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Full Length Research Paper

Rainfall seasonality in the Niger Delta Belt, Nigeria

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This paper examined rainfall seasonality in the Niger Delta, Nigeria, using both monthly and annual rainfall data from 1931 to 1997. The data was retrieved from the archives of the Nigerian Meteorological Agency in Lagos. The data was collected on 9 synoptic stations in the region. The statistical tools employed for the study are the cumulative index analysis and the percentage of mean. The result indicated a wet season with over 95% of the total annual rainfall in the area. It also showed a long wet season from February/March to November and a short dry season from December to January/February. Besides, this study observed a northward increase in rainfall in part of the eastern side of the Niger Delta. The variation of rainfall in this locality could probably be as a result of rainfall determinant factors different from the inter tropical discontinuity. This study is important for agricultural planning and other socio-economic activities.

Key words: Annual rainfall, wet season, dry season, seasonality.

INTRODUCTION

Many investigators have sought ways of explaining rainfall seasonality (Winstanley, 1974; Walsh and Lawler, 1981; Mason, 1998; Goddard et al., 2001; Goddard and Mason, 2002; Sumner et al., 2001; Tennant and Hewitson, 2002; Lyon, 2003; Lyon and Barriiston, 2005; Lyon and Mason, 2006; Wilson and Dawe, 2006; Li et al., 2006; Hickel and Zhang, 2006; Sansom and Thomson, 2007; Moron et al., 2007). Rainfall seasonality is the distributional pattern of rainfall on monthly basis in a defined geographical area (Ayoade, 1994). Ayoade (1988) established that seasonal precipitation distribution is equally as important as the total amount in both tropical and extra-tropical areas. Wilson and Dawe (2006) identified rainfall seasonality in Trinidad, West Indies, using autocorrelation, a mathematical facet of Time Series Analysis. Walsh and Lawler (1981) linked rainfall seasonality in Africa, to latitude. They discovered that seasonality is low in equatorial areas but increases rapidly with latitude, particularly towards the Sahara where the highest seasonality index (S.1) values are found. In like manner, Ayoade (1970) noted increasing seasonality in the rainfall of Nigeria with distance from the coast as part of the continental scale latitudinal pattern. However, Winstanley (1974) established significant correlation between early seasonal rainfall and seasonal total in West Africa. He used 30 years rainfall data (1931 to 1960) for 59 stations from the Atlantic coast to Chad and obtained a significant correlation between June rainfall (early seasonal rainfall) and seasonal total.

Other studies have investigated July-August rainfall known as the 'Little dry season" as a component of rainfall seasonality in Nigeria (Crowe, 1951; Ilesanmi, 1981; Adedokun, 1978, Adefolalu, 1983; Adejuwon et al., 1990; Gbuyiro and Orji, 2005; Gbuyiro and Orji, 2005; Adejuwon and Odekunle, 2006; Gbuyiro and Adefisan, 2007): Hamilton and Archbold (1945) associated July/August rainfall with subsidence inversion found in 800 to 850 mb levels. Also, Adedokun (1978) associated rainfall seasonality with the effect of the descending branch of Walker circulation.

Literature aforementioned revealed that no detailed study has been carried out on rainfall seasonality in the Niger Delta. Previous understandings included two stations namely Port Harcourt and Warri. The stations are too few to make adequate generalization for a large area like the Niger Delta that covered over 29,100 km^2 (Ogunkoya and Efi, 2003). The present study is an attempt at filling the gap created by inadequate literature

