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# Effect of Rainfall Variability on Water Supply in Ikeduru L.G.A. of Imo State, Nigeria

*(Pp. 223-241)*

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**Abstract**

*The paper examined the effect of rainfall variability on water supply in Ikeduru L.G.A., Imo State. Data collected were analyzed using regression analysis and analysis of variance. The result of the analysis led to the rejection of the first and second null hypotheses and the acceptance of the alternatives, which are that there is a strong relationship between rural water supply in the study area and the rainfall; and that there is a significant difference in the sourcing of water supply among communities. At the onset of the rainy season, most of the water sources in Ikeduru L.G.A. are not reliable. Rainfall change points were detected to be 1991 and 1997. Reduction in rainfall amount as revealed by trends and variability patterns, adversely affects rural water supply and in turn puts rural dwellers in jeopardy. The indicated linkage/strong relationship implies that the aquifer;*

*the source of borehole water in the area and source of the various rivers (Mbaa, Oramiriukwa, Okatankwo) found in Ikeduru L.G.A. mainly depends on rainfall for recharge. The study made several recommendations, one of them being that concerted efforts by the people, civil societies, government as well as N.G.Os are needed for the amelioration of the adverse effects of climate change and rainfall variability on water supply through the massive development of groundwater sources.*

**Keywords:** Climate change, Imo State of Nigeria, Rainfall variability, Water.

## Introduction

Rainfall is a renewable resource, highly variable in space and time and subject to depletion or enhancement due to both natural and anthropogenic causes (Abaje, 2010). Climate is, with particular reference to rainfall, known to be changing worldwide and there has been growing concern as to the direction and effects of these changes on settlement and infrastructures (Chaponniere and Smokhtin, 2006). Thus, hydrological resources such as streams, rivers and ponds that are mainly rain-fed, are adversely affected by climate change. Many people, especially in the rural areas of Nigeria, depend on rivers, streams and rainfall harvest for their water supply in the face of infrastructure challenges.

Climate change has caused a shift in the seasonal variability of weather and climate and thus a shift in the normal timing and length of wet and dry seasons and increase in the seasonal fluctuation of the water bodies. Rainfall variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, e.t.c.) of rainfall on all spatial and temporal scales beyond that of individual precipitation events (Odjugo, 2010). He further explained that like climate change, variability maybe due to internal or external variables. In Nigeria, changing rainfall patterns have been observed by researchers such as Anyadike (1993), Nnaji (2001) and Ulor (2006). Nnaji (1999) observed unusual change in the occurrences of wet and dry season regimes in sub-Saharan Africa, while annual decadal and inter decadal variations in rainfall have been reported by Anyadike (1993) and Ulor (2006).

Odjugo (2005, 2009) observed decline in rainfall amount in Nigeria. The decreasing rainfall, increasing temperature and evapotranspiration have resulted in either reduction of water levels or total dry up of some rivers and lakes in Northern Nigeria, while Lake Chad in Nigeria is reported to be



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shrinking in size at an alarming rate since the 1970s (Chindo and Nyelong, 2005; Odjugo, 2007)..

In Nigerian sahel region, there has been a 25 percent decrease in precipitation on average in the last 30 years (Nkomo et al., 2006). There are observable reductions in precipitation in other parts of Nigeria, (Boko et al., 2007). Generally, Nigeria has a tropical climate with variable rainy and dry seasons. However, average precipitation is expected to increase in Nigeria while Africa's climate will generally become more variable.

Regions of the world show an overall net negative impact of climate change on water resources and freshwater ecosystems. The beneficial impacts of increased annual runoff in many areas are likely to be, in some areas, countered by increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risks (IPCC, 2007).

According to Glantz (1987) and Tarhule and Woo (1997) droughts, rainfall variability and water scarcity constitute the major constraint to the attainment of self- sufficiency in food production and development of regions. This is because a deficiency of precipitation can possibly lead to a depletion of stream discharge and reservoir storage, which would in turn affect sectors such as public utilities (power and water supply) sector (Tarhule, 1997).

In Nigeria of 1996, the estimated national annual consumption was 6,502 million litres per day (mld) which far outstripped the supply of 2,957 (mld). Climate change as occasioned by rainfall variability in Nigeria, would further compound the inability of the country to meet people's demands for water.

