A SPATIO- TEMPORAL ANALYSIS OF DROUGHT IN THE NORTH WESTERN NIGERIA USING SATELLITE REMOTE SENSING AND PRECIPITATION DATA

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ABSTRACT

Drought episode has become a common phenomenon in the sub-Saharan Africa which the North western region of Nigeria is part of. The reason was being the susceptibility of the entire Sahel region of Africa to climatic anomalies. Considerable public attention is being drawn to the Sahel zone of Africa since three to four decades now due to several drought experienced throughout the region.

Drought, an incessant calamity, however, is difficult to prevent but the effects on humanity and other impacts on the environment can be mitigated through prediction, early warning and other management strategies. The AVHRR (Advanced Very high resolution radiometer) data have been explored for monitoring vegetation and NDVI (Normalized difference vegetation index) data being generated for the whole Africa, so also the installation of ARTEMIS (Africa real time environmental monitoring using imaging satellites) at the FAO remote sensing centre in 1988. Thus employing remote sensing techniques in studying drought by using normalized difference vegetation index, temperature conditions index, vegetation health index, estimated monthly rainfall and cloud conditions, from NOAA (AVHRR) and FAO (ARTEMIS) respectively make scientific research of the present time empirical. The use of (precipitation) ground truth data is also relevant to this study where relationships between meteorological drought and agricultural drought can be established.

An in-depth study covering about 17 to 30 years based on data availability is conducted over Northwestern states in Nigeria with the aid of remotely sensed data and precipitation data. Precipitation (rainfall) data of 1975-2004 from NIMET (Nigeria Meteorological Agency) was used, as well as vegetation health index and vegetation index data from NOAA and FAO, for 1985- 2002 AND 1982-1999 respectively.

The Findings based on the ground truth data reveals many years of drought incidence. Also vegetation health index data of July 1985-2002 and vegetation index data of 1982-1999 detects several years of drought condition in the study area of 6 states. Though, the study established that Northwestern region of Nigeria is a disaster prone area with particular reference to drought, the paper still makes some possible suggestions towards reducing the effects of the disaster on humanity.

CHAPTER ONE

1.1 INTRODUCTION

In view of global climatic anomalies, drought incidence is not strange to African continent especially in the Sahel region on which the northwestern part of Nigeria lies.

Rainfall measurement in Nigeria dates back to over 80 years, and some periods within the last century are widely reported to have experienced low rainfall and drought conditions, example, the Sahelian droughts of 1968 that lingered on till 1985/87 affected northern Nigeria, which had tremendous socio-economic impacts on the areas where pressure on available resources are on the increase in the face of a fluctuating rainfall regime (Usman, 1993). This paper embraced application of satellite remote sensing techniques and the use of precipitation data to analyze drought spatio-temporarily in the northwestern Nigeria.

1.2 DEFINITION OF THE PROBLEM

No doubt, one cause of "famine" in northern Nigeria is the failure of crops resulting from insufficient rainfall, this region with extremely varying climate was severely hit by droughts and famines during the Sahelian drought episode of late 1960's to 1980's. The entire zone is primarily agricultural oriented including animal husbandry, which naturally should be rainfall dependent, but rainfall failure have triggered off famines in some areas with an inadequate food security structure. Katsina for example suffered alone 13 years of drought from 1982 -1999 (NIMET 2001, in table 1). The drought causes death of animals and drop in farm yields, also is responsible for the social backwardness and general poor quality of life especially among the less privileged ones.

1.3 AIM AND OBJECTIVE

The purpose of the study is to develop a reliable drought assessment mechanism in the study area using ground truth and remote sensing data in order to achieve the following objectives:-

i) To demonstrate the use of vegetation index and other satellite data with ground truth data for monitoring regional drought.

ii) To identify drought affected areas of high magnitude in order to assess the scale of drought impacts in the areas.

iii) To suggest possible solutions towards management of the disaster so as to reduce the impacts on humanity.

