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# Impact of Rainfall Regime on Cocoa Production in Etung Local Government Area, Cross River State - Nigeria

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**ABSTRACT—** ***This study examined the impact of rainfall regime on cocoa production in Etung Local Government Area of Cross River State, Nigeria. The impetus for this study was provided by the declining trend in cocoa production coupled with the world-wide climatic change. Data for the study included rainfall amount, rainfall duration, rainfall intensity, temperature, relative humidity and total cocoa production from 1978 to 2007. The data were obtained from the meteorological station Ikom, Cross River state, Nigeria. The statistical techniques employed in analyzing the data included the times series using least square estimation method, multiple correlation and multiple regression. The result revealed a significant decrease in rainfall amount in the study area. Also, there exist a significant relationship between rainfall duration and intensity and cocoa production. It is recommended that farmers adapt to changing climate by cultivating the tolerable cocoa species to less rainfall in the area. It is highly recommended that data recording and management be improved to facilitate further water resource management research and development, based on reliable information. Government should establish an agricultural data-base centre where all information relating to agriculture can be obtained easily when is necessary. This will go a long way to solve the problem of non-available agricultural data and inconsistencies in the available ones, which have hampered planning in Nigeria overtime.***

**Keywords—** Rainfall regime, cocoa production, climate change, rainfall intensity, Etung.

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## 1. INTRODUCTION

In spite of recent technological and scientific advances in genetic agriculture, weather is still the most important variable in agricultural production (Nigerian Meteorological Agency (NIMET, 2007). Climatic parameters such as temperature, rainfall, humidity, as well as sunshine hours affect the agricultural output of any region. These factors have an integrated impact on the growth of cocoa plant. Cocoa is cultivated in areas having hot-humid climates, with average rainfall of between 1150mm and 2500mm and a temperature range of 18°C to 32°C.Such areas lie along the equator in West Africa, Central and South America, and Asia (Ojo and Sadiq 2010).

A weather pattern with prolong dry season which encourages bush burning is very disastrous to agriculture. On the other hand, incessant rainfall for several weeks, as it normally occurs in July and September easily leads to rapid spread of cocoa black pod diseases which is very contagious. This poses hardship to farmers because black pod can drastically reduce the yield of cocoa (Scammel, 1980).

Cocoa plays a fundamental role in the economy of Cote d' Ivoire, Ghana, Cameroon and Nigeria all in West Africa. It is one of the most important cash crops in West Africa, and it is grown largely (78 per cent), by small scale farmers in this region (Asamoah and Baah 2008). In 1990, Africa's share of the total world cocoa production was a mere 17 per cent. In 1996, the total production from Ghana, Nigeria, Cameroon and Cote d' Ivoire, accounted for 65per cent of global output (International Cocoa Organization (ICO, 1997).

However, since the late 1980's the cocoa sector has been subjected to several major economic shocks that have led to new institutional and organizational frameworks. This was particularly the case with countries such as, Cameroon and Cote d' Ivoire, whose economies depended heavily on the cocoa sector. Apart from the mining sector, Ghana's cocoa sector, of the economy contributes more than 38 per cent to the nation's treasure. The story is not different in Nigerian where apart from oil sector, cocoa is the single most important cash crop in the agricultural sector which commands the most foreign income to the Nigerian economy (Cocoa Research Institute of Nigeria (CRIN), 2002).

Cocoa is mainly cultivated in the rain forest zone of Cross River State, basically in Ikom, Etung, Boki,and Obubra Local Government Areas, with the total annual rainfall ranging from 1200mm to 3000mm. Cocoa farming provides income for more than 70 per cent of indigenes in Etung Local Government Area. In recent times, the yield from cocoa trees has been steadily declined (CRIN, 2002). The major elements of climate likely to be considered as being responsible for this decline are rainfall, temperature, wind speed, cloud and evaporation. Although all these factors are interdependent but with regard to intensity of individual action on agriculture as a whole, rainfall appears to be the most important (Ojo & Sadiq, 2010; Omonona & Akintunde, 2009).It is on this basis, that this study is centered on impact of rainfall regime on cocoa production.