The situation of water supply and management is even more complex in rural areas where majority of the people are poor, especially women and children , and have to travel several kilometers to fetch water for the household (Nnodu, 2008). The water fetched may not be wholesome for drinking and other domestic uses as is the case in some part of Akwa Ibom, where people drink dirty water for fear of angering the gods (Akpabio, 2006). An understanding of the dynamic relationship between water sources and rainfall variability may be useful in developing future water projects. While the paper focuses on how changes in precipitation patterns may affect water availability, its specific aim is to examine the effect of rainfall variability on water supply in Ikeduru Local government area of Imo State, Nigeria. The study objectives are to detect trends and variability pattern of rainfall over a thirty-year period (1975-2005); to ascertain the relationship between the sources of water and the problems of shortage of water being experienced and to identify how communities in the study area adapt to the effects of rainfall variability on water supply. The study hypothesized on whether there is a relationship between rainfall amount/variability pattern and rural water supply in the study area and on whether there are significant differences in the sourcing of water in the study area's communities.

**The study area**

Ikeduru Local Government Area is one of the 27 local government areas of Imo State, Nigeria (see Fig.1). It is located on longitudes $7^0 04^{'E}$ and $7^0 14^{'E}$ and latitudes $5^0 29^{'N}$ and $5^0 39^{'N}$. It is in the humid tropics with over 2,000 mm of rainfall per annum and a mean annual temperature of about $27^0$C. The rainy season commences in March/April and ends in October/November. Ikeduru belongs to the tertiary period of the geological era with coastal plain sands which are centicular, unconsolidated and sandy. The area is drained by series of rivers and streams (namely; Mbaa, Oramiriukwa, and Okatankwo). These are the major water resources in the area. The distributaries and tributaries of these rivers effectively drain the area. These rivers are also characterized by dry valleys which are usually covered by flood water during periods of high rainfall. Flood water infiltration during the rainy season recharges the aquifer.

Ikeduru has the following autonomous communities; Iho, Umudim, Inyishi, Amatta, Uzoagba, Akabo, Ngugo, Avuvu, Amakohia, Okwu, Ugiri-Ike, Atta, Eziama, Amaimo and Ikembara (see Fig. 1). Ikeduru is densely populated with about 199,316 people according to the 2006 National Population Census figures and has an annual growth rate of 9 percent. The economic activities here include farming, trading, few banking services and civil services at Iho which is the L.G.A. headquarters.

**Methodology**

Data were collected from primary sources using questionnaire, oral interview and personal observation . Secondary data such as past daily/monthly/annual rainfall amounts (1976-2005); volume of water supplied from the main rivers and other relevant information were obtained from Nigerian Meteorological Services records, Imo State Water Corporation records, Imo State Water Development Agency records, literature and the internet. Water demand, supply and adequacy at the boreholes, streams and rivers were determined by estimating the size of containers used, the number of times the containers were used in the observation period and the number they really would have wanted to use.

Presently the study area comprises of 24 autonomous communities and these communities were divided into 4 groups with 6 communities in each group for easy study. A total of 240 copies of questionnaire were randomly distributed to the sampled population of the sampled communities. Officials at the local government headquarters were also served with some copies of the questionnaire. The entire 240 copies of questionnaire distributed were completely returned by the respondents. Oral interview was conducted for the aged who have historical insights on the subject matter but who cannot read or write. The data obtained were presented in tables of frequencies and percentages. To analyze the data, the regression analysis and the analysis of variance (ANOVA) test were employed. They were used to test the two hypotheses at 0.05 significance level.

**Results and discussion**

In the study area, the beginning of the rainy season in March/April is usually characterized by intense outbursts of rain which last for a short duration depositing about 20mm to 50mm of rain. The annual rainfall statistics collected from Nigeria Meteorological Services (NIMET) Owerri, which is our reference station for the study area, showed that rainfall has not been consistent especially with reference to its volume, both annual and decadal, for the past 30 years from 1976 to 2005. Fig. 3 shows that annually, rainfall shows some level of variability around an annual mean of 2,000mm.

