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SPATIAL PATTERN OF DROUGHT OCCURRENCE IN UPPER BENUE RIVER BASIN AREA, NIGERIA.

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ABSTRACT

Spatial variability of drought occurrence in Upper Benue River Basin area, Nigeria was examined. Data of monthly rainfall records for a period between May and October, which formed the growing season in the area were collected and analysed for period of 40 years from 45 rainfall stations spread over the area. Rooy's rainfall anomaly index (RAI) was used to compute drought indices. The result shows that localized patterns of droughts have occurred in the rainy season months, especially in the months of May, June, September and October. The influence of locational factors namely latitude, longitude and altitude was examined and it was found out that latitude and altitude contributed to sharp contrast in rainfall distribution between the north and southern zone of the area. The result was discussed with respect to agriculture and environmental management.

KEYWORD: Drought, Rainfall, Longitude, Latitude and altitude.

INTRODUCTION

The study of spatial variability of rainfall is an important consideration in the study of drought in a given region especially, in the tropics where rainfall not only tend to be more variable than in the temperate region but also more seasonal in its incidence within a year. Spatial rainfall variability is the amount by which the actual rainfall at given station differs in average from its mean value either above or below. Water inform of rainfall is a major determinant of productivity and sustainability in a functional ecosystem. However, the knowledge of rainfall variability of a given region is necessary because of its implications on the physical, social, economic and political environment.

Several works have been done on drought in various regions world-wide. There is no universally accepted definition of the phenomenon. Various researchers evolved their own definition according to their own specific requirement (see for example, Ayoade, 1988 Partha-sarathy et al 1987 and Schulze, 1984). The inherent content of the various definitions remain the same – i.e. drought conditions results from inadequate rainfall. Based on this, most report on drought now acknowledged that there are several types of drought such as agricultural, hydrological and meteorological drought.

Despite the recognition of the influence of rainfall variability on the socio-economic and political environment of a given region, relatively very little research has been directed at studying the actual consequences of drought caused by rainfall variability over Upper Benue River Basin area. However, cursory observation of long-term rainfall trends over the basin area reveals that drought conditions prevail over the basin area mostly in the month of May, June and October. However, the extent of intensity and severity of drought in the basin area had not been investigated.

It is against this background that this study is designed to examine the spatial pattern of drought occurrence in Upper Benue Basin Development Area.

METHOD OF STUDY

(a) The study area:

The study area is the Upper Benue River Basin Development area of Nigeria. It is one of the eleventh River Basins Authority created in 1976 for the management of the water and agricultural resources of the country (Adebayo, 1997). The Authority also performs other functions of improving the standard of living of rural dwellers like constructions of dams, boreholes processing and marketing of agricultural products within the basin areas, resettlement of those affected by the activities of the river basin development authority (e.g. construction of dams) and provision of rural electrification scheme to the peasant farmers who primarily engages in agricultural occupation (UBRBDA, 1999).

The basin areas lies mainly between Lat $6^0 31^1$ and 12^0N and between Longitude $9^0 34^1$ and $11^0 29^1$E, covering five states viz: Adamawa, Taraba, Bauchi, Gombe and Borno. (see Fig. 1).

The basin area falls within the tropical Savanna climate with distinct wet and dry seasons. Rainy season lasts for about six months (May – October) while the dry season spans from November to April. Rainfall in the basin varies from place to place, mean annual rainfall ranges from 2000mm in Gembu (on the Mambila Plateau) south of the basin area to 800mm at Nafada in the northern part of the basin area (Adebayo, 1997). Thus, rainfall decreases south to north following the latitude providing the southern parts of the basin with higher rainfall amounts than in the north extreme parts. This is also followed by decrease in length of rainy season northward with a difference of about of about 107 days between the southern and the northern parts of the basin (Adebayo, 1997).

Temperature in the basin area also do vary seasonally, with the hottest month as April while coldest month is December or January with mean minimum temperature of about 17^0C due to the presence of harmattan winds blowing from the continental interior.

However, the southern most parts of the basin experience relatively low temperature throughout the months of the year because of the influence of high altitude in the area.

Apart from small areas in the high Plateau (Mambila) which support montane vegetation and some relict forest in low lying grounds along the southern boundary of the study area, the whole of the areas are covered by savanna vegetation. This vegetation type consists of tall grasses (elephant grasses) and scattered trees of which baobab trees are common. The vegetation is denser and taller in southern and eastern parts of the basin than in the northern part due to the presence of relief associated with frequent rainfall of higher intensity.