## 2. OBJECTIVES OF THE STUDY

The objectives of this study are to:

1. Examine the variability and trend of the annual rainfall of the study area from 1978 to 2007.
2. investigate the relationship existing between total cocoa production and rainfall stressors in the study area

## 3. RESEARCH HYPOTHESIS

1. There is no significant change in annual rainfall in the study area during the period (1978 – 2007) under study.
2. There is no significant relationship between fluctuation in the rainfall stressors (rainfall duration and intensity) and cocoa production.

## 4. THE STUDY AREA

The research area, Etung Local Government Area of Cross River State of Nigeria is one of the eighteen (18) Local Government Areas of Cross River State. It lies in the central part of the state with elevation of approximately 50-60 meters above sea level. It is located between latitudes $5^o$ 00'04" N and $6^o$ 00'05'' N, and stretches between longitudes $8^o$ 00'05'' E and $9^o$ 00' 05'' E (Figure 1).

Etung Local Government Area has boundaries with Ikom and Boki Local Government Areas by the North, Cameroon Republic in the East, Ikom by West and in south by Akampka Local Government Area. It also has a land mass of 903.22 km2 (Ministry of Lands and Survey, 2008). It has a total population of 80,196 and is inhabited by the Ejagham speaking people.

Etung lies in the equatorial zone with mean annual rainfall ranging from 1500mm to 3000mm. It has a daily maximum temperature average of $29^oC$ during the rainy season. While the daily maximum temperature during the dry seasons is $35^0$ C. February and March are the hottest months with temperatures ranging from $31^0$ C to $35^0$ C due to the prevailing dry harmattan wind originating from the north blowing towards the south. Similarly the coolest months are August and January with temperature as low as $12^0$ C during the early hours of the day in January.

Etung Local Government Area is part of the Cross River rainforest, which now constitutes an important part of what is left as tropical forest of Nigeria, described by Petters (1993) as the nation's microcosm. It is also reputedly the most significantly rainforest left anywhere in West Africa and one of the most diverse ecosystems in the world (Ogbonaya, 1996). The forest includes: (a) Okwongwo division and (b) Oban division of Cross River National Park. The Etung rainforest belongs to the latter group or category, which contains the highest tropical biodiversity in Africa, with remarkable wildlife (FEPA, 1991), including the rare Red-headed Rock fowl, Golden Pato, Red Columbus, the Drill, Needle Clawed Galago, Bates Pigmy antelope, and the rare Olive Ibis. This ecological zone has the highest number of species composition of rare and endangered plants including trees, shrubs, herbs etc. in Nigeria (Gbile, 1981). The dominant species here include: *Khayasp, Entandophragma sp. Miliciaexelsa, Naucleadilderrichii, Lophiraalata* and *Dispyrous species.*

The Nigeria's tropical high forests including Cross River National Park covers an area of 7290 $km^2$ (CRS Forestry Department, 1994). The total area of Cross River National Park alone is 375,000 hectares, and was established by decree No. 36 of 1991 (Orhiere, 1997). Farming is the main economic activity in this area. Lumbering activities are also carried out due to the rich forest resources such as iroko and mahogany. Tourism activities have also increased in the area due to the development of the Agbokim Waterfall. By virtue of its proximity to Cameroon, several economic activities thrive in the area including, warehousing retailing and wholesale of goods such as textile, shoes and pots. Like most local governments, Etung Local Government owned primary and secondary institutions as well as communication outlets.

Hunting and gathering of wild fruits and palm tapping constitute the specific forest economic activities, and the food crops are cassava, banana, cocoyam, okro, maize, rice, plantain, yams and vegetables. Although agricultural practice is this area is dependent on rainfall, while flooded areas are widely cultivated with rice, maize, cassava and okro that grown by the system of mixed cropping.

