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# Watershed Management and Ecological Hazards in an Urban Environment: The Case of River Ajilosun in Ado Ekiti, Nigeria.

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**Abstract:** Vegetation growth/vegetal cover has played significant role in watershed management and its protection against ecological hazards in an urban environment. Urbanization plays a significant impact in the alteration of the ecological equilibrium of an environment. As city grows, watersheds are thrown into ecological entropy resulting to environmental disruptions. The paper demonstrates effect of deforestation and urban development on River Ajilosun drainage basin in Ado-Ekiti, Nigeria. The ecological impacts of flooding and erosion were studied by collecting direct field data on width of flooding and width of channel bank erosion. The basic equipment employed for the measurement are the tape, ranging pole and a piece of plank (tie rod). The data were analyzed with both the descriptive and inferential techniques. The result of the analysis revealed that ecological hazards caused by urbanization in the drainage basin included flooding and erosion which exhibited spatial variation across and along the profiles of the drainage basin. The study revealed further that deforestation and urban physical development affects the environment of the lower reaches of the drainage basin through flooding and also caused increased erosive effect of flooding in the downstream reaches of the Ajilosun drainage basin.

**Keywords:** Watershed, Vegetation, Urbanization, Management.

## 1. Introduction

One of the visible causes of the impacts of the upstream development of a river on the areas downstream is the clearing of the primordial forest cover and their subsequent replacement with cultural features of environmental development. Generally, deforestation precedes settlement evolution and the process often results to modification of terrains with obvious impacts on the general environment. Such impacts are usually highly impressive and impactful when they occur within a watershed.

River Ajilosun drainage basin in Ado-Ekiti, Nigeria is a rapidly expanding watershed in respect of mass deforestation and urban development. The creation of Ekiti-state in 1996 and the naming of Ado-Ekiti as the capital city has had a tremendous impact on the watersheds in the city. Particularly, the drainage basin has been intensively developed with several modifications to the terrains in its upper course which coincides with one of the areas of earliest evolution of settlement in the city [4]. This development no doubt might have had some environmental impacts on lives and activities in the downstream reaches of the drainage basin.

Therefore, the paper is set out to examine the environmental effects of the removal of forest following rapid urbanization of the city has caused for the settlement in the lower reaches of the basin. The paper looks at the entire basin, assesses the extent of urban development and discusses the consequences of such development on the drainage basin.

## 2. Environmental Setting of River Ajilosun Drainage Basin in Ado-Ekiti, Nigeria.

River Ajilosun drainage basin traverses the terrains of Ado-Ekiti in Nigeria within Latitudes $7^0 35^1$ and $7^0 38^1$ North of the Equator and Longitude $5^0 15^1$ East of the Greenmich Meridian (Figure 1). The drainage basin runs in the North-West and South-East directions of the city occupying the central section in close proximity to the Central Business District of the city.

River Ajilosun drainage basin is a 4th order basin using

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Strahlers' (1952) ordering method. The drainage basin forms part of the upper segment of the larger River Ogbesse drainage basin and has a planimetric drainage area of 18.125km$^2$ [4] and a main channel length of 6.20km. The drainage basin has numerous first order segments. However most of the segments have either being eutrophicated through the processes of urbanization or converted to concrete storm drains to evacuate storm flows emanating from high rainfalls and expanding impervious surfaces of the basin terrains.

The headwaters of River Ajilosun drainage basin is in the 'dambos' at the Odo Aremu quarters of the city where it forms an indefinite channel clad with linear growth of riparian bushes. The terrains predominantly consist of undulating plains with slopes ranging from $2^0$ to $4.8^0$. This is with an exception of Ayoba, a regolith mantled hill located in the North West axis of the drainage basin with an average slope gradient of $31^0$ (see figure 2). The hill is the highest relief in drainage basin standing at 540metres above the general level surface. With the highest relief of 390metres in the valley of River Ajilosun, the basin has a relative relief of 150metres indicating a generally undulating relief.

Widespread modifications of the environmental of the drainage basin began in 1953 when the settlement was made the headquarters of Ekiti Division. Since that date urbanization has progressed in the settlement. However, the climax of the series of modifications in the environment took place with the creation of Ekiti State on October 1st 1996 and the naming of Ado-Ekiti as the capital city. Since then rapid urbanization and increased demand for land acquisition for various developmental projects has progressed with unprecedented intensity.

Being a tropical location, the city enjoys the tropical climate with two seasons that is the rainy season and the dry season. The two seasons are usually determined by the Tropical Maritime and the Tropical Continental air masses. The mean annual rainfall totals varied between 1200mm and 1400mm with over 80% of the rainfall events concentrating between June and early October (Figure 3). Rainfall in the area is highly intensive with between 75% and 8o% of the total rainfall consisting of the medium to high intensity occurrences.