(b) Procedure

A reconnaissance survey was carried out to identity all the rainfall stations in the basin. A total of 45 stations covering the five states were identified from the Upper Benue River Basin

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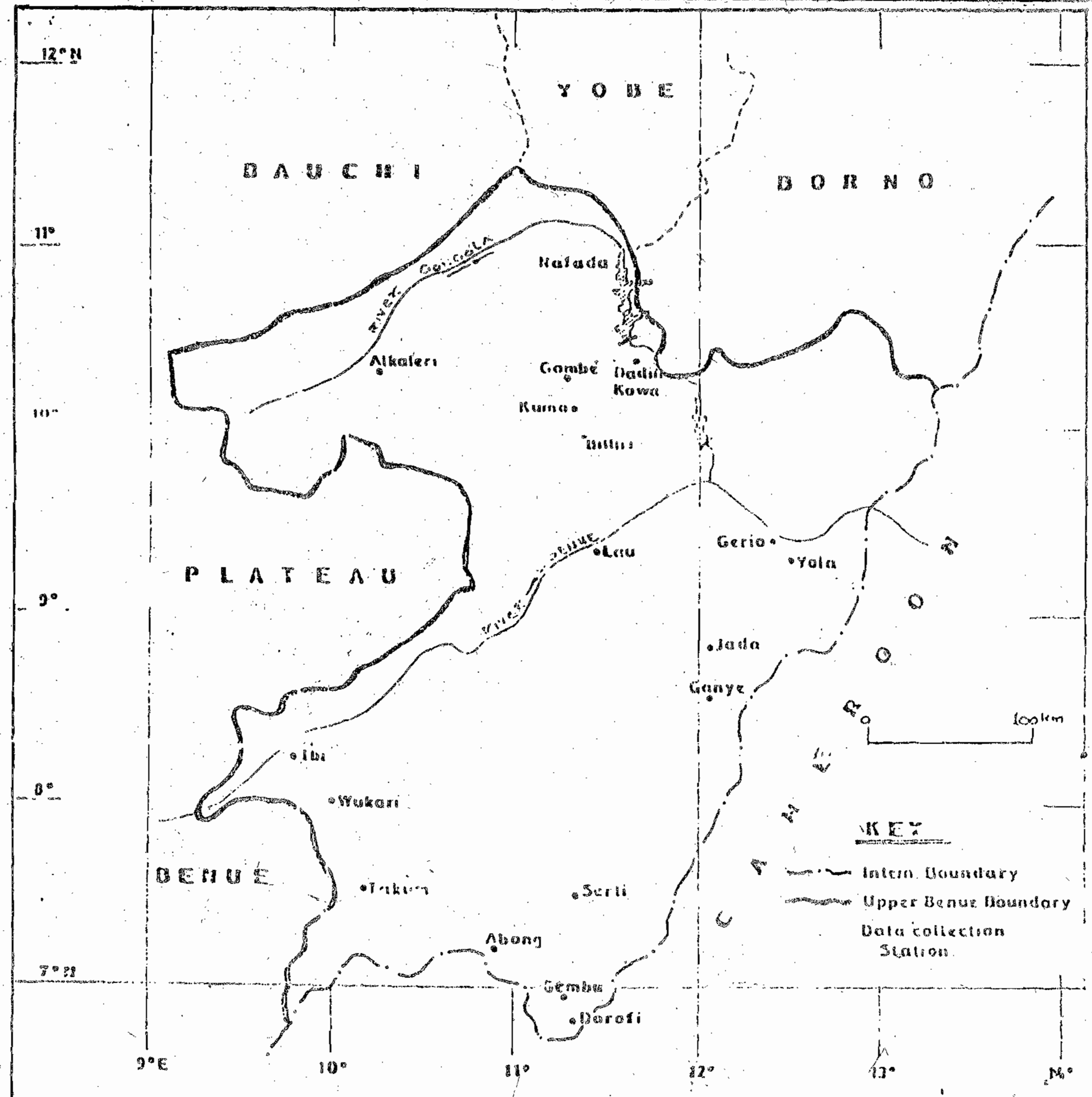

Fig. I MAP OF STUDY AREA SHOWING DATA COLLECTION STATIONS.