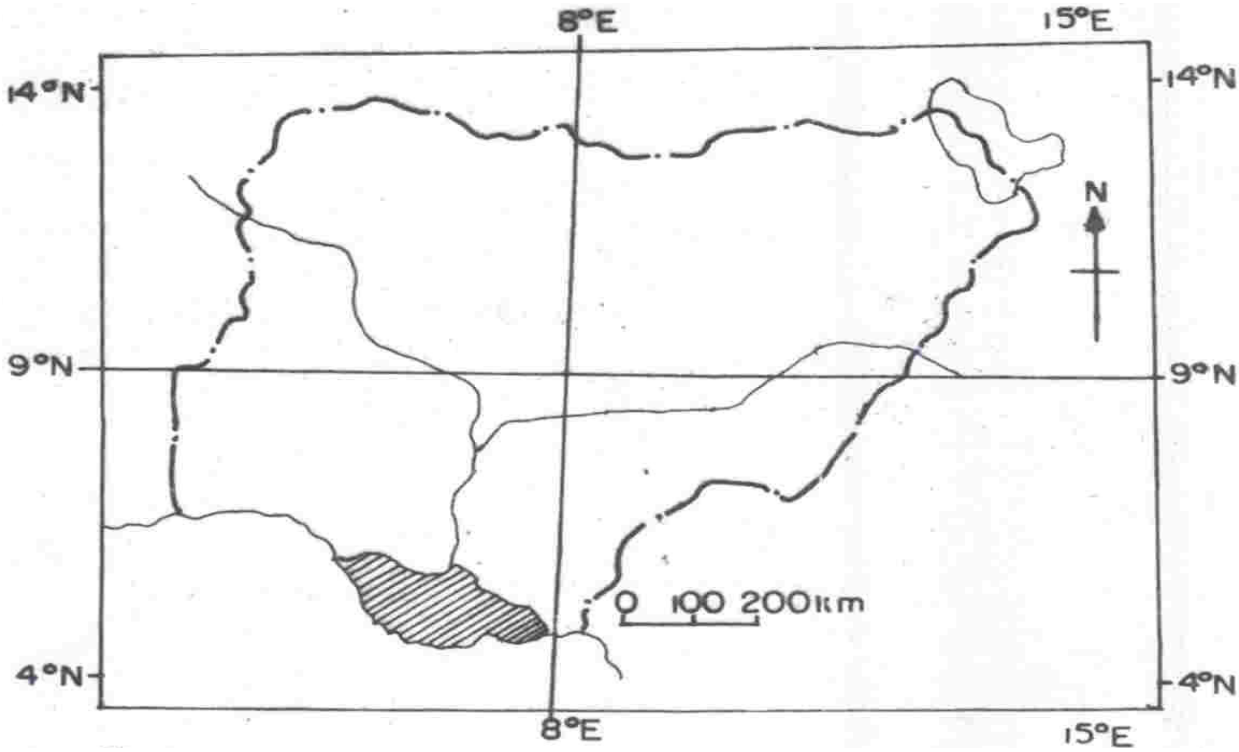


Figure 1. Location of the Niger Delta in Nigeria.

on rainfall seasonality in the study area. This study aimed at examining rainfall seasonality in the study area. The objectives of the study are to: (1) Assess the pattern of rainfall distribution in the study area; (2) Examine the percentage contribution of seasonal rainfall to the annual rainfall total in the study area; (3) Identify the causes of the pattern of rainfall distribution in the study area; and (4) Examine rainfall attributes in the study area.

STUDY AREA

The study area, Niger-Delta is one of the largest deltas in the world (Singh et al., 1995). It is located in Southern Nigeria and covers a land area of over 29,100 km^2 (Ogunkoya and Efi, 2003). It lies between longitude 5.05°E and 7.35°E and latitude 4.15°N and 6.01°N (Figures 1 and 2).

However, the Niger-Delta lies mainly within the wet equatorial climatic region, but in its northern extremities, the climate is the tropical wet and dry climate. Between February to November, the climate of the coastal zone is dominated by the tropical maritime air mass while the remaining December to January is under the influence of the dry tropical continental air mass. These two air masses are separated by the inter-tropical discontinuity (ITD), which is a zone of relatively low pressure system. This zone controls the north-south movement of rainfall in the tropics (Lamb, 1983; Bello, 2008). The mean annual rainfall decreases from about 4500 mm around the coastal margin to about 2000 mm around the northern fringe of the study area. The thermal regime as indicated by mean annual temperature exhibits a marked uniformity. The range for most stations is from 27°C along the coastal fringe to about 28°C in the interior of the study area (Emielu, 2000). The relative humidity decreases slightly in the northern fringe where it averages about 80% as compared with 85% in the south. The study area is under continuous high cloud cover as a result of humidity. The wind tends to be omni-directional in the dry season but is concentrated in the south, southwest and west directions in the rainy season (Ogunkoya and Efi, 2003).

METHODOLOGY

Sources of data

The climatic data used for this study consist of monthly rainfall data from 1931 to 1997. The data were collected from the archives of Nigeria Meteorological Agency, Oshodi, Lagos and International Institute of Tropical Agriculture (IITA), Ibadan. The stations for which data were collected include Warri, Sapele, Forcados, Yenagoa, Ahoada, Port Harcourt, Degema, Onne and Opobo (Table 1). The British standard rain gauge and dines titling siphon rainfall recorders were used in recording the data from these stations. NIMET observers carried out the reading of these instruments. The information from NIMET about the characteristics of the stations showed that the data employed in this study have