CHAPTER TWO

2.1 METHODOLOGY

2.1.1 DATA COLLECTION AND DESCRIPTION

The ground truth (Precipitation) data got from NIMET (Nigerian Meteorological Department), Lagos for 30 years (1975-2004) for the 6 states in the study area, based on annual rainfall. Drought detection was done using mean annual rainfall description of less than or equal to 0.5 standard deviation as recommended by IDM (Indian Meteorological Department). The description includes, >M-S: severally drought (SD), M-S: moderately drought (MD), M±0.5S: Normal rainfall (NR), M+S: moderately excess rain (ME), and >M+S: severely excess rain (SE). Also remotely sensed data got from NOAA (AVHRR) and FAO (ARTEMIS), include imagery on vegetation health index of Nigeria/1985-2002), for July being the peak rainfall month in Nigeria, and Vegetation index (vi) data classified on Nigeria ecological zones from 1982- 1999, based on rainfall months (May-Sept). Ecological zones covering the study area are marked as BO5, BO9, B10, and B11. For results presentation, monthly VI and monthly RF on each zone for two drought years and two non drought years were extrapolated.

TABLE I: KATISNA AND YELWA ANNUAL RAINFALL WITH DROUGHT DESCRIPTION

KATSINA						YELWA				
S/N	YR	RR(X) mm	X –M	X- M/S	DESCRIPTION	YR	RR(X) mm	X –M	X- M/S	DESCRIPTION
1	1975	537.5	35.9	0.01	NR	1975	972.3	45.3	9.1	NR
2	1976	537.5	9.5	3.3	NR	1976	889.1	-38.2	-7.6	NR
3	1977	597	69	0.02	ME	1977	864.3	-63	-0.01	ND
4	1978	526	-2	-7.0	NR	1978	887.4	-39.9	-7.99	NR
5	1979	776.3	248.3	0.09	SE	1979	1014.4	87.1	0.02	SE
6	1980	773.4	245.4	0.09	SE	1980	881.4	-45.9	-9.2	WR
7	1981	554.8	26.8	9.4	NR	1981	895.9	-31.4	-6.3	NR
8	1982	495.4	-32.6	-0.01	MD	1982	1071.6	144.3	0.03	SE
9	1983	425.3	-102.7	-0.04	MD	1983	583.9	-343.4	-0.07	SD
10	1984	390	-138	-0.05	MD	1984	970.5	43.2	8.7	NR
11	1985	423	-105	-0.04	MD	1985	792.7	-134.6	-0.03	MD
12	1986	563.9	35.9	0.01	NR -	1986	1008.2	80.9	0.02	NR
13	1987	382.1	-145.9	-0.05	MD	1987	746.5	-180.8	-0.04	SD
14	1988	684.1	156.1	0.05	SE	1988	940.3	13	2.6	NR
15	1989	642.7	114.7	0.04	ME	1989	906.2	-21.1	-4.2	NR
16	1990	541.5	13.5	4.8	NR	1990	751.5	-175.8	-0.04	SD

17	1991	359	-169	-0.06	SD	1991	1107.1	179.8	0.04	ME
18	1992	310.3	-217.7	-0.08	SD	1992	1045.7	118.4	0.02	ME
19	1993	262	-266	-0.09	SD	1993	922.7	-4.6	-9.2	NR
20	1994	519.2	-8.8	-3.1	NR	1994	1057	129.7	0.03	ME
21	1995	431.1	-96.9	-0.003	MD	1995	1183.3	256	0.05	ME
22	1996	259.8	-268.2	-0.09	SD	1996	670.3	-257	-0.05	SD
23	1997	446.2	-81.8	-0.03	MD	1997	1069.9	142.6	0.03	ME
24	1998	411.4	-116.6	-0.04	MD	1998	1091	163.7	0.03	ME
25	1999	409.4	-118.7	-0.04	MD	1999	1556.2	628.9	0.13	SE
26	2000	676.6	148.6	0.05	ME	2000	998	70.7	0.01	NR
27	2001	699.1	171.1	0.06	SE	2001	1,199.4	272.1	0.05	ME
28	2002	726.2	198.2	0.07	SE	2002	983.3	56	0.01	NR
29	2003	744.2	216.2	0.08	SE	2003	1079.4	151	0.03	ME
30	2004	698	170	0.06	SE	2004	1079.4	152.1	0.03	ME