Development (UBRBDA) records and maps. These stations have varying length of rainfall records. To satisfy the analytical technique used in this study, only 23 rainfall stations with 15 or more years of monthly rainfall data were considered. Thus,

Data analysis include Rooy's (1965) Rainfall Anomaly Index (RAI) which was used to recast the numerous data and the influence of locational factors (latitude, longitude and altitude) on drought intensity in the basin area was also observed and discussed.

Rooy proposed that, the relative degree of abnormality for any given interval is reflected in the respective departure population. This, extreme anomalies may be accepted as representing commensurable degree of "dryness" or "wetness". Statistically, that a closer approach to

$R.A.I. = +3(P - P)/(M - P)$ ....(1)

or

Where P is the actual precipitation, P is the mean of long term precipitation, M is the mean of 10 highest values of P on record and X is the mean of 10 lowest values of record. The arbitrary threshold value of +3 and –3 have been respectively assigned to the mean of 10 most "extreme" positive and negative anomalies. From the above equations, it follows that R.A.I = 3 for P = M and R.A.I. = -3 for P = X. The classification of nine different abnormality classes is given against a scale of numeric values for the relative rainfall anomaly index (RAI) (see table 2).

Thus, RAI values between –1 and +1 are considered normal value equal to or less than –1 are indicative of moderate to extreme dryness. Similarly, values of RAI equal to a greater than +1 reflects condition of excess moisture. Thus index is a normalised measure of dryness or wetness over an area.

However, it is observed that this index has several advantages.

1. It is relatively simple, both in computation and application
2. It is easily applicable in an area like Upper Benue River basin where there is paucity not only in rainfall data in some stations but of other hydro

meteorological data namely, soil moisture, discharge etc especially on a long term and consistent basis.

3. It can be applied to a single or relatively few stations.

4. It ca be applied in a large area where there exist glaring seasonal differences, this is because rainfall anomaly for the relevant calendar period is exposed in relation to the long term average rainfall for that specific period, hence no seasonal weighing.

Table 2: Rooy's Rainfall Anomaly Index Classification

Index value	Class Description	Remark
Greater than 3.00	Extremely wet	Wetness
2.00 to 2.99	Very wet	Wetness
1.00 to 1.99	Moderately wet	Wetness
0.50 to 0.99	Slightly wet	Wetness
0.49 to –0.49	Near normal	Near normal
-0.50 to -0.99	Slightly dry	Dryness
-1.00 to -1.99	Moderately dry	Dryness
-2.00 to -2.99	Very dry	Dryness
Less than –3.00	Extremely dry	Dryness

Spatial variability of wet and dry conditions is also depicted using figures (see Figure 2 – 7) for the growing season months (May – October) in the basin area.

Fig. 2 shows the spatial pattern of RAI in May. Dry conditions prevail over the whole of the northern parts of the basin area from Latitude 7^0N and above. However areas of Near Normal conditions are found in the central zones around Ibi, Wukari and Takum areas of Taraba State. On the other hand, moderately wet to very wet conditions are observed in the southern parts around Maisamari, Abong, Serti, Mayo-

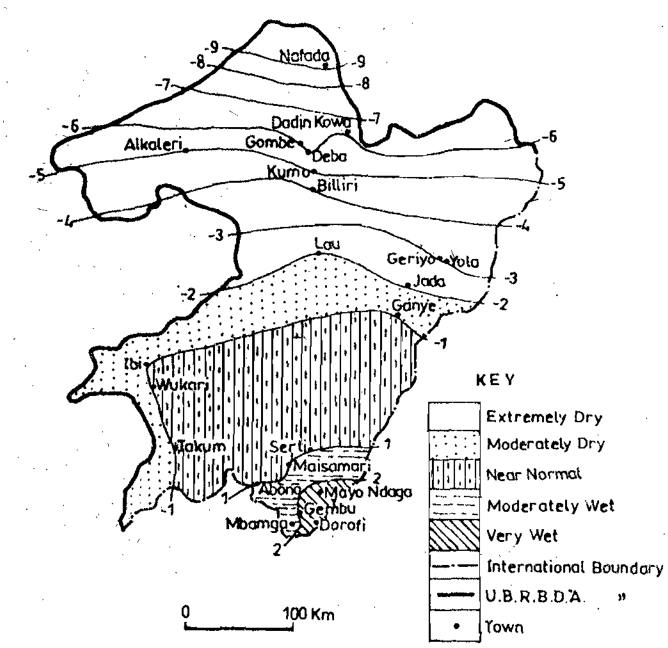

Fig. 2 : Mean RAI Isolines map for the month of May

monthly rainfall data were collected from 23 stations (see Table 1) for the period between 1960 – 1999 (40 years) from the archives of the Upper Benue River Basin Development authority Yola.