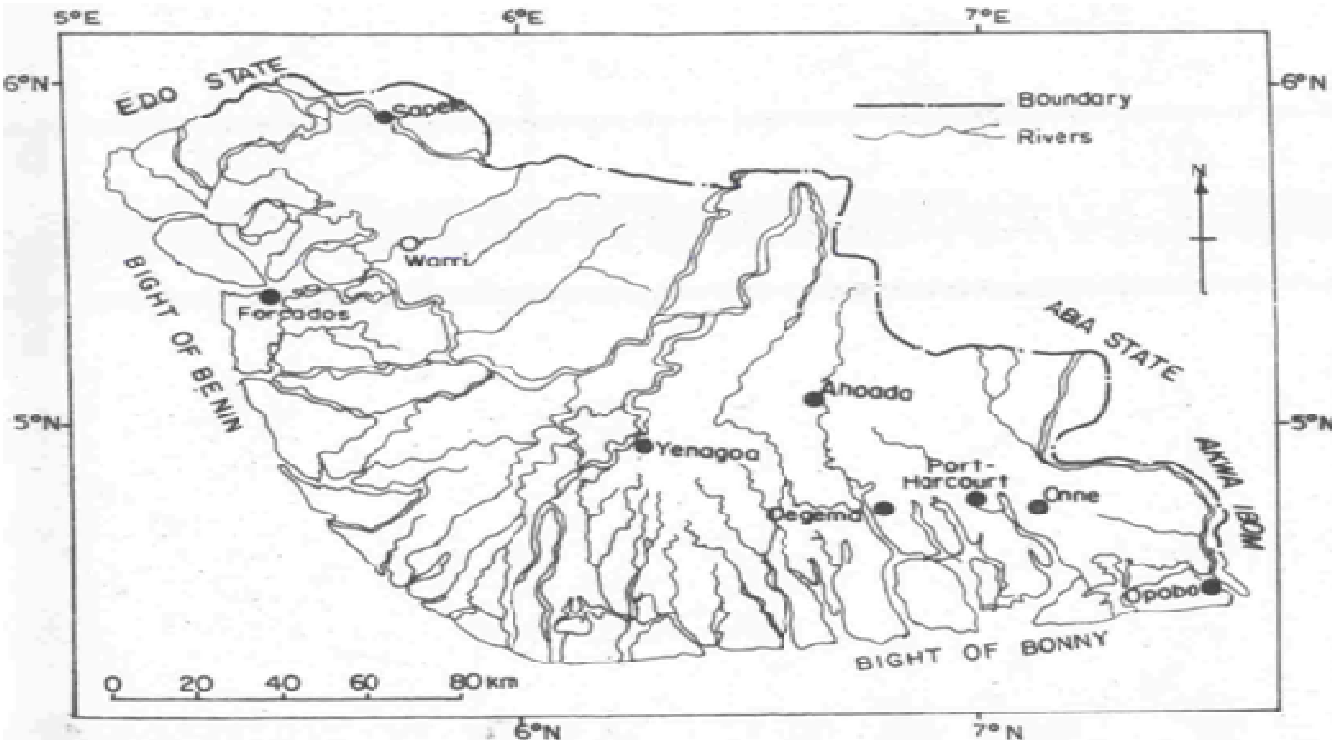


Figure 2. The study area showing sampling locations.

Table 1. Location of stations at Nigeria Meteorological Agency, Oshodi, Lagos and International Institute of Tropical Agriculture (I.I.T.A), Ibadan (1999).

S/N	Station	Latitude (°N)	Longitude °E	Altitude (m)	Data record
1	Sapele	05.55	05.41	6.1	1931-1997
2	Warri	05.31	05.44	6	1931-1997
3	Forcados	05.25	05.26	3.0	1931-1997
4	Yenegoa	04.58	06.16	5.0	1961-1997
5	Ahoada	05.03	6.39	9.06	1973-1997
6	Port Harcourt	04..45	07.01	9	1931-1997
7	Degema	04.43	06.46	3	1931-1997
8	Onne	04.44	07.02	11.35	1977-1997
9	Opobo	04.29	07.35	3.1	1931-1997

not been affected by site relocation. The data has been assessed and confirmed for consistency.

Data analysis

In the preliminary treatment of computation of the totals and mean were employed for the analysis of monthly and annual rainfall in each of the station. Percentage of mean was the statistical tool employed for seasonal variation. This involves the addition of mean rainfall figures during the wet season months and the dry season months to arrive at wet and dry season totals. The percentages of both the wet and dry season totals in relation to the mean annual totals were calculated. Cumulative index analysis was used for the examination of the extent of the seasonal period. It is expressed as: C.I = D (51-AP) / RN. C.I is the cumulative analysis, D is the number of days in that month, AP is the total accumulation of rain before 51 mm rainfall has been reached, RN is the total number of days of that month. Rainfall onset is the period when 51 mm of rains is expected (Walter, 1967). Monthly rainfall values over time showed fairly continuity of rainfall after 51 mm have fallen. This amount ensures sufficient moisture in the soil to maintain crop growth and gives a reasonable guarantee that planting would be successful if started two weeks later. The end of rains is the date after which less than 51 mm of rain is expected. This index is preferred to accumulate percentage of 5-days because it is more efficient (Walter, 1967, Davy et al., 1976). The fact that rain fall for certain number of days does not guarantee that it will be sufficient enough for planting. Except that rainfall reaches certain amount in

Table 2. Seasonal variation of rainfall (mm) in the Niger Delta.

S/N	Station	Mean Annual Rainfall (mm)	Dry season rainfall amount (Dec-Jan/Feb)	Percentage of mean rainfall in the dry season (Dec-Jan/Feb.)	Wet season rainfall amount (Feb/March-Nov)
1	Sapele	2389	88	3.68	2301
2	Warri	2807	66	2.28	2743
3	Forcados	3442	85	2.47	3357
4	Yenagoa	3191	43	1.35	3148
5	Ahoada	2393	51	2.13	2343
6	Port-Harcourt	2372	64	2.70	2308
7	Degema	2361	66	2.80	2295
8	Onne	2438	95	3.90	2343
9	Opobo	3767	97	2.57	3670

Table 3. Monthly average values of rainfall and accumulated total in the Niger Delta (1931-1997).

Station	No. of years	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Accumulated total	
														Onset	End
Sapele	67	20.6	44.0	102.6	185.4	216.7	328.7	441.9	282.7	395.1	268.4	79.6	23.2	64.7	23.2
Warri	67	26.2	58	131	225.2	263.1	368.9	474.5	343.1	450.0	323.3	104.7	39.8	26.2	39.8
Forcados	67	42.2	42.8	137.2	191.4	320.6	551.7	691	341	540.6	401.5	123.5	58.8	84.5	42.2
Yenagoa	37	42.7	69.1	157.6	263.9	310.2	375.9	424.6	444.6	552.3	356.5	143.1	51.1	42.7	42.7
Ahoada	67	25.6	57.6	129.6	207.1	259.5	281.9	322.4	277.2	350.5	275.1	133.9	40.3	25.7	40.3
Port-Harcourt	25	31.3	60.4	168.1	177.8	213.0	270.5	393.0	352.5	367.1	264.4	76.2	19.3	31.3	19.3
Degema	67	29.3	61.1	135.7	183.0	243.3	290.1	341.2	29.5	377.5	261	112.6	35	29.3	35
Onne	21	25.4	47.5	144.6	157.7	271.6	305.2	361.6	388.6	335.2	260.9	123.3	26.2	72.9	26.2
Opobo	67	47.3	81.6	139.8	238.6	354.6	534.6	697.4	483.3	511.2	437.4	192.1	49.4	47.3	49.4

the soil, crop survival may be at risk.