Trading is another occupation of the people. The items engaged in the trade are mostly food items. The food crops which form major agricultural activities along the flood plains are planted during the dry season after the recession of the flood water. During the rainy season, the stream overflows its banks and the flood water brings about accumulation of nutrients and alluvium for the cultivation of these crops as earlier mentioned.

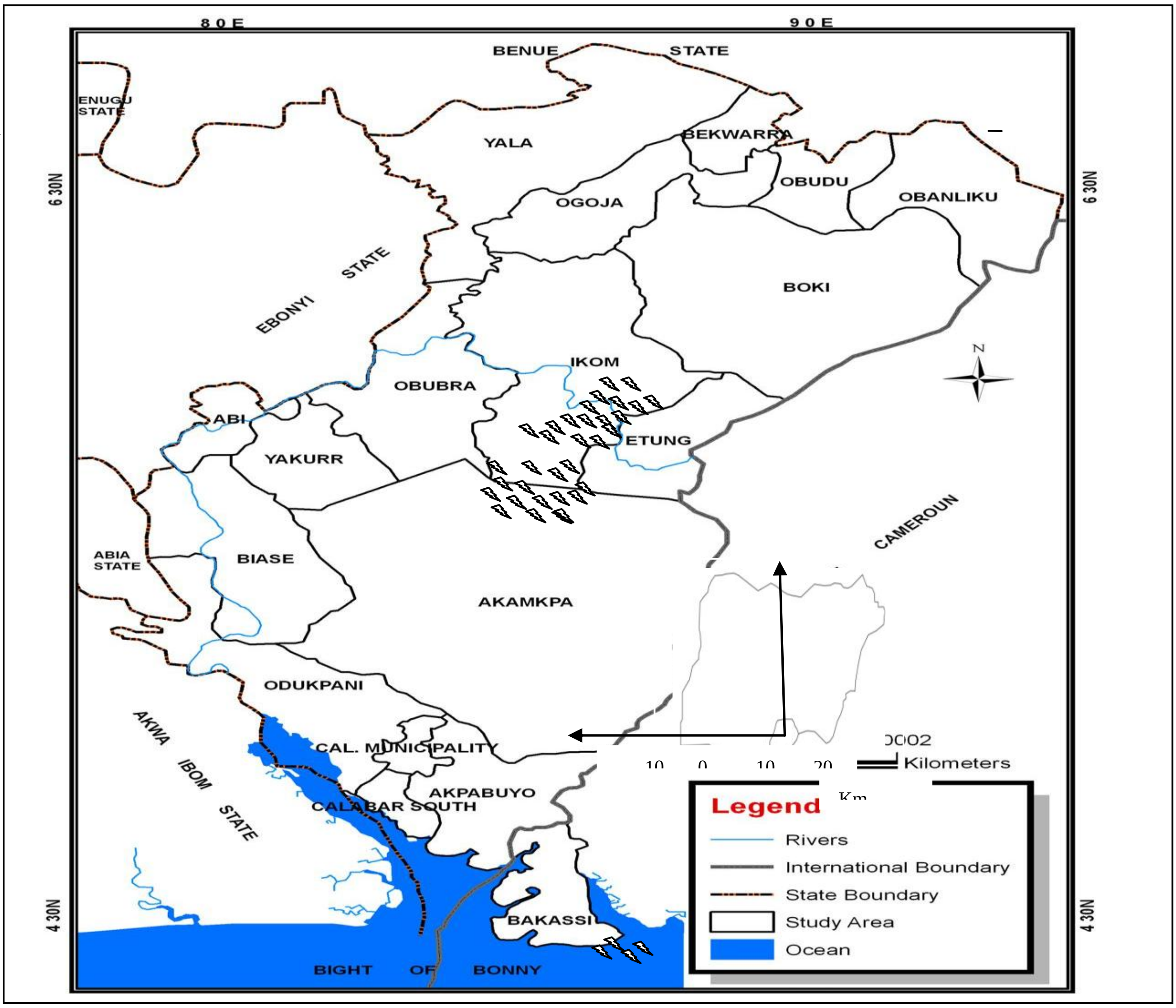


Figure 1: The study area

Cocoa is a major cash crop cultivated in the area. It has generated substantial income to households involved in its cultivation and revenue to the Local government as well as the adjoining environs. The current challenges experienced in the fluctuations in rainfall tend to have adverse effects on the cocoa yield in the area. This is the driving force in this study.