Table 1:Rainfall stations with years of data available

S/No	Station	Year
1	Yola	40
2	Lau	17
3	Jada	16
4	Kumo	21
5	Nafada	21
6	Takum	27
7	Serti	19
8	Biliri	15
9	Gembu	40
10	Dadin-kowa	27
11	Wukari	23
12	Ganye	19
13	Mbamnga	15
14	Mayo-Ndaga	16
15	Dorofi	21
16	Deba	18
17	Talasse	15
18	Ibi	16
19	Gombe	19
20	Alkaleri	27
21	Maisamari	17
22	Abong	19
23	Lake-Gerio	15

commensurability is obtained by using the mean of several "extremes" as a threshold value for departure. Based on this, he contented that the long term average amount and the seasonal distribution of rainfall may accordingly be accepted as the "normal" rainfall requirement for maintaining the local economy, whilst the "relative degree of abnormality" should be measured against the statistical population of the past departure from the "appropriate" average rainfall. He thus put forward his anomaly index (R.A.I) as follows:

$$R.A.I. = -3(P - P) / (X - P) \quad \text{......(2)}$$

5. Lastly, the index has been tested by Adeyemi (1992) and found comparable with other beautiful or elegant indices like that of Mooley (1980) and Palmer (1965). The application of R.A.I. is simple, from equation one and two above, it is obvious that any of the two equations can be used. A closer inspection shows that both equations yield the same result. Thus, the choice of any is subjective, and in this study, positive RAI (equation...1) is employed using equation 1, monthly rainfall anomaly index is calculated. This involves the following steps.

i. Calculating P (long term average) for the individual months at each station.

ii. Calculating M(average 10 highest value) by ranking the year by year monthly values for the stations and selecting the highest 10 values.

iii. Applying equation...(1)

iv. This procedure is repeated for the individual months in each station.

RESULTS AND DISCUSSIONS

To understand the spatial patterns of drought occurrence in Upper Benue River Basin area the mean values fo the selected stations are used to summarize the variability of RAI values over the basin area, and interpretation of the values was done in line with the Rooy's Rainfall Anomaly Index Table, (see Table 2). The mean values of RAI during the growing seasons months (May – October) were mapped and discussed separately to identify rainfall variability in each month in the basin area (see Figures 2 – 7).
Ndaga, Gembu, Dorofi and Manamnga. This general situation may be ascribed to the fact that may (the beginning of rainy season in the basin area) have most of its rainfall derived from thunderstorm (Adefolalu, 1991). The occurrence of these storms over northern Nigeria and indeed the basin area is erratic and concentrated more in perhaps the central part than in the southern and northern zones of the basin area.

Fig. 3 shows the spatial patterns of RAI for the month of June. In the month of June, slightly wet to near normal conditions prevails over most of the basin area, except slightly dry to moderately dry conditions which occurs around Nafada, Kumo, Alkaleri, Gombe and Biliri areas. However, slightly wet to extremely wet conditions prevails around Ibi, Wukari, Takum, maisamari, Serti, Gembu, Mayo-Ndaga, Dorofi, Mbamnga and Abong respectively