There is also some level of variability with reference to decadal rainfall volume. In this regard, the second decade (1986-1995) is the most rain sufficient decade having decadal volume of 24,537mm. The first decade (1976-1985) had a rainfall volume of 21,180mm. The last decade (1996-2005) had a decadal volume of 23,127mm which can be said to be an intermediate value between the former two decades. We can say that there is a general downward trend (see Fig. 4); a fact corroborated by Ngongondo (2006) who in his study of rainfall variability and groundwater availability in southern Malawi observed a general decline in rainfall with alternating wet and drier years detected since 1954. He observed that the variation pattern mainly followed the El Nino and southern oscillation and the La Nina episodes. Thus, the problem of access to potable water or outright scarcity of water for an average household especially during the dry season is very enormous. This situation is likely to become even more acute as climatic impacts and escalating water demand combine (IPCC, 2001).

With the onset of rain, large depressions produce ponds which can be used for washing and bathing while aiding groundwater recharge.

Table 1 highlights the frequency and percentage distribution of respondents by their assertions with respect to the various sources of water available in the different communities. Sources of water in Ikeduru L.G.A. are varied; they range from wells to rivers/ streams. Some of the respondents in the study communities claim they are served by one to five boreholes. Others claimed they have between six to ten boreholes serving their village. Community and individual boreholes exist in Ikeduru L.G.A. Some of the community boreholes are hardly functional. From table 1, 10.4 percent of the respondents obtain water through rainfall harvesting. About 24.2 percent said their main source of water is from rivers/streams, while 16.6 percent indicated well as their source of water. Some of the rivers/streams namely Mbaa, Okatankwo, Oramiriukwa and their tributaries in Ikeduru L.G.A. are seasonal, while others are perennial. Boreholes and underground tank sources had 35.8 percent and 6.3 percent respectively, while 6.79 percent of the respondents obtain water from water vendors. From the analysis, borehole and well have the highest score of 35.8 percent and 24.2 percent respectively. It is however important to note that excessive borehole and well water withdrawal may cause water table drawdown. Thus, the determination of aquifer dimensions and sources of recharge are essential to water resource evaluation and planning especially in mitigating the effects of water scarcity. This is in agreement with Abaje (2010) that decline in the annual rainfall yield may lead to the lowering of the water table. This has an implication for digging of wells, construction of boreholes and other groundwater exploitation projects that depend on water from recharged aquifers. For perennial wells, water level is maintained until the rains arrive again in April, while seasonal wells do not last so long.

In the face of water sources identified in Ikeduru , the respondents were asked to estimate in standard buckets of 12 litres each, the quantities of water demanded for use daily. For this research, water demand is the actual amount of water needed by the people for their activities. Results of the conversion are presented in Table 2. The demand per household is almost similar from one group to another. Ikeduru has people with similar water needs and water supply shortages from the inadequate number of water sources available. This explains why water demand per household is almost similar.

The appreciable socio-economic status of these rural people, their closeness to Owerri urban area, and the presence of some cottage industries is responsible for high water demand of 501 to 700 litres per household per day for 30.4 percent of the respondents and 701 and above for 13.3 percent of the respondents (see Table 2).

Several researches have revealed that in rural areas of LDCs (Least Developed Countries) the demand for water can hardly be met (Ayoade, 1984; Chima, 1989; Uzoma 1997). This is mainly as a result of the absence of rains during the dry season. According to European Commission (1998), the fulfilment of humankind's basic need for a supply of safe-drinking water remains an important part of today's challenge. Entries in Table 3 show the frequency and percentage distribution of respondent's perception of level of water adequacy among water users in the study area.

From Table 3, 47 percent of the respondents were of the view that water supply is inadequate especially from rainfall and stream flow in the study area. About 13.3 percent of the respondents claimed that water supply is highly adequate from boreholes, while 22.1 percent of the respondents were of the opinion that water supply is fairly adequate. Finally, 17.5 percent of the respondents said water supply is moderately adequate. The nature of water inadequacy varies across the year. The end of the dry season is the most precarious period because none of the available sources is dependable. From the analysis, it was only water supply from boreholes that was considered to be highly adequate. Boreholes and wells are recharged during the rainy season and the possible sources include direct infiltration of rainwater, regional groundwater rise and floodwater infiltration through stream channel seepage. Floodwater infiltration during the rainy season recharges the aquifer such that water table, despite fluctuations, is easy to access throughout the long dry season, providing a reliable source of groundwater (Tarhule and Woo, 1997). One promising strategy may be to develop water abstraction technologies that allow continued use of the aquifers during the transition period or, even throughout the dry season.