## 5. LITERATURE REVIEW

Recent researches have shown a tremendous decline in cocoa production in Nigeria. For example, studies by Oyekale, et *al* (2009) on climatic change effect on cocoa production revealed that a number of factors was responsible for the vulnerability of cocoa yield decline to variable climate. Major climatic elements identified by them were rainfall, temperature and sunshine. These elements were observed to have been the most important climatic factors that affect cocoa production.

There are other empirical studies which have shown that environmental and socio-economic variables can influence cocoa cultivation over time. Available literature tends to discuss environmental impact in terms of shade cocoa biodiversity and habitat conservation, enhanced nutrient cycling, carbon sequestration to offset climate change effects, and hydrological cycling (Keite and Caldas, 1992; Karine, 2001; and Clay, 2004). The extent of services of each of these functions is determined by each agro forest's shade composition and density. The regional land use composition will affect the degree and quality of ecosystem-level functions of which the individual cocoa farms are part (Gockowski 2002).

The environmental impacts of sunlight on cocoa are potential contamination from agrochemicals, soil depletion, and increased threat of pests, deforestation, habitat loss, decreased fauna and flora populations and forest fragmentation. However, there are cases where full sunned cocoa can bring environmental benefits by increasing the productivity per hectare to the extent that farmers do not encroach on primary or secondary forests, the land is used over the long- term on a rotational basis, and genetically improved cocoa varieties are used that reduce the need for inputs (Clay 2004).

As reported by Beer (1987) nutrient cycling is more efficient in shaded systems than in no- or low-shade cocoa farms. Farmers without shade are dependent on fertilizers to maintain soil nutrient levels. Nutrient cycling in shaded cocoa farms is directly affected by the particular shade or fruit tree species and their management. Tree species differ in levels of above ground biomass productivity, rate of their biomass decomposition and fine root biomass productivity (Beer 1987).The pruning regime and management of shade and neighbor trees is a tool for the farmer to adjust the microclimate for the cocoa as well as the timing and quantity of nutrient transfer from tree to soil. Shade cocoa cultivation increases soil aeration and drainage capacity allowing for slow, consistent nutrient release. Decaying organic matter on shaded farms hosts a diversity of organisms that aid in decomposition and nutrient cycling, notably beneficial fungal mycorrhizae (Rice and Greenberg 2000).

The planting density and pruning practices of leguminous species will affect the amount of nitrogen fixed. Some planting schemes allow shade species grow freely while manage the shade species intensively for particular results.

Predictably soil is better conserved and erosion is less of a threat in shaded than in un-shaded cocoa systems. This is particularly true during heavy rainstorms. However the degree of soil conservation depends on the amount of shade tree resides allowed to stay on the farm, especially in form a mulch layer during the rainy season when erosion threat is at its highest. Erosion can be prevented in no shade systems through mulching if sufficient labor and organic architecture to distribute rain drip evenly and prevent water channels forming from tall shade species.

The habitat conservation potential of cocoa agroforests largely depends on the floristic and structural diversity of the tree canopies coupled with the surrounding land use composition. Diverse canopies provide important habitats, resources and niches for a variety of plants and animals (CATIE 2000). Studies in Costa Rica show that diverse cocoa farms can harbor high species richness equivalent to that of forest ecosystems. In some cases, managed cocoa farms can support higher richness and abundance of migrant and resident bird species (Parrish 1998). Although, sampled forest plots had more diverse tree species. The canopy cover and height of the cocoa farms was sufficient, similar to preserve a high degree of habitat functions for avian populations.