£x = 15,829.3 x = Individual Rainfall Value £x = 27,818 source = (NIMET/IDM 2008)
M = 528 M = Mean of all the Values M = 927
S = 2,841 S = Standard deviation S = 4,994

TABLE 2 (YELWA) MONTHLY RAINFALL (RF) AND MONTHLY VEGETATION INDEX (VI)

ZONE	**BO9**		**MAY**	**JUNE**	**JULY**	**AUG.**	**SEPT.**	**TOTAL**
D YR	1985	M.RF	39.7	86.4	283.7	170.3	160.1	740.2
		M.VI	0.17	0.24	0.33	0.41	0.43	1.58
ND YR	1982	M.RF	98.5	92.2	199.7	244.9	144.1	779.4
		M.VI	0.18	0.26	0.30	0.34	0.38	1.46
D YR	1990	M. RF	76.6	82.6	198.7	157.9	195.1	710.9
		M.VI	0.26	0.27	0.37	0.47	0.45	1.82
ND YR	1999	M.RF	54.8	133.0	231.1	609.9	330.6	1359.4
		M.VI	0.19	0.29	0.39	0.46	0.44	1.77

TABLE 3: (SOKOTO) MONTHLY RAINFALL (RF) AND MONTHLY VEGETATION INDEX (VI)

ZONE	**BO9**		**MAY**	**JUNE**	**JULY**	**AUG.**	**SEPT.**	**TOTAL**
D YR	1985	M.RF	0.0	95.2	96.7	143.3	71.1	406.9
		M.VI	0.1	0.1	0.2	0.31	0.33	1.04
ND YR	1983	M.RF	44.7	154.3	229.4	127.9	63.2	619.5
		M.VI	012	0.17	0.27	0.36	0.36	1.28
D YR	1992	M. RF	38.9	61.9	150.9	132.5	164.8	549.0
		M.VI	0.14	0.16	0.28	0.33	0.34	1.25
ND YR	1998	M.RF	6.9	88.7	180.6	183.1	314.9	834.3
		M.VI	0.14	0.18	0.24	0.32	0.36	1.24

Source: FAO (ARTEMIS) 2003.

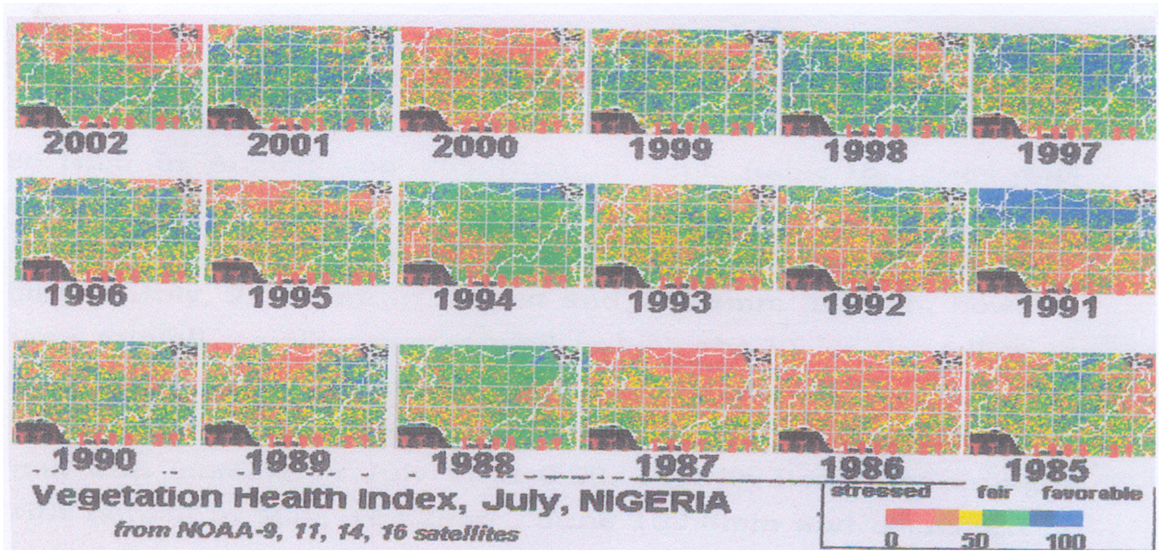

Figure 1. Image of Vegetation Health Index, July, Nigeria.