Data collected from Imo State Water Corporation was recorded annually in cubic metre ($m^3$) and converted to tonnes (tons) for easy manipulation and computing. The water supply availability data gotten spans from 1995 to 2005 and is seen in Table 4. The data shows that water supplied has not been consistent both in quantity and availability for the periods between 1995 and 2005. Refer to table 4. Some of the respondents are of the opinion that water is presently scarce when compared with past rainfall volume, while some others claim that water is presently more available when compared with past rainfall volume.

Table 5 is used to test for the hypothesis which states that;

$H_o$: There is no relationship between rural water supply and rainfall amount/variability pattern in the study area.

$H_1$: There is a relationship between rural water supply and rainfall amount/variability pattern in the study area.

To get other variables, Table 5 is expanded into Table 5.1 below: Table 5.1 is derived from Table 5 and it is used to test the first hypothesis.

This relationship is tested using Regression Analysis.

Tc – calculated value is 4.8060

T – critical value is 1.833

Significance level of 0.05.

The result shows that the calculated value (4.8060) is greater than the critical value (1.833). We reject the null hypothesis and accept the alternative that there is a relationship between rural water supply in the study area and rainfall (see Fig. 5 and Fig. 6). This result agrees with Eldredge et al. (1988) that investigated the changing patterns of rainfall for western Sudan using annual and monthly series. Their result showed that a relatively dry condition has persisted in the region since 1966 due mainly to a decline in rainfall during July, August and September of that year This applies to our study area. The statistical test result is confirming that water availability and supply is vulnerable to climate change and rainfall variability.

Testing of the second hypothesis:

$H_o$: There is no significant difference in the sources of water supply available to the communities in Ikeduru. (the study area).

$H_1$: There is significant difference in the sources of water supply available to the communities in Ikeduru. (the study area).

Analysis of variance (ANOVA) was applied to see if there is a significant difference in available sources of water among communities . Table 6 depicts the ANOVA table on the summary of the six groups employed in examining the significance of the difference in the water supply sources of the study area.

Calculation for the F-ratio is obtained by dividing the between group mean sum of squares by the within group mean sum of squares. Thus, we have

193.3 /16.7 = 11.5748

= 11.57

Computation of F-critical value:

The F- critical value = F5, 18-(1-0.05) = F5, 18-0.95 = 2.77

Since the F- ratio (11.57) is greater than the critical value of F (2.77), we reject our null hypothesis, and accept the alternative, thus affirming that there is a significant difference in the sources of water supply available for the communities of the study area. The population of Ikeduru depends on many water supply sources which are both natural and improvised.

However from this study, changes in water supply due to rainfall variability point to the need for new adaptation strategies.

**Conclusion and recommendation**

This paper addressed the effect of rainfall variability on water supply in Ikeduru , Imo State. The study revealed that water sources such as rivers, wells and boreholes have been adversely affected with regard to their discharge and flow capacities as a result of rainfall variability. The study revealed that there is a general decline in trend of rainfall in volume and occurrence. It also established that there is a significant relationship between rural water supply and rainfall pattern in the study area, as well as a significant difference in the sourcing of water supply available to the communities in the study area. The coping strategies identified are merely survival strategies which may not meet the required standard for optimal use of water, but continuously lead to poor sanitary conditions. The situation is expected to worsen in the future in the face of unreliable fluctuations in weather conditions.

Due to the total dependence on the immediate environment for water supply, the study recommends that laws protecting water resources be enforced;

greater efficiency in water use should be promoted and that research efforts should be intensified in the area of water supply and management. Also, government should partner with the people to protect and maintain existing watersheds and intensify efforts in providing potable water for the people. An improvement in rain-harvesting techniques, construction of rain catchments back-up tanks and modification of existing rain picking troughs by the use of closed conduits instead, is necessary. Finally, government policies and infrastructural development in the area should be based on recent rainfall trends and efforts should be made by the people, non-governmental agencies and government to check the effects of global warming and climate change on rural water supply. One option may be to encourage the development of groundwater sources through water abstraction technologies that permit continued use of the aquifers even to the end of dry season and the building of reservoirs. The people of Ikeduru L.G.A. can collaborate with government and NGOs to execute water projects using locally available resources; this will in fact enable them to cope with new changes and to also imbibe the development of new technologies.