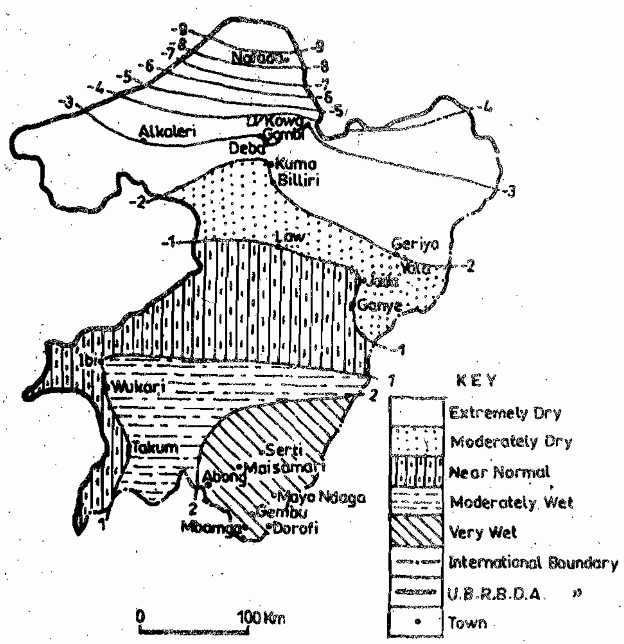

Fig. 3 : Mean R A I Isolines map for the month of June

This general pattern of increase in rainfall amount may be connected with the fact that this month marks the proper beginning of the rainy season over the basin area.

In July, the general condition has slightly changes with very wet conditions prevailing around the central and northern zone of the basin area (see Fig. 4). And extremely wet conditions prevailed around Takum, Serti, Abong, Maisamari, Mayo-Ndaga, Gembu, Mbamnga and Dorofi in the southern zone of the basin. This month therefore may be

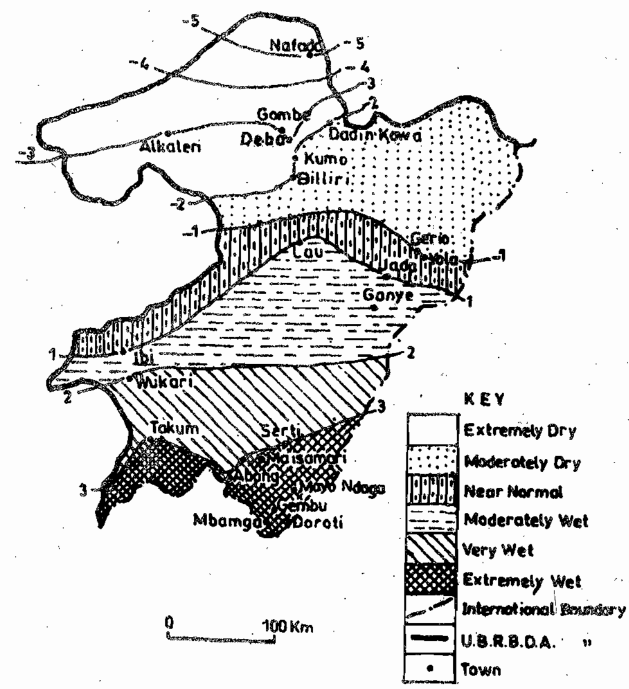

Fig. 4: Mean RAI Isolines map for the month of July

tagged Near Normal spatial conditions over the basin. The mapped pattern of all the areas shows a south-north gradient. It declines from greater than 0.50 in the south to 0.49 in the central parts and less than –0.50 in the northern zone indicating a dry conditions.

For August, the spatial pattern is similar to that of July, except that for an absence of very dry conditions in almost all parts of the basin areas (see fig. 5). By August, the whole of the basin areas and elsewhere in the northern parts of Nigeria are entirely under the influence of rain bearing south westerlies. This is why all the stations have a positive record of RAI values indicating wet conditions of different categories.