RESULT

The seasonal variation of rainfall in the Niger Delta is shown in Table 2. Table 3 showed monthly average values of rainfall and accumulated total in the Niger Delta while the rainfall onset and cessation dates are shown in Table 4. Rainfall starts in February/March and terminates November/December The mean annual rainfall indicated a northward decrease in rainfall from 3817 mm in Opobo to 2355 mm in Degema (04.43°N to 06.46°E) and a northward increase to 2371 mm in Harcourt (04.45°N, 07.01°E) and 2393 mm in Ahoada (05.03°N, 06.39°E) in eastern Niger Delta (Figure 3). However, there was a decrease in rainfall from the south-northward in western part. Yenagoa contributed the highest percentage of rainfall to the annual total with 98.65%, while Onne contributed the least percentage of 96.10%. Like the annual rainfall, the mean wet season rainfall decreased from 3670 mm in Opobo northward to 2295 mm in Degema (Figure 4). From Degema, rainfall increase north-ward to 2308 mm in Port Harcourt and 2343 mm

Table 4. Dates of onset and retreat of rains in the Niger Delta.

S/N	Station	Onset of rain	Retreat of rain
1	Sapele	8th March	20th November
2	Warri	12th February	27th November
3	Forcados	8th March	26th December
4	Yenegoa	3rd February	26th December
5	Ahoada	9th February	17th November
6	Port Harcourt	10th February	26th November
7	Degema	12th February	28th November
8	Onne	5th March	34th November
9	Opobo	1st February	30th November

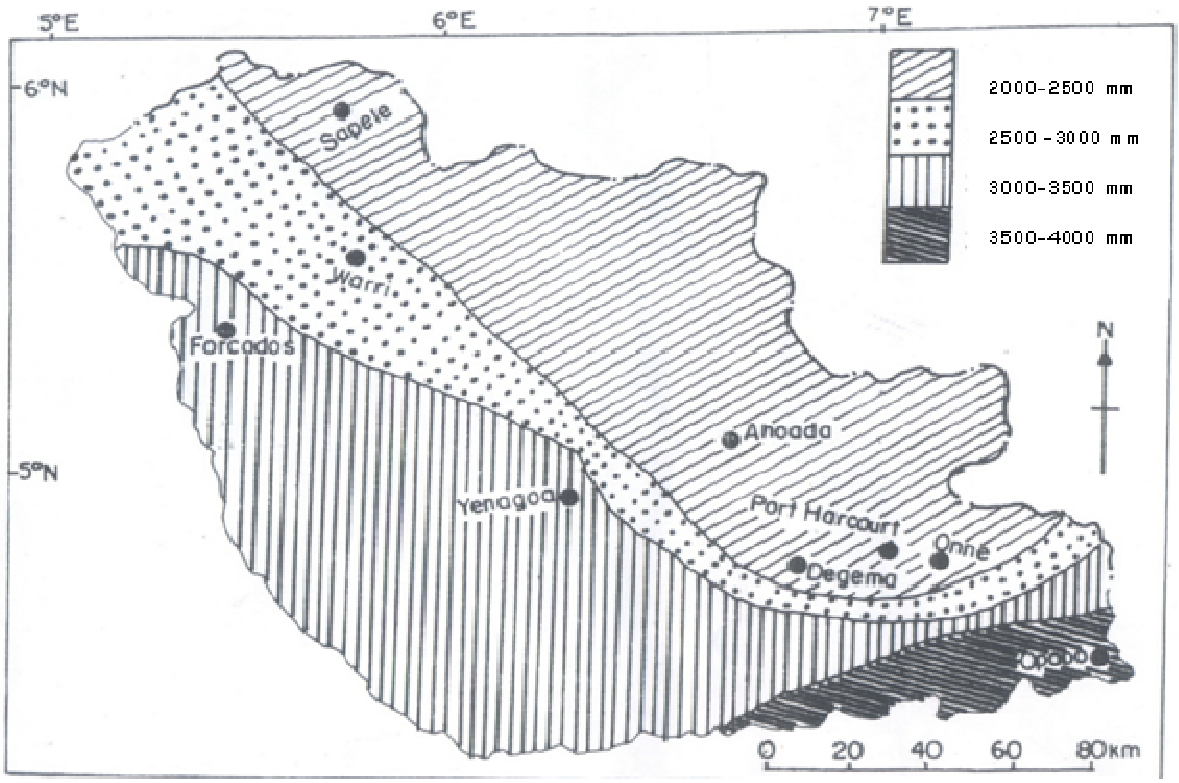


Figure 3. Mean annual rainfall (mm).

in Ahoada. However, rainfall progresses northward from Forcados to Sapele in the Western Niger Delta.

The rainfall amount during the dry season period decreased from 97 mm at Opobo to 51 mm at Ahoada in the eastern side of the Niger Delta (Figure 5). At the western side, Forcados and Warri recorded 85 and 66 mm rainfall respectively. The percentage contribution of dry season rainfall to the annual rainfall total was highest at Onne with 3.90% and lowest at Yenagoa with 1.35%, respectively

The mean monthly rainfall in the Niger Delta was lowest in December and January (Figure 6). There is a monotonic increase in rainfall at all stations until August when there is a modest general reduction in the amount of rainfall except for Onne. The increase of rainfall in September is followed by a general decrease of rainfall till December.