Shade cocoa agroforests in southern Cameroon have been shown to preserved habitat for are plants such as the ebony woods (genus Diospyros) and Docryodes butteri and avian species such as lesser hornbills, black casqued hornbills and African gray parrots.

Diverse cocoa agroforests will have the maximum habitat conservation value when established in concert with patches of protected forest and vegetative corridors between agricultural areas and protected areas.

Shaded cocoa farms provide more hydrologic benefits than other land uses such as annual food cropping systems. They are for example better at controlling sediment loads in local watersheds and water recharge systems. However the extent of shaded farmed in the overall landscape is the determinant of the hydrologic benefits.

In South western Nigeria, where weather pattern is predicted to introduce new precipitation regimes, Afolabi,Omnijo and Aderibigbe (2009) researched on the effects of rainfall pattern on soil moisture, soil temperature and plant growth in alfisol soil of the humid forest transition zone. That to simulate six precipitation regimes which cover the maximum range to be expected under climate, a portable irrigation system was designed to modify the frequent of monthly rainfall events with the constant delivery rate of water, while maintaining contemporary average precipitation consistent with the 10 year average rainfall for this location. It was observed that seasonal soil moisture correlated with the above ground plant biomass ($R = 0.447$, $P = 0.029$) and by reducing irrigation frequency, soil moisture content decreased by 42per cent, $p < 0.001$. Manipulating the number of precipitation events and inter-rainfall intervals, while maintaining monthly rainfall average affected plant growth. Even with monthly rainfall averages that are similar to contemporary monthly precipitation averages, decreasing the number of monthly rainfall events reduced plant growth through soil moisture deficits. Although many have speculated that climate change will increase ecosystem productivity, their results show that a reduction in the number of monthly rainfall events while maintaining monthly average influence moisture and temperature dynamics, which ultimately affect the plant growth.

Furthermore, changes in the mean condition, for most systems and communities, fall within the coping range, whereas, many systems such as agricultural, are particularly vulnerable to change in the spread, duration and intensity of extreme events outside the coping range Hulme, (2003), Smith (1993)and Carter(1996) in Afangideh (2006) documented that many social and economic systems including agriculture, forestry, water resource management, human health and transportation have many possible adaptation measures, initiatives or strategies with potential to moderate change impact if implemented. Such possible adaptation measures included the change of topography of land, the use of artificial systems to improve land, water availability against soil erosion, the change of farming practices, the change of timing of farming operation the use of different crop varieties, the use of government and institutional policies and programs and finally researching into new technologies.

## 6. METHOD OF STUDY

**Sources of data**

Data for this study were collected from secondary sources. These sources were the Nigeria Meteorological (NIMET) station Ikom, and Produce Department, Ministry of Agriculture and Natural Resources, Calabar.

**Method of data collection**

Annual rainfall amount and rainfall duration data were collected from the NIMET station in Ikom from 1978 to 2007 (30) years. Data on cocoa production were obtained from the Produce Department, Ministry of Agriculture and Natural Resources for the corresponding period. Data on rainfall intensity were derived from the annual rainfall data using the formula:

$$\text{Rainfall intensity} = \frac{\text{rainfall amount}}{\text{rainfall duration}}$$ (NIMET) Ikom 2010.

The time series was used to examine the variability and trend of annual rainfall for the years (1978 – 2007) under study. This technique was chosen because it can be considered as an arrangement of statistical data collected with respect to the time of occurrence. The result was displayed in a diagram. A trend line was fitted to the times series using least square estimation method. According to Yamane (1967), the least square estimation method is one in which we can fit the computed trend line $y_c$, to the observed data so that the sum of the squares of the deviations are at a minimum. That is, $\alpha^2 + \beta^2 + \gamma^2$ = minimum

**Data presentation and discussion of findings**

Data on annual rainfall amount in Etung; from 1978 -2007; rainfall stressors for 1978 -2007; and total cocoa production in Etung Local Government Area is presented and discussed below:

Table 1: Annual rainfall amount in Etung; from 1978 -2007.

| Year | Annual rainfall amount (mm) |
|---|---|
| 1978 | 2289.5 |
| 1979 | 2342.3 |
| 1980 | 2648.5 |
| 1981 | 2974.1 |
| 1982 | 2473.1 |
| 1983 | 1949.3 |
| 1984 | 2160.9 |
| 1985 | 1982.1 |
| 1986 | 2311.7 |
| 1987 | 2068.8 |
| 1988 | 1762.4 |
| 1989 | 1902.0 |
| 1990 | 1855.4 |
| 1991 | 2412.0 |
| 1992 | 2039.7 |
| 1993 | 2089.4 |
| 1994 | 2308.7 |
| 1995 | 2326.1 |
| 1996 | 2299.4 |
| 1997 | 4381.1 |
| 1998 | 2255.5 |
| 1999 | 1823.6 |
| 2000 | 2349.1 |
| 2001 | 1924.7 |
| 2002 | 2216.2 |
| 2003 | 2154.7 |
| 2004 | 1971.2 |
| 2005 | 1979.0 |
| 2006 | 2219.0 |
| 2007 | 2406.5 |

Source: NIMET station, Ikom (2010).

Table 2: Rainfall stressors for 1978 -2007

| Year | Duration of rainfall in days | Annual intensity of rainfall in mm |
|---|---|---|
| 1978 | 163 | 14.0 |
| 1979 | 160 | 14.6 |
| 1980 | 157 | 16.9 |
| 1981 | 159 | 18.7 |
| 1982 | 159 | 15.6 |
| 1983 | 140 | 13.9 |
| 1984 | 149 | 14.5 |
| 1985 | 158 | 12.5 |
| 1986 | 155 | 14.9 |
| 1987 | 144 | 14.6 |
| 1988 | 159 | 11.2 |
| 1989 | 163 | 12.9 |
| 1990 | 163 | 11.4 |
| 1991 | 173 | 13.9 |
| 1992 | 170 | 12.0 |
| 1993 | 152 | 12.9 |
| 1994 | 166 | 13.9 |
| 1995 | 153 | 15.2 |
| 1996 | 165 | 13.9 |
| 1997 | 162 | 27.0 |
| 1998 | 142 | 15.9 |
| 1999 | 138 | 13.2 |
| 2000 | 155 | 15.2 |
| 2001 | 150 | 12.8 |
| 2002 | 150 | 15.8 |
| 2003 | 167 | 12.9 |
| 2004 | 156 | 12.6 |
| 2005 | 148 | 13.4 |
| 2006 | 167 | 13.3 |
| 2007 | 154 | 15.6 |

Source: Fieldwork, 2010.

Table 3: Total cocoa production in Etung Local Government Area

| Year | Annual rainfall amount (mm) | Total yearly production (tones) | Mean monthly production (tones) |
|---|---|---|---|
| 978 | 2289.5 | 44.058.0 | 3671.00 |
| 1979 | 2342.3 | 30,972.5 | 2581.04 |
| 1980 | 2648.5 | 41,682.0 | 3473.00 |
| 1981 | 2974.1 | 73,736.0 | 6144.83 |
| 1982 | 2473.1 | 27,555,5 | 2296.29 |
| 1983 | 1949.3 | 12,242.0 | 1020.16 |
| 1984 | 2160.9 | 32,252.5 | 2687.70 |
| 1985 | 1982.1 | 96,523.5 | 8043.62 |
| 1986 | 2311.7 | 40,374.0 | 3364.00 |
| 1987 | 2068.8 | 11.684.0 | 973.67 |
| 1988 | 1762.4 | 104,242.0 | 8686.83 |
| 1989 | 1902.0 | 45,839.5 | 3819.95 |
| 1990 | 1855.4 | 58,384.5 | 4865.37 |
| 1991 | 2412.0 | 82,818.0 | 6901.00 |
| 1992 | 2039.7 | 56,888.5 | 4740.70 |
| 1993 | 2089.4 | 44,125.5 | 3677.12 |
| 1994 | 2308.7 | 52,897.5 | 4408.12 |
| 1995 | 2326.1 | 53,739.0 | 4478.2 |