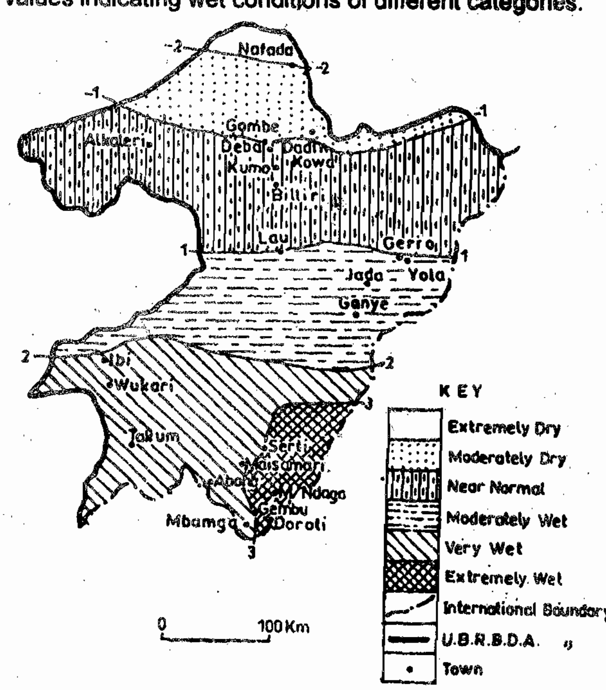

Fig. 5: Mean R A I Isolines map for the month of August

In the month of September, the very wet and extremely wet conditions have shifted to the southern part of the study area (see Fig. 6). The northern zones around Biliri, Kumo, Alkaleri, Deba, Gombe and Dadin Kowa have begun to experience slightly dry conditions. This condition may be attributed to the southward movement of the Inter Tropical Discontinuity (ITD). This ITD sometimes called Inter-tropical convergence zone when it occurs over the ocean, represents a moisture boundary separating the tropical continental air mass of northern origin from the tropical air mass of northern origin from the tropical air mass of the Atlantic origin. This surface movement of the zone influences the distribution of rainfall in Nigeria (the study area inclusive) in particular and West African region as a whole Adeyemi, (1992). The ITD starts its southward migration around September and October with the subtropical highs and tropical continental air mass gaining the upper hand on its northern edge Ayoade, (1983). The southward passage of ITD tends to be more rapid than the northward migration. Therefore, the month of September is

Table 3 shows that latitude has a significant negative correlation with RAI values throughout month formed growing season in the basin. The negative values indicate that the higher latitudinal position of stations in the study area the lower the RAI value signifying dryness hence drought conditions.

The Longitudinal position exhibits negative correlation (although not significant) with R.A.I values. The negative relationship suggest that the higher the Longitude, of a place the drier it tends to be, such that stations in the northern parts of the basin experiences more dry conditions than those in the southern parts.

However, on the other hand the altitudinal position exhibited significant positive correlation with RAI values. Thus, stations on high altitude have higher RAI values indicating conditions of wetness, this explains why area on the Mambila Plateau experience little or no dry conditions in the growing seasons months (May – October). This is confirmed by Nieuwolt (1982) who rightly observed that

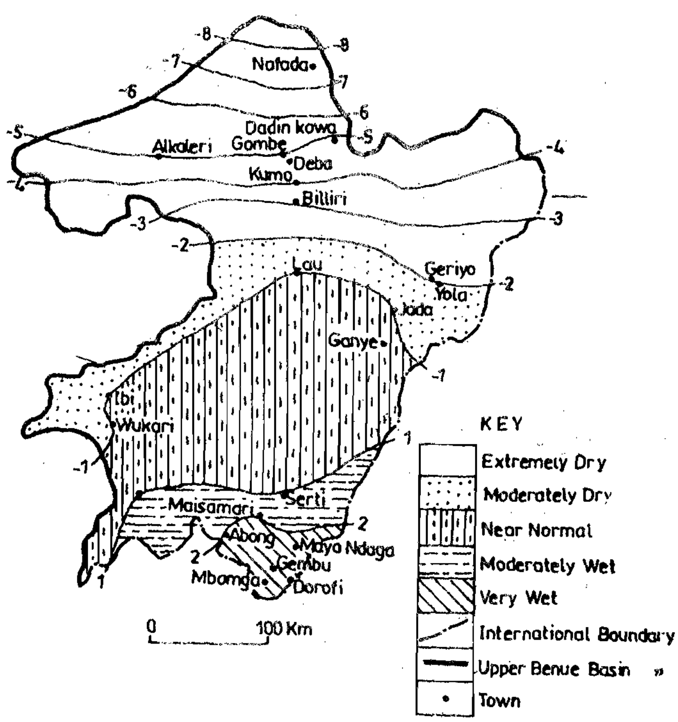

FIG. 6: Mean RAI Isolines map for the month of September

Table 3:Correlation of mean monthly RAI with locational factors.

	May	June	July	Aug.	Sept.	Oct.	Mean RAI
Latitude	-0.917	-0.823	-0.649	-0.581	-0.760	-0.519	-0.883
Longitude	-0.195	-0.276	-0.026	-0.088	-0.137	-0.051	-0.124
Altitude	0.673	0.604	0.639	0.607	0.890	0.270	0.755

0.423 is significant at 5%

mountains and highlands receive more rainfall than nearby lowlands, at least on their wind ward sides. This according to him is the result of orographic lifting process, which increases rainfall in all climates. This process is reinforced by strong differences in water vapour content between regions and the predominance of vertical air movement in tropics that helps in the uplift of the water vapour content.