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**Table 1: Sources of Water Available in Ikeduru L.G.A.**

| Resources of water | Group 1 | Group 2 | Group 3 | Group 4 | Group total | % |
|---|---|---|---|---|---|---|
| Rainfall harvesting | | | | | 5 | 0.4 |
| Stream/Rivers | 3 | | | 2 | 0 | 6.6 |
| Wells | 1 | 7 | | 3 | 8 | 4.2 |
| Boreholes | 5 | 8 | 5 | 8 | 6 | 5.8 |
| Underground storage tank | | | | | 5 | .3 |
| Water vendor | | | | | 6 | .7 |
| **Sum Total** | | | | | 40 | 15.0 |

***Source: Field survey, 2010.***

**Table 2: Quantity of Water Respondents Demand per Household per Day**

| Water quantities demanded (litres) | Group 1 | Group 2 | Group 3 | Group 4 | Group No. Total | % |
|---|---|---|---|---|---|---|
| 300-500 | 25 | 39 | 36 | 35 | 135 | 56.3 |
| 501-700 | 9 | 27 | 20 | 17 | 73 | 30.4 |
| 701 and Above | 9 | 11 | 6 | 6 | 32 | 13.3 |
| Sum Total | | | | | 240 | 100.0 |

***Source: Field survey, 2010.***

**Table 3: Water Adequacy Level of the Respondents**

| Level of Water Adequacy | Group 1 | Group 2 | Grou p 3 | Group 4 | Group No. Total | % |
|---|---|---|---|---|---|---|
| Highly adequate | 7 | 8 | 10 | 7 | 32 | 13.3 |
| Moderately adequate | 9 | 6 | 15 | 12 | 42 | 17.5 |
| Fairly adequate | 18 | 15 | 9 | 11 | 53 | 22.1 |
| Inadequate | 29 | 33 | 30 | 21 | 113 | 47.1 |
| Sum Total | | | | | 240 | 100.0 |

***Source: Field survey, 2010.***

**Table 4: Water Supply Data in Cubic Meters for the Period of 1995-2005**

| S/N | Year | Hours | Water Supplied ($M^3$) |
|---|---|---|---|
| 1. | 1995 | 181754.0 | 15994390 |
| 2. | 1996 | 14111.5 | 12418140 |
| 3. | 1997 | 17503.0 | 15402640 |
| 4. | 1998 | 15115.2 | 133010400 |
| 5. | 1999 | 17142.3 | 15085243 |
| 6. | 2000 | 17034.0 | 10351500 |
| 7. | 2001 | 16981.0 | 14943280 |
| 8. | 2002 | 16693.5 | 14690280 |
| 9. | 2003 | 19638.5 | 17281880 |
| 10. | 2004 | 15993.0 | 14073840 |
| 11. | 2005 | 18736.3 | 16487987 |

*Source: Imo State Water Corporation*

**Table 5: Annual Rainfall (cm) against Annual Water Supply/Availability (tons) for The Period of 1995-2005**

| Rainfall (x) in (cm) | Water Supply / Availability (y) in (tonnes) |
|---|---|
| 2622 | 15994 |
| 2672 | 12418 |
| 2890 | 15403 |
| 1642 | 13301 |
| 2515 | 15085 |
| 2337 | 10352 |
| 2304 | 14943 |
| 2083 | 14690 |
| 2370 | 17282 |
| 1768 | 14074 |
| 2546 | 16488 |

**Table 5.1: Regression Table**

| X | Y | $X^2$ | $Y^2$ | xy |
|---|---|---|---|---|
| 2622 | 15994 | 6874884 | 255808036 | 41936268 |
| 2672 | 12418 | 7139584 | 154206724 | 33180896 |
| 2890 | 15403 | 8352100 | 237252409 | 44514670 |
| 1642 | 13301 | 2696164 | 176916601 | 21840242 |
| 2515 | 15085 | 6325225 | 227557225 | 37938775 |
| 2337 | 10352 | 5461569 | 107163904 | 24192624 |
| 2304 | 14943 | 5308416 | 223293249 | 33845760 |
| 2083 | 14690 | 4338889 | 215796100 | 30599270 |
| 2370 | 17282 | 5616900 | 298667524 | 40958340 |
| 1768 | 14074 | 3125824 | 198077476 | 24882832 |

| | | | | |
|---|---|---|---|---|
| 2546 | 16488 | 6482116 | 271854144 | 41978448 |
| $\sum x=25749$ | $\sum y=160030$ | $\sum x^2 61721671$ | $\sum y^2=2366593392$ | $\sum xy= 376451037$ |