| | | | |
|---|---|---|---|
| 1996 | 2299.4 | 48,899.5 | 4074.87 |
| 1997 | 4381.1 | 56,372.0 | 4697.66 |
| 1998 | 2255.5 | 28,016.0 | 2334.66 |
| 1999 | 1823.6 | 19,339.0 | 1611.58 |
| 2000 | 2349.1 | 72,295.0 | 6024.58 |
| 2001 | 1924.7 | 39,535.0 | 3294.58 |
| 2002 | 2216.2 | 31689.0 | 3969.41 |
| 2003 | 2154.7 | 47.633.0 | 2640.70 |
| 2004 | 1971.2 | 41.164.0 | 3430.33 |
| 2005 | 1979.0 | 115.927.0 | 9660.58 |
| 2006 | 2219.0 | 130,321.0 | 10860.00 |
| 2007 | 2406.5 | 132.638.0 | 11053.10 |

Source: Produce Department, Ministry of Agriculture, Calabar (201 0).

Table 4: Zero-order correlation matrix for cocoa production and rainfall stressors

| | Total cocoa production (y) | Rainfall duration ($x_1$) | Rainfall intensity ($x_2$) |
|---|---|---|---|
| Total cocoa production (y) | 1.00 | 0.35 | -0.06 |
| | | 1.00 | 0.38 |
| Rainfall duration ($x_1$) | | | 1.00 |
| Rainfall intensity ($x_2$) | | | |

Source: Fieldwork (2010).

Data presented in Table 1 was used to examine the variability of annual rainfall in Etung Local Government Area from 1978 – 2007. This was achieved using the time series. Figure 2 shows the fluctuation or variability in annual rainfall. The figure reveals that annual rainfall in Etung Local Government Area of Cross River State, Nigeria, varies over the study period (1978 – 2007).

While annual rainfall was below 2500mm in 1978, the amount of rainfall increased to about 3000mm in 1981. After 1981, rainfall amount decreased to 2000mm in 1983. The amount of rainfall varied between 1800 and 2400mm from 1984 – 1996. The graph also revealed that rainfall amount reached its peak of about 4400mm in 1997, but dropped again to 2200mm in 1998 and further down to 1800mm in 1999. There was an almost steadied rainfall amount of 2000mm in 2004 and 2005. From the foregone discussion, it can be said that there was a significant variation in the amount of rainfall in the area during the study period.