The soils are highly erodible due to the availability of thick depth of weathered overburden averagely varying in thickness between 0 and 14metres [3]. The charnockite rock forms the predominant rock type in the basin and the parent material from which the soils are formed basically. The charnockite-derived soils yield weathered overburden which are predominantly made up of 70% of silt and silty-sand sediments. (Figure 4).

The 308,626 population of Ado-Ekiti in 2006 [5], the 2030 projected population of 1,111,953 and the annual growth rate of 2.23% are quite enormous and, may have implications for the rate of deforestation and urbanization. As at present, major land uses in the Ajilosun drainage basin consist of the residential, commercial and institutional types, water resources and some developed open spaces. Extent of landuse may cause general modifications of the basin terrains and its degree of liability to environmental hazards.

## 3. Method of Study

Data were collected from direct observation of the situation in the field. Some data were also generated through direct field measurements of erosion, flooding and distance of houses to the river banks. For the measurement of erosion, flooding and distance of houses from the river, the tape, a piece of tie rod and ranging poles were used. The extent of urbanization and physical development in the River Ajilosun drainage basin was calculated from the topographical map of Ado-Ekiti containing the drainage basin on scale 1:50,000. The use of the particular map scale was conditioned by availability. The data collected from the topographical map was complemented with field work in order to augment the data on built up area of the drainage basin. Such field data included the extent of riparian vegetation along the channel banks and the spatial extent of the floodplains.

Analysis of the data was done with the descriptive statistics of the mean, range, standard deviation and percentages. The inferential statistics used are the correlation, linear regression and analysis of variance. Snedecor's F and Student's t statistics were the basic tests employed for testing the hypothesis generated.

## 4. Results and Discussion

### 4.1 Historical Episode of the Spatial Growth and Physical Development of Ajilosun Drainage Basin.

Ado-Ekiti as a settlement came into existence at about 1413 AD which is roughly over 780 years ago [2][6]. The settlement which started as a farmstead at three centres Odo-Ado, Oke-Isa and Adebayo existed as scattered farmsteads and huts interspersed with patches of bush and thick bracket of forest growth [2].

Gradual development of the city began in 1953 after its establishment, when it was named the headquarters of Ekiti Division**.** When Ekiti Division became one of the major regional development territories comprising Nigeria in the first republican dispensation in 1963, much faster developments were witnessed in Ado-Ekiti.

The creation of more states in Nigeria in 1979 nevertheless brought more developments to Ado-Ekiti as it named the headquarters of Ado-Ekiti Local Government Area one of the seventeen (17) local governments (councils) in old Ondo State. Ondo state was one of the nineteen (19) states carved out of the old Western Region by the former military head of state, Rtd Major General Olusegun Obasanjo.

Since 1979, Ado-Ekiti has witnessed rapid influx of immigrants into the settlement. The climax of such population growth really began with another impetus (given by) the creation of Ekiti State on October, 1st 1996 by the late head of state, General Sanni Abacha. More inward movement/migration into the settlement have had greater environmental and ecological consequences on the terrains of the city with obvious impacts on watersheds and the rainfall –runoff relationship of the city surface.

Ado-Ekiti has a population growth rate of 2.23% per annum. Between 1963 and 2006 the population of the city witnessed an increase of about 83% and as at 2008 the city population was projected to be population of 1,111,953 year [7]. The implication of this figure is that with the current annual growth rate the city may likely double its population in 31 years. One important thing to note here is that the current rapid population growth in the city has started having a serious impact on the environment and the ecological relationships in the city. However, such effects have been more conspicuous in the watershed areas of the city.

In the past 52 years, or precisely since independence, the rate of deforestation has been on the increasing trend in Nigeria.

This is particularly the situation in the South western Nigeria in which River Ajilosun in Ado-Ekiti is located. The figures 4 a-e illustrates the position being discussed. The illustrations show the progressive reduction on the spatial extent of forest cover in the country. A cursory look at the figure shows that between 1500 and 1900 there were more forest areas in the South western Nigeria than what the situation was much later on in 1991 and even to a less spatial extent today. Similarly, there has been a progressive decrease in the spatial coverage by forest vegetation in Ado-Ekiti. Owolabi (2011) discovered that the percentage of forest in the city has shown a continuous rapid decrease in spatial extent over the years as of today, less than 35% of the entire city terrain is under forest cover [8] (Figure 5).

The calculations/estimation from topographical map of Ado-Ekiti containing River Ajilosun drainage basin on scale 1:50,000 showed that 64.16% of the total drainage basin area of 18.128km$^2$ was completely urbanized in 1966. The percentage increased to 20.0km$^2$ in 1986 [1]. But in 2006 about 64% of the Ajilosun drainage basin have been deforested and given to physical development [4]. The implication of this development on the environment is that it brought about increased extent of impervious surfaces which consequently contributed to the reduced or attenuated infiltration capacity of the basin surface. The phenomenon concomitantly reduced the time lag between the start of rain and the generation of runoff. This accounts for the widespread flash flooding experienced in the drainage basin in the recent years.