**Table 6: Analysis of Variance of the Sources of Water Supply in Ikeduru L.G.A.**

| Source of Variation | Degree of Freedom | Sum of Squares | Mean Squares |
|---|---|---|---|
| Between groups | 5 | 966.6 | 193.3 |
| Within groups | 18 | 301.4 | 16.7 |
| Total | 23 | 1268 | - |

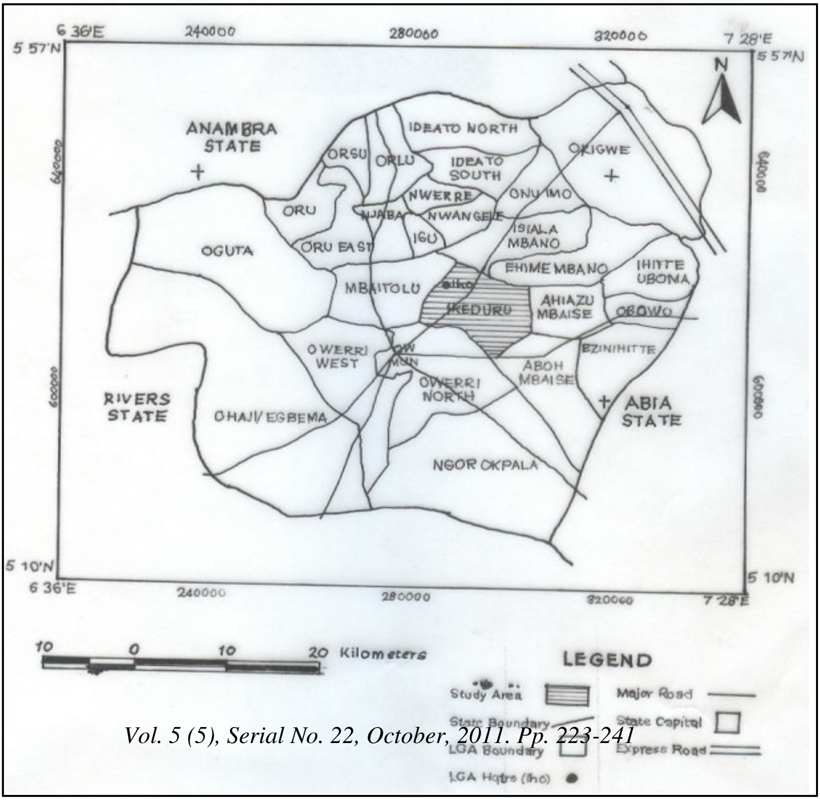



Fig. 1: Mtate showing Ikeduru L. G. A.