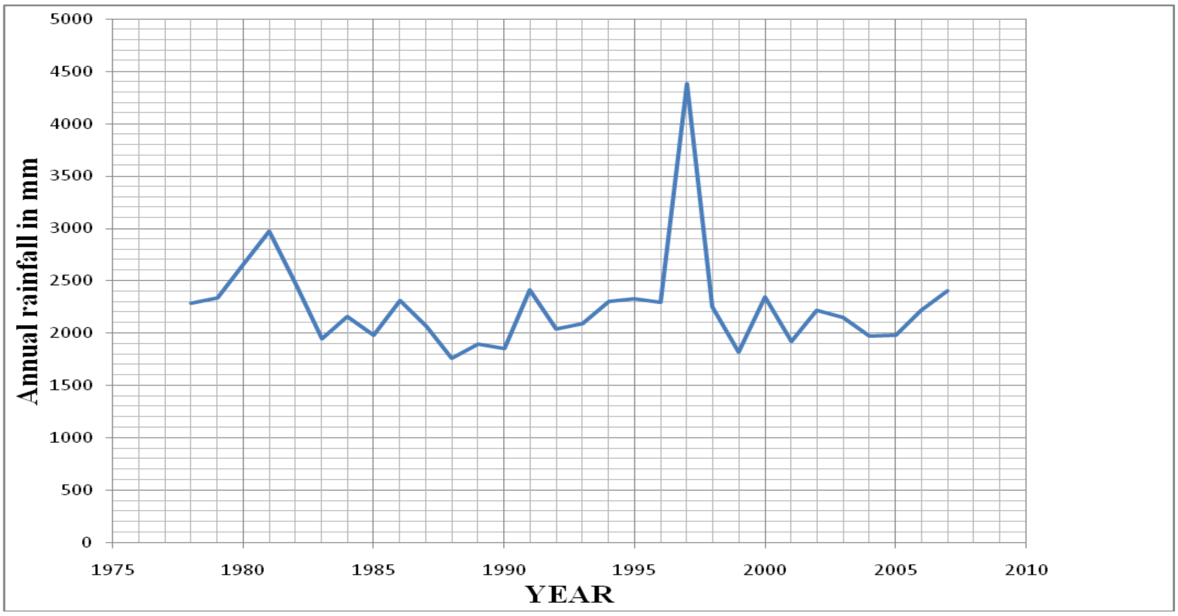


Figure. 2 Variability in annual rainfall from 1978 – 2007.

Relationship between cocoa production and rainfall stressors

Data on rainfall stressors are found in Table 2 while those for annual cocoa production are in Table 3 and Table 4 presents the zero-order correlation matrix of the relationship between, cocoa production and rainfall stressors. The table reveals a positive relationship between rainfall duration and total cocoa production with a correlation coefficient of 0.35. A very low negative relationship (r = -0.06) exists between rainfall intensity and total cocoa production.

From the multiple correlation analysis,

$ryX_1X_2$ or R = 0.58
$R^2 = 0.34$ or 34 per cent

The coefficient of multiple determinations reveals that 34 per cent of the variation in y (cocoa production) is explained by $x_1$ and $x_2$ acting together. This means that, if $x_1$ and $x_2$ (rainfall duration and rainfall intensity) are known, then we can predict about 34 per cent of the variation in total cocoa production.

In testing the significance of the relationship:

$H_o$: There is no significant relationship between fluctuation in the rainfall stressors (rainfall duration and intensity) and cocoa production.

$H_1$: There is a significant relationship between fluctuation in the rainfall stressors (rainfall duration and intensity) and cocoa production.

In testing the significance of the relationship:

$t_{cal} = 3.78$
Degree of freedom (N – 2) = 30 – 2 = 28
$t_{tab} = 2.05$

Since $t_{cal}$ (3.78) > $t_{tab}$ (2.05), the null hypothesis is rejected and the alternative accepted. This means that, there is a significant relationship between fluctuation in the rainfall stressors (rainfall duration and intensity) and cocoa production.

## 7. RECOMMENDATIONS

In the present reality of climate change and its impact on agricultural output as well as the environment in general, this research therefore puts forward the following recommendations to help solve the problems as observed in the area.

i. Farmers should adapt to the cultivation of drought tolerant cocoa species in the area, such as Amazon forester and Prinitario groups.

ii. There is need for climatologists and meteorologists to make suggestion to government for the promulgation of policies that will make provision for upgrading the level of knowledge in the management of the environment and natural resources in the area.

iii. It is highly recommended that data recording and management be improved to facilitate further water resource management research and development, based on reliable information.

iv. Government should establish an agricultural data base centre where all information relating to agriculture can be obtained easily when necessary. This will go a long way to solve the problem of non- available agricultural data and that of inconsistencies in the available ones of which have hampered planning in Nigeria overtime.

## 8. CONCLUSION

This study has revealed that the amount of rainfall in the study area has been on a decrease for thirty (30) years under consideration. This is related to the general change in climate all over the world. This change affected the rainfall duration and intensity with a significant impact on cocoa production. This may have resulted from a number of factors which include the age of the cocoa plants, management practices and the species of the cocoa.

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