CONCLUSION

One could argue that we cannot forecast the on set of a drought, its magnitude, or duration. It is even difficult to identify whether or not a region is in the midst of drought situations, crop season, can only be saved by a timely rainfall. Usually for food security, farmers should adopt early planting of crops that grows and thrive within short periods of time and some drought resistant crops.

Secondly, since it is believed that time and space representation of a rainfall variability would provide a most comprehensive and useful record of a large-scale features of the study area's rainfall history, more meteorological stations be established to keep up to date series of these representations which could be used to furnish excellent considered the end of growing season in most areas of the northern zones of the basin.

In the month of October, similarly condition to that of September prevails in the northern zone of the basin with most stations beginning to experience dry conditions due to the rapid southward retreat of ITD. The central zone on the other hand, experiences Near Normal to slightly wet conditions. This is due to the fact that these stations are within the zone that experience double maximum rainfall, whose second peak usually come by October during the southward retreat of the ITD (see Fig. 7).

From the foregoing, there is a clear evidence of severe to extreme negative anomalies over a wide area in the basin, extending right across the interior to the northern most part. This exhibit drought period with expected disastrous affects to the economy of the basin area and even to the general welfare of its inhabitants.

In a sharp contrast to this, examples of extreme positive records of rainfall anomaly are recorded over almost all the stations of the southern zone of the basin indicating moisture availability for almost all the growing season months (May – Oct) in the basin, which is capable of sustaining the local economy.

This sharp contrast in rainfall variability between the north and southern zone of the basin is highly inclined to the influence of locational factors (Latitude, Longitude and Altitude) on rainfall distribution in the basin area. The essence of introducing these factors is to assess the contribution of each factor to the pattern and intensity of drought in the area. The influence of each factor is examined and described below (see table 3).

materials for drought information as well as for synoptic research.

Finally, this and other drought studies, one could assert that we already know a lot about the physical aspects of drought and about how different societies (or even the same society under different conditions) respond. Thus in order to minimize the effect of drought conditions on people and environment of the affected areas, the following measure are suggested. Since we are aware that drought episode affect the environment, we therefore call on the government to exhibit a strong interest and much concern about drought by taking into consideration pre-occurrence measures to avoid a fire-brigade approach to drought crisis.

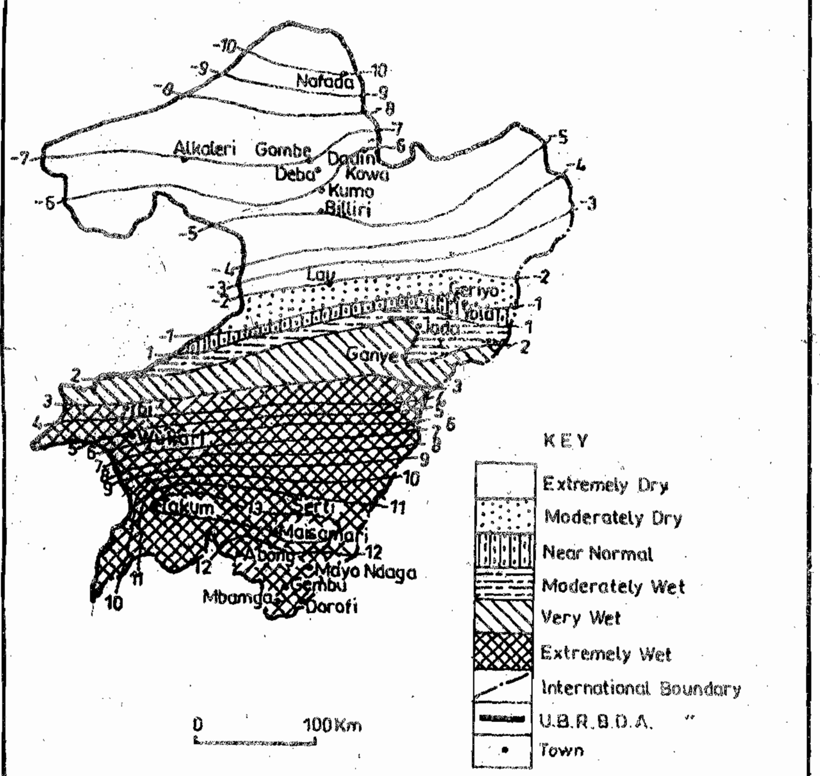

Fig. 7: Mean RAI Isolines map for the month of October

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