DISCUSSION

As noted in the result, rainfall starts in February/March and terminates November/December. Both the annual and the wet season rainfall showed a decreased rainfall

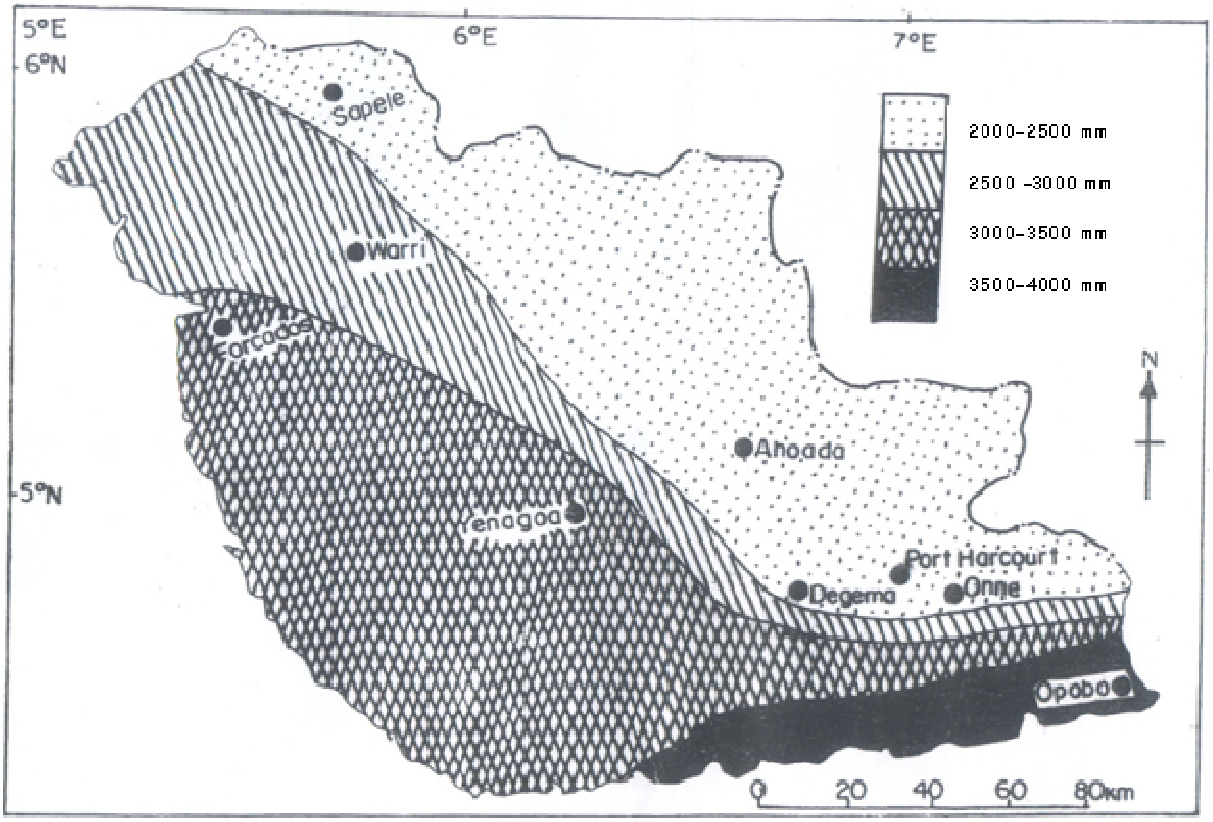


Figure 4. Mean wet season rainfall (mm).