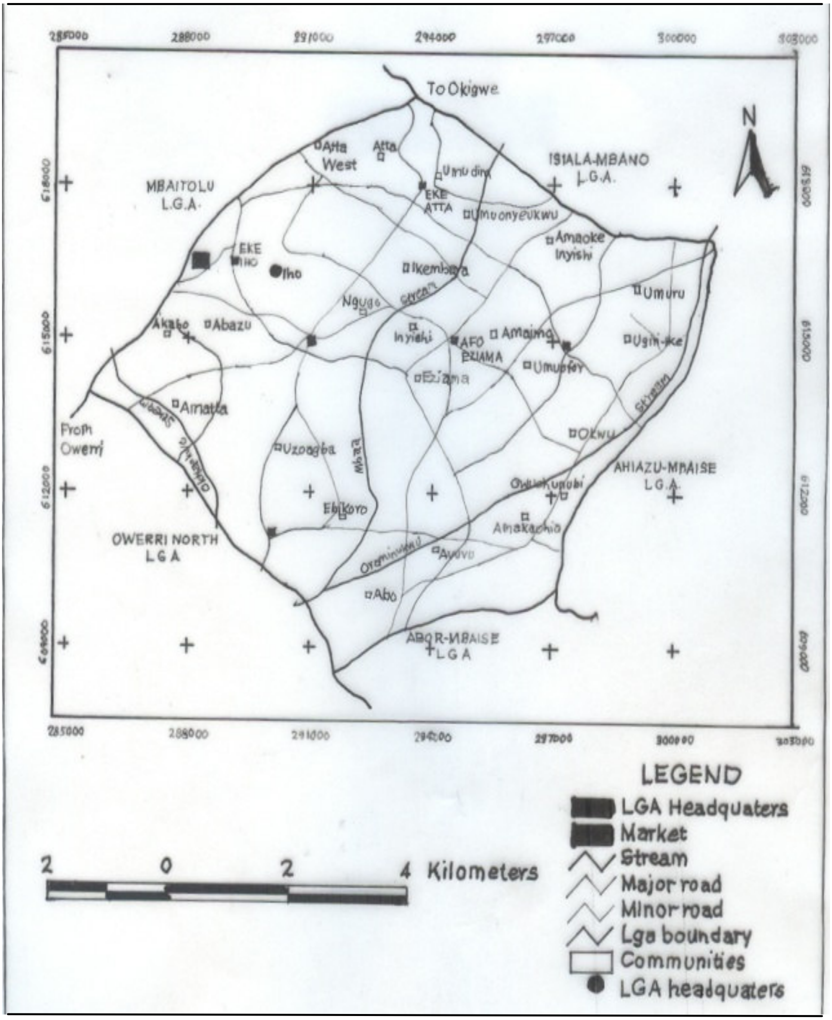
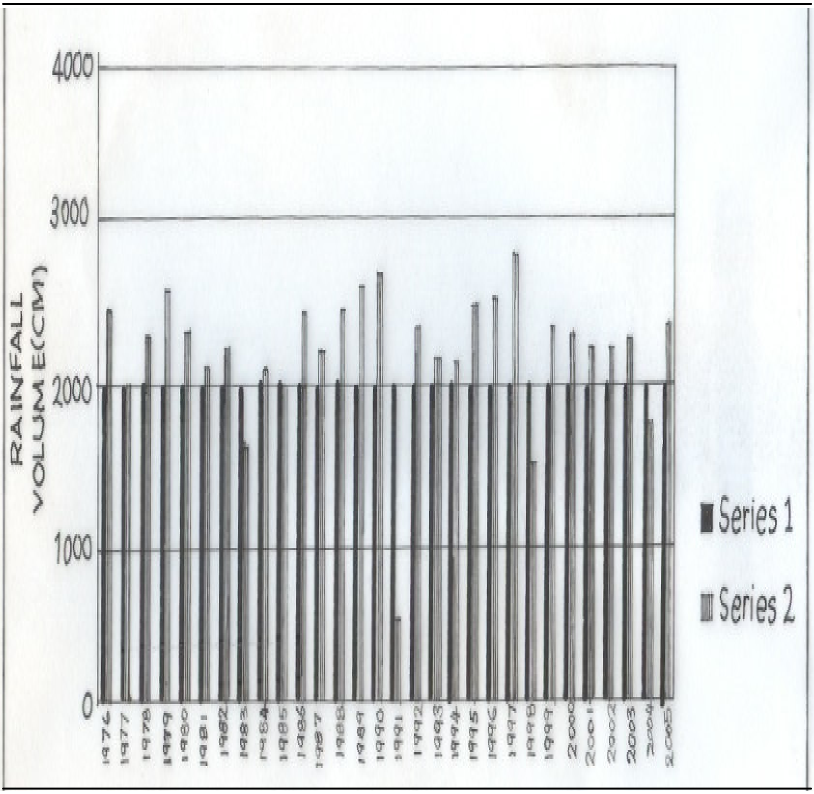



Fig 2: map of Ikeduru L. G. A. showing her communities




YEARS

Fig 3: Graph showing Annual Rainfall for Owerri (1976-2005)

