An appraisal of the eco-climatic characteristics in Northern Nigeria African Journal of Environmental Science and Technology, 7(8): 748-757, August 2013 DOI: 10.5897/AJEST12.161 ISSN 1996-0786 2013 Academic Journals http://www.academicjournals.org/ AJEST
30. Ifabiyi, I.P. and S. Ojoye, 2013. "Rainfall Trends in the Sudano-Sahelian Ecological Zone of Nigeria" Earth Science Research; 2(2); 2013 ISSN 1927-0542 E-ISSN 1927-0550 Received: January 15, 2013 Accepted: June 13, 2013 Online Published: July 19, 2013doi:10.5539/esr.v2n2p194 URL: http://dx.doi.org/10.5539/esr.v2n2p194 accessed on 12/03/2014
31. Olatunde, A.F. and J.K. Aremu, 2013. Return Periods of Drought Intensities in Some Stations in Northern Nigeria Journal of Environment and Earth Science www.iiste.org ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)

32. Omonijo, T.O. and E.C. Okogbue, 2014. Trend Analysis of Drought in the Guinea and Sudano-Sahelian Atmospheric and Climate Sciences 4, 483-507 http://www.scirp.org/journal/acs
33. Groove, A.T., 1973. A note on the remarkably low rainfall of the Sudan zone in 1913 Savanna, 2: 133-138.
34. Adeaga, O., 2002. "Management of Drought Risk in the Sudano-Sahelian Region of Nigeria" a paper presented at Regional Hydrology-: Bridging the Gap between Research and Practice (Proceedings of the fourth International FRIEND Conference held at Cape Town. South Africa. March 2002). IAI IS Publ. no. 274. 2002. 157.
35. Brown, L.R., 2006. The Earth is Shrinking: Advancing deserts and rising seas squeezing civilization Earth Policy Institute http://www.earth-policy.org/Updates/2006/Update61.htm
36. Nwafor, J.C., 2006. "Environmental Impact Assessment for Sustainable Development. The Nigerian perspective": Environmental Problems in Nigeria and Poverty – Environment links, pp: 529-533. EDPCA, 2006
37. National Planning Commission, 2009. Nigeria's Vision 20:2020 Report of the Vision 20:2020 National Technical Working Committee on Employment
38. Iloeje, N.P., 1965. A New Geography of Nigeria, Ikeja.
39. Olofin, E.A., 1987. Some Aspects of the Physical Geography of the Kano Region and Related Human Responses Departmental Lecture Note Series No. 1, Department of Geography, Bayero University, Kano
40. Blench, R., 2004. Natural Resources Conflicts in North Central Nigeria: A Handbook and Case Studies Cambridge, Malam Dendo Ltd.
41. Federal Ministry of Environment, 2012. National Strategic Action Plan for Implementation of the Great Green Wall for the Sahara and Sahel Initiative
42. Mortimore M. and M. Adams, 2001. Farmers Adaptation, Change and Crisis in the Sahel: Global Environmental Change, 11: 49-57.
43. Federal Republic of Nigeria, (FRN), 2000. National Action Program (NAP) to Combat Desertification and Mitigate the Effect of Drought. Towards the Implementation of the United Nations Convention to Combat Desertification and Mitigate the Effect of Drought in the Country.
44. Okorie, F.C., 2003. Studies on drought in Sub-Saharan region of Nigeria using statelite remote sensing and precipitation data.http://www.mathaba.net/gci/docs/research/nigeria-drought.htm
45. Harris, F. and S. Mohammed, 2003. Relying on Nature: Wild Foods in Northern Nigeria. Ambio, 32(1): 24-9.
46. Weed, M., 2005. "Meta Interpretation": A Method for the Interpretive Synthesis of Qualitative Research Journal of Qualitative Social Research Forum Vol 6, No 1 (2005) accessed onlined @ http://www.qualitative-research.net/index.php/fqs/issues/view/13.
47. Von Rooy, M.P., 1965. A Rainfall Anomaly Index (RAI) Independent of Time and Space Notos, 14: 43
48. McKee, T.B., N.J. Doeskem and J. Kleist, 1993. The Relationship of Drought Frequency and Duration to Timescale in Proceeding of the Eight Conference on Applied Climatology, Anaheim, Califonia, 17-22, January, 1993
49. Intergovernmental Panel on Climate Change (Task Group on Data Scenario Support for Impact and Climate Analysis -TGICA) (2010): Expert Meeting Integrating Analysis of Regional Climate Change and Response Options Meeting Report Intergovernmental Panel on Climate Change ISBN 978-92-9169-128-9 (2010).
50. Mortimore, M. and M. Adams, 1999. Working the Sahel! Environment and Society in Northern Nigeria London: Routedge also accessed online www.aiaccproject.org/Final Report/.
51 . Okunola, R.A. and A.D. Ikuomola, 2010. "The socio-economic implication of climatic change, desert encroachment and communal conflicts in Northern Nigeria American Journal of Social and Management Sciences Online: 2151-1559, doi:10.5251/ajsms.2010.1.2.88.101©2010,ScienceHuâ, http://www.scihub.org/AJSMS
52. Oluwasemire, K.O., S.A. Sanni and N.O. Nnoli, 2012 Traditional capacity for weather prediction, variability and coping strategies in the front line states of Nigeria Journal of Agricultural Sciences, 3(4) (2012), Article ID:20106,6 pages DOI:10.4236/as.2012.34075.