CHAPTER THREE

3.1 RESULTS AND CONCLUSION

3.1.1 RESULTS

The states in the region under study include, Sokoto, Zamfara, Kebbi, Katsina, Kano and Kaduna. For the period under study, Yelwa (Kebbi State) within (zone BO9) had 6 drought years; Kano (zone B10) had 9 drought years, Katsina 13 years. Sokoto (zone B11) 10 years and Kaduna 9 drought years (table 1). Some states had 2 years or more continuous agricultural drought, being more devastating to agriculture than intermittent drought years, as observed in Kano, (1989/1990), Kaduna (1983-85), Katsina (1983-1985), (1991-1993) etc. (Table 1).

For the monthly rainfall and monthly vegetation index; monthly VI reflects Rf availability or deficiency in the same month or previous month. Increase in rainfall for each month or the previous month will lead to increase in VI for that month, but decrease in monthly RF and total seasonal RF causes Low VI, hence drought. For instance 1992 drought year in Sokoto, May RF was 38.9 with VI 0.14, June RF was 61.9 with VI 0.16, July RF= 150.9 with VI 0.28 and total RF for the season = 549.0 with total VI 1.25. But non-drought year (1983) May RF = 44.7 with VI 0.12, June RF = 154.3 with VI 0.17, and total seasonal RF = 619.5 and total VI = 1.28. In Yelwa (1985) drought year may RF was 39.7 and VI 0.17, June RF = 86.4 and VI 0.24, July RF= 283.9 and VI 0.33. With total seasonal RF of 740.2 and total VI of 1.58. But in 1999 Non-drought year, total RF was 1,359.4 with total VI 1.77 see (table 2-3).

For vegetation health index, the imagery shows that Sokoto had severe drought in 1985 and moderate drought in 1992. This indicates stress from the VHI map (fig 1), which conforms to the result in table 4. From the table Sokoto had 96.7mm RF on July in 1985 with VI value of 0.2 of the same month. The stress condition arises due to non green colour of the vegetation, indicating lack of chlorophyll, which is unhealthy condition caused by rainfall deficiency. So colour is used here to assess the vegetation condition as a reflection of rainfall. Also in 1986 and 1987, Sokoto had drought, 1988 was fair year general but 1989, 1990 and 1992 were drought years in kaduna and Yelwa as indicated stressed in the VHI map. 1991, July was favourble in Sokoto, Katsina and Kano, 1993 was fair in Kaduna and 1995 was stressed in Sokoto and so forth.

3.1.2 Conclusion

"Drought is a climatic phenomenon, so as climate can either be normal or abnormal, the probability of drought occurrence on the global environment is positively skewed". This study focuses on reliable drought assessment mechanism using remote sensing applications. With the aid of available precipitation and remotely sensed data, a relationship between meteorological drought and agricultural drought was established. The correlation was shown on the vegetation index being the resource out put as a reflection of rainfall input (resource base). In that regard some development were observed in the monthly VI prior to monthly RF, but in some other cases, the VI decreased considerably due to the aridity of the region. The results generally show many years of drought in the area, and period under study. Only one state (Yelwa) experienced the least years (6 years) of drought, while Katsina the highest, had 13 years drought incidence.

3.1.3 RECOMMENDATIONS

1. Researchers should employ the proper use of remote sensing techniques in drought and other related studies, since remote sensing data have some advantages over ground truth data including accuracy and reliability.
2. There is a need to conduct regular comprehensive resource analyses, in the region, which would take into consideration, cropping pattern water resources and other land use pattern of the areas.
3. Team of experts to develop continuous operational early warming system should be established in the ministry of agriculture.

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