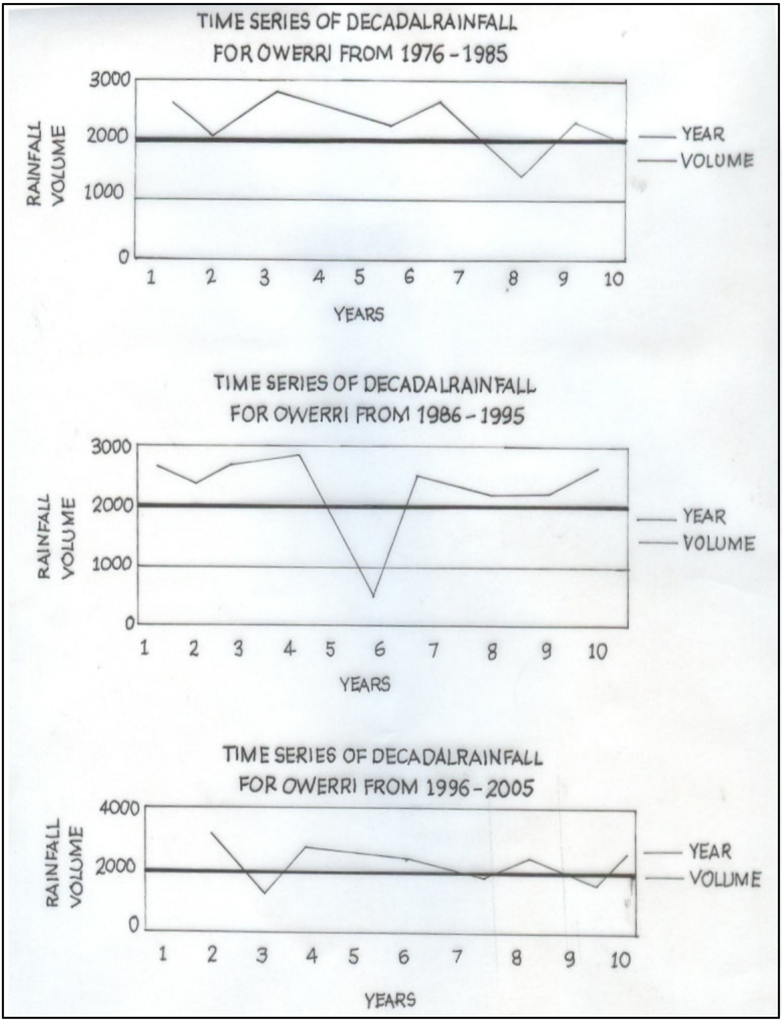



Fig. 4: Time Series of Decadal Rainfall for Owerri
(1976-1985, 1986-1995, 1996-2005)

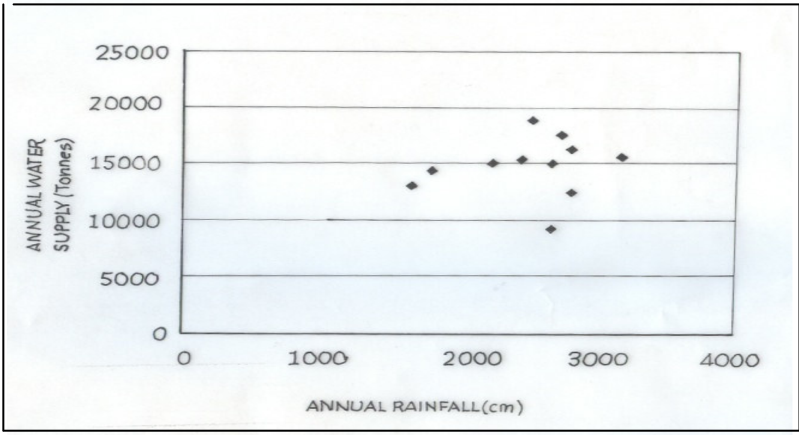



Fig. 5: Graph showing the Regression of Annual Rainfall (cm) on Annual Water Supply (tonnes)

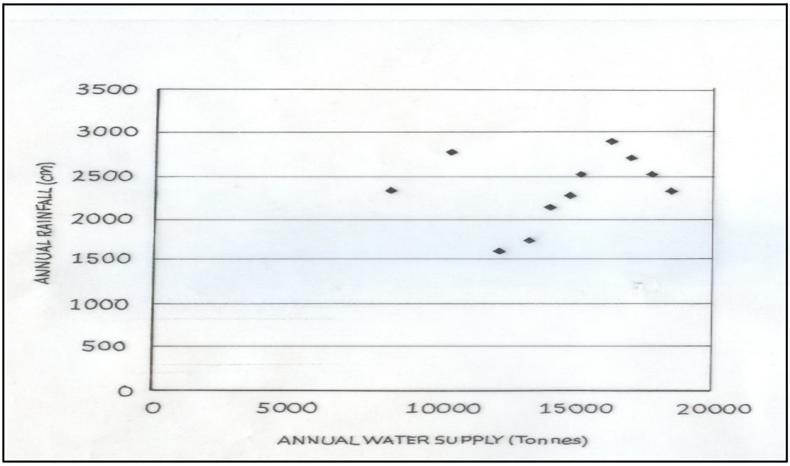



Fig. 6: Regression of Annual Water Supply (tonnes) against Annual Rainfall (cm)