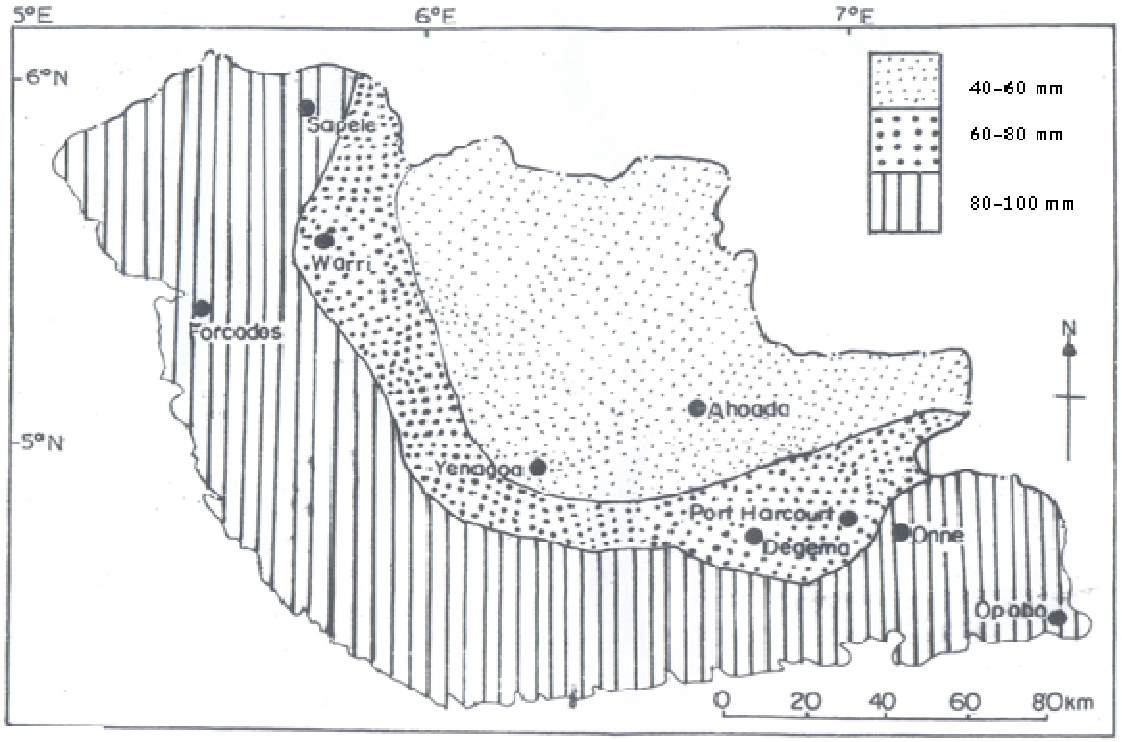
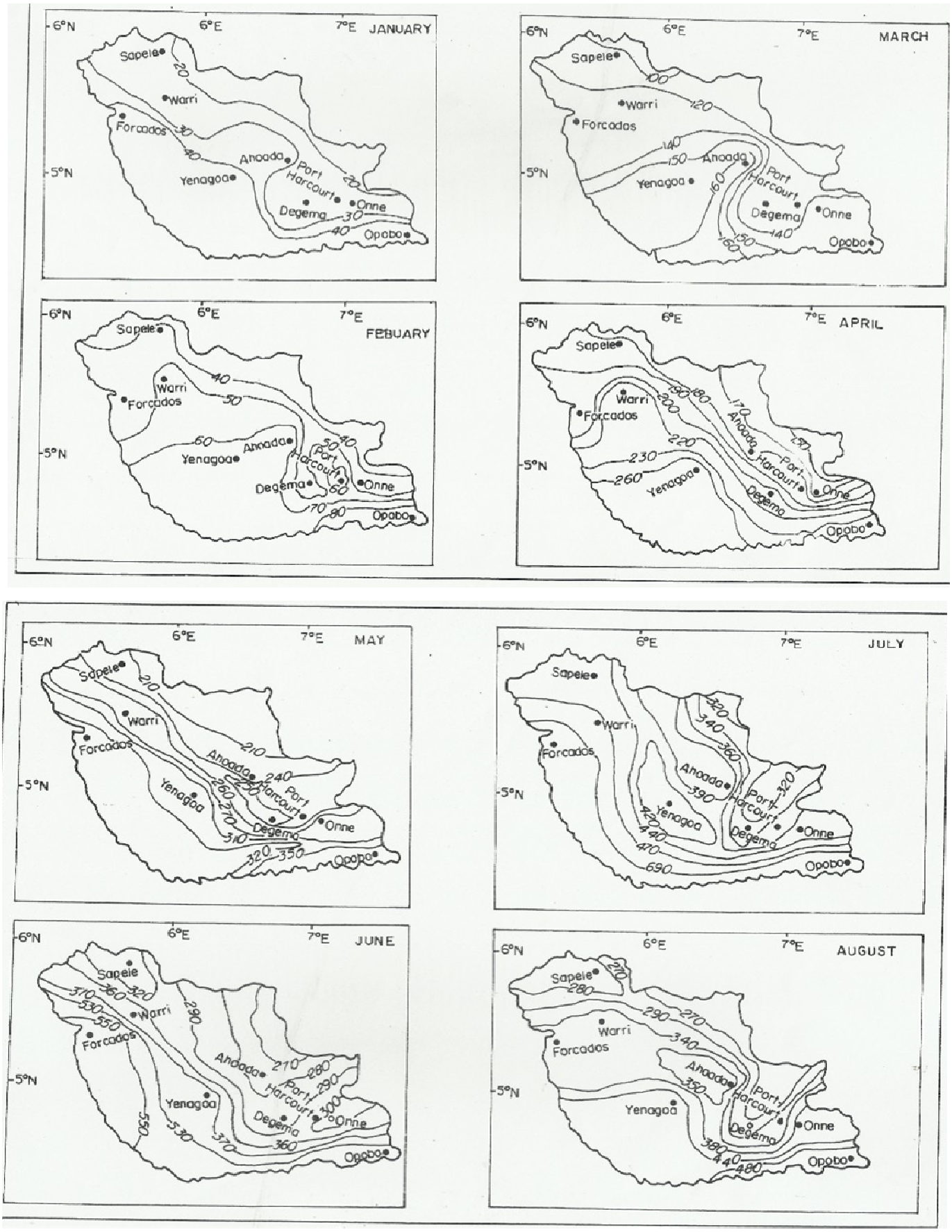


Figure 5. Mean dry season rainfall (mm).


JANUARY
FEBUARY
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MAY
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AUGUST
6°N
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Port Harcourt
Degema
Onne
Opobo

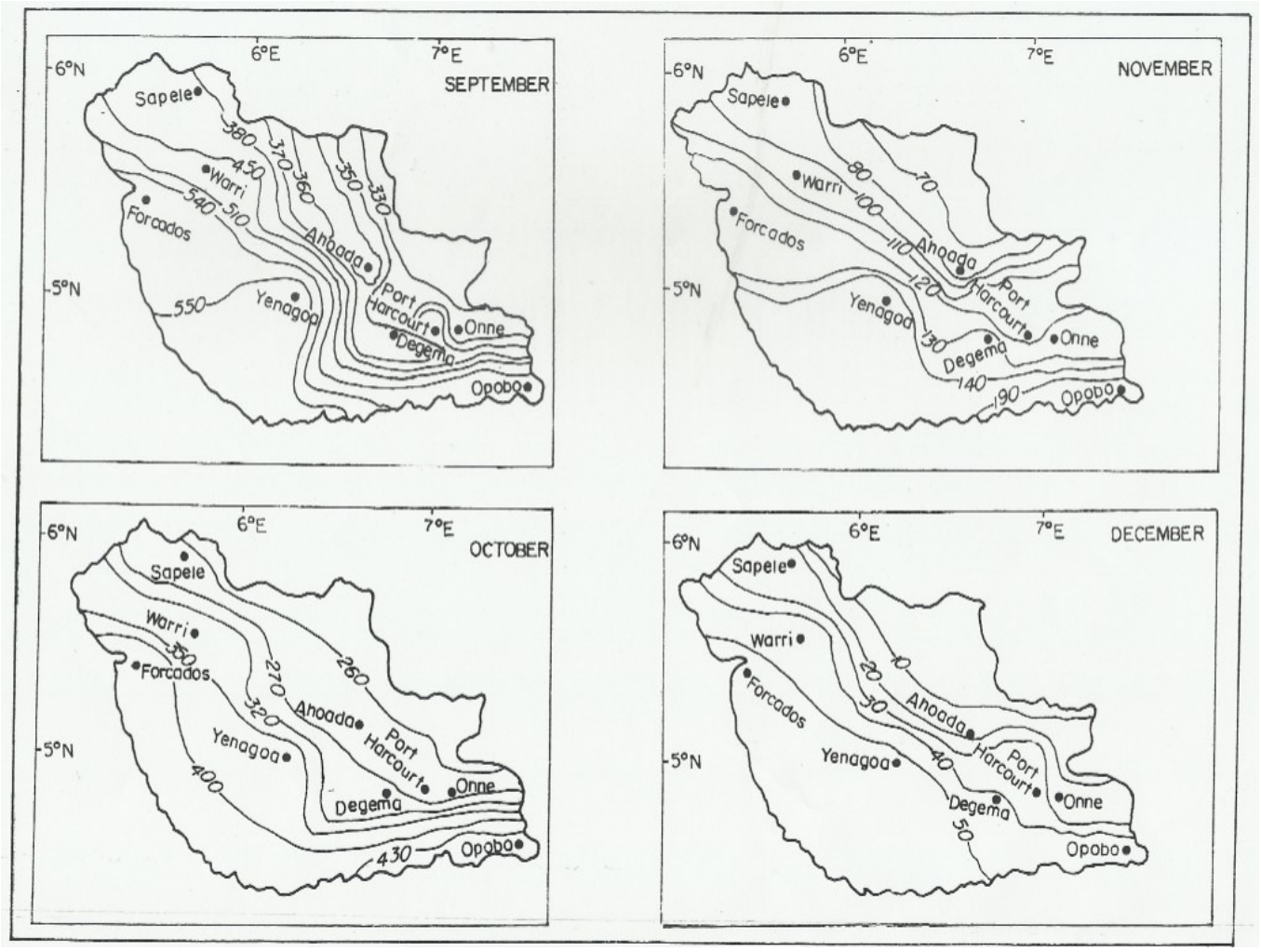

Figure 6. Distributional pattern of mean monthly rainfall (mm) in the Niger Delta.

from the south northward in the western Niger Delta and an increased rainfall in the south northward in some part of the eastern side of the Niger Delta (Table 2). Rainfall progresses from the south-northward in Degema (04.43°N, 06.46°E), Port Harcourt (04.45°N, 07.01°E) and Ahoada (05.03°N, 06.39°E) in the eastern side. The wet season spanned February/March to November with over 95% of the annual rainfall total in this area. The northward increase of both annual and wet season rainfall from Degema to Ahoada disagreed with some earlier studies on rainfall distribution in Nigeria (Obasi, 1965; Ayoade, 1974; Adejuwon et al., 1990). These studies used Warri and Port Harcourt stations to generalize on rainfall in the region. Besides, most of the studies associated rainfall in the region mainly to the influence of the inter-tropical discontinuity. They noted that the amount, seasonal distribution, the type of rainfall and the length of the wet season in the Niger Delta depend largely on the fluctuating ITD. The ITD, a boundary between the moist tropical maritime air mass (mT) of the Atlantic Ocean and the dry continental air mass (cT) of the Sahara is the zone of relatively low pressure system which drives atmospheric circulation over Nigeria in general (Farmer and Wigley, 1985), and the Niger Delta in particular. The south-north rate of change seems to be influenced mainly by I.T.D, which migrates gradually northwards and more rapidly southward through the whole wet season period (Obasi, 1965). The climatic characteristics and differences in the region can be understood in terms of the various weather zones which constitute the basic components of the Nigerian climate. This includes the harmattan, the dry but humid weather, the steady rain and drizzle, the disturbance line thunderstorms and the little dry season. Which of these weather types occur at a particular place, their time of occurrence, their duration and the intensity with which the phenomena develop are determined mainly by the location of that place relative to the fluctuating ITD (Ayoade, 1974). However, the northward increase in rainfall in the eastern Niger Delta could also be

attributed to rainfall determinant factors beside the ITD. Cameroon Mountain influences rainfall in Opobo and Port Harcourt area (Adefolalu, 1983). The relief factor provides a trigger action for convection (Ayoade, 1974) and help to bring an increase in rainfall when the meteorological conditions are favourable. Relief record maximum influence on rainfall in the wet season because uplift of any air body over high relief affects moist, warm air susceptible to instability and rainfall. The impact of disturbance lines is highly noticeable in the region during this period. Disturbance lines connote 'an intense linear pressure system which travels across West Africa, especially in wet season and bring heavy fall of rain' (Monkhouse and Small, 1978). The disturbance lines over West Africa belong to the typical perturbation known as easterly wave, which can be traced from the longitude of Lake Chad (Trewatha, 1966).

The dry season period is characterized by low rainfall. Rainfall at this period is less than 5% of the annual total. There was a decrease in rainfall from the south-northward in the study area. Sapele experiences longer dry season than most of the stations in the region, possibly because of its location at the northern extreme and therefore responsible for the high rainfall amount received at this location during the dry season. The position of the I.T.D greatly determines the length of the dry season. The ITD is only a few kilometers from the coast in December when the whole region is under the influence of the dry harmattan and only a few showers occur along the coast (Ayoade, 1974). The seasonal distribution of rainfall shows that December and January rainfall are more restricted to the coastal stations like Opobo and Forcados. At this period of the year, the ITD is located furthest south and most of the region is covered by the dry tropical continental air mass. By February, the areas receiving rainfall extend inland. The ITD remains in this coastal area until late February to early March when the northward movement begins (Obasi, 1965).

The wet season is marked by short period of semi-dry season in July /August in the Niger Delta. This period is associated with serious decline in rainfall. The period of July /August is termed the 'the little dry season' (Obasi, 1965; Adedokun, 1978; Adefolalu, 1983; Adejuwon and Odekunle, 2006; Gbuyiro and Adefisan, 2007). According to Obasi (1965), the phenomenon of little dry season is discernible roughly from the coast to latitude 5°N. This has earlier been noted by Hamilton and Archbold (1945) who maintained that there is low rainfall at the mid-wet season south of 10 N in spite of the moist air flow over the area. The relatively low rainfall which usually occur during this period is due to the fact that, there is tendency for an inversion layer to develop within the maritime monsoonal air mass, thereby incubating convective activities (Ayoade, 1974). Walker circulation due to southern oscillation resulting from anomalies in tropical precipitation is one of the causes of rainfall variability in West Africa in general and the Niger Delta in particular (Bjerkenes, 1969). (Adedokun, 1978); Olaniran, 2002). The unusually low sea surface temperature is observed in the Gulf of Guinea. This region serves as a zone of heat sink due to the upwelling of the cold water of the coast. The upwelling of the cold water at the coast is affected by the action of cold Benguella current and a two-sided divergence of the Ekman transport found within the Guinea coast (Flohn, 1971). The chilling and effect of this current may inhibit precipitation along the coastal area but enhance rainfall further inland after appropriate warming has taken place. Adedokun (1978) referred to ocean-atmosphere interaction as the dominant causes and sources of precipitation in the Southern Nigeria.

The mean monthly rainfall in the Niger Delta was lowest in December and January (Figure 6), The lowest rainfall of 40 mm was received in January along coastal stations like Opobo and Forcados while 20 mm was received towards the interior. In February, the rainfall amount received increased to 80 mm in the coastal stations and 40 mm in the interior. By this time, the ITD has stated advancing northward. There is a monotonic increase in rainfall at all stations until August when there is a modest general reduction in the amount of rainfall except for Onne. The decrease could be attributed to the little dry season at this period. July marks the peak period of rainfall in Sapele, Forcados, Ahoada and Opobo. The increase of rainfall in September is followed by a general decrease of rainfall till December when the coastal area of Opobo received 50 mm while the interior receives about 10 mm rainfall. By this time, the whole Niger Delta is under the influence of the dry harmattan air from the Sahara desert. The location of the ITD is at the coast.

Beside these factors, other dominant factors controlling rainfall in the Niger Delta include SSTA, and the local factors. The SSTA according to Palmer (1986) arises from the warming of the Tropical Atlantic Ocean south of the ITD. Consequently, this leads to the weakening of the pattern of circulation of the atmosphere over the tropics. The weakened circulation reduces the intensity of the southwest monsoon flow into West and Central Africa and, consequently the rainfall over southern Nigeria (Bello, 2008).

Local features also influence rainfall in the Niger Delta. Heavy rainfall would be expected during wet season because the coast is crossed obliquely by rain bearing wind. Between Forcados and Port Harcourt, the coast has a pronounced curvature being concave towards land and convergence of streamlines normal to the coast line will be located inland. Apart from this, there are little or no differences in the properties of the incoming air-stream from the ocean surface and that over the delta (Adefolalu, 1983). Adefolalu, (1983) further maintained that in the west of Warri, the early morning rainfall maximum is related to day and night flow patterns from the land and sea (land-sea breeze effect) synoptic and sub-synoptic (meso-scale) features during the summer months and the

curvature of the coast6 line. These enhance maximum cloud build-up in the area, thereby resulting in high precipitation rates.

Conclusion

The study has examined rainfall seasonality in the Niger Delta Belt, Nigeria. Over 95% of the rainfall was received in the wet season, while less than 5% was received in the *dry* season. Rainfall starts in February/March and terminates November/December. The phenomenon of the little dry season' dominated the mid wet season. Both the annual and the wet season rainfall decreased in amount from the south-northward in the western part of the Niger Delta, but increased in the eastern side, especially from Degema northward. Apart from the ITD, other factors controlling rainfall in the region include the ocean-atmosphere interaction, relief, line squall, and the local features. These factors were noted to be responsible for the variation of rainfall in this area. The study of rainfall seasonality is very important for agricultural planning and for other socio-economic activities.

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