Incessant and perennial flooding in River Ajilosun drainage basin is one of the two environmental cum ecological hazards brought about by the deforestation and resultant physical development of the drainage basin. The upstream reaches of River Ajilosun drainage basin which makes part of the beginning of settlement evolution in the basin is characterized by nucleated but haphazard pattern of settlement. This has reflected in the series of flooding which the basin has been exposed to in the recent years. The problems created by flooding continues in frequency and magnitude as urbanization and deforestation progress in the city.; However, the greater impacts of the deforestation and physical development of the basin in the upper course has been felt more in the lower reaches than at any other reaches of the basin. For instance, hazards of flooding and erosion are more pronounced in the downstream segments particularly at Moferere, Ajilosun Street and Olope areas of the basin. Substantial volume of floodwater causes inundation and pronounced channel bank degradation. These processes are particularly more obvious during the peak of the rainy season in June, July and September.

Repeated incidence of flooding of River Ajilosun drainage basin has caused wanton destructions of both physical and cultural features and concomitant dastard environmental consequences between 1976 and 1986. Following destructive ecological and environmental impacts of flooding in the drainage basin, the state government in collaboration with the municipal authority commenced the channelization of the upstream segment of River Ajilosun in 1985. The areas covered by the project included Odo Aremu, Orojuda, Ologoro, Odo Otu, Atikankan down to Fayose Shopping Complex at Ajilosun Street. The concrete channelization terminated behind the Cross of Salvation Evangelical Church opposite the Little by Little Plaza in Ajilosun Street. The effect of the concrete channelization of the drainage basin reflects in the rejuvenation of the water velocity and its erosive impact on the channel areas beyond the terminus of the concrete channel.

Urban development and deforestation in the upper reaches of the Ajilosun basin may have contributed to the increase in runoff generation and flood flow in the non concrete reaches of the basin. This explains the rationale for greater dissection of the River Ajilosun channel area at the Moferere, lower Ajilosun and Olope segments of the basin. The contrasting dimensions of the mean channel depth mean channel width and channel capacity of River Ajilosun reflects the disparities in the effect of urban physical development and deforestation between the upper and lower reaches of the basin (Table 1). The mean channel depth value in the lower reaches indicates more pronounced impact of the upstream floodwater in the lower channel area.

Following extensive mass deforestation for urban development, most of the tree and plant species in the city, and particularly in Ajilosun drainage basin, have disappeared. However, some remnant vegetal covers are found along the river courses as riparian growth. The vegetation growth along the water courses plays an important role in anchoring the soil particles and protecting channel bank soils from fluvial erosion. Thus channel in-caving and channel bank collapse are attenuated and could be where such vegetal growths occur along River Ajilosun course at Moferere [4]. The spatial variation in the contribution of urbanization to environmental hazards in the drainage basin was exemplified by the result of ANOVA analysis in Table 2 and it depicts ANOVA F value of 38983128.595 for the contribution of urban development to flooding. The 'F' value y of 38983128.595 was significant at 95% probability implying that urban development factors contributed to spatial variation in their effect on the incidence of flooding across the basin space.

The impact of flooding on the ecological relations in the River Ajilosun drainage basin has threatened sustainable socio-physical processes in the basin. Loss of both natural and human capital has generated untold hardship on the inhabitants of the basin. For instance, in September 2009 an Okada (commercial motorcycle) rider was drowned in the heavily flooded ditch of Ajilosun while the popular Ajilosun Bridge also gave way to erosion caused by excessive storm flow in the month. One other way in which urbanization of the upstream of the drainage basin has effect on the downstream is through refuse sedimentation of the lower reaches channel. Refuse of all sort are dumped into the channel by people living in proximity to the channel. The implication of this is that during the first rains, the hydraulic capacity of the channel is reduced and free flow of water is impeded with the resultant lateral migration of channel flood flow to the adjacent areas of the channel banks.

The generation of mammoth waste is a direct consequence of rapid urbanization of the entire city and of the Ajilosun drainage basin in particular. Thus as population increases in the city of Ado-Ekiti so is the quantity of waste being produced. The problem of waste management has to do with the provision of adequate disposal facilities and the issue bordering on regular disposal of such wastes. Inadequate availability of the refuse/waste metal bins within

**Table 1:** Descriptive Statistics of Channel Width and Channel Depth of River Ajilosun Drainage Basin

| Variable | | N | Mean | Std. Deviation | Std Error | 95% Confidence Interval for Mean Lower Bound | Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| Channel width | Upper Stream segment | 75 | 3.4 | 1.9337 | .22 | 2.96 | 3.56 | 2.1 | 11.3 |
| | Lower Stream segment | 75 | 8.34 | 2.2776 | .26 | 7.82 | 8.86 | 5.1 | 15.6 |
| | Total | 150 | 5.89 | 3.2504 | .26 | 5.36 | 6.42 | 2.1 | 15.6 |
| Channel Depth | Upper Stream segment | 75 | 1.35 | .22058 | .025 | 1.30 | 1.40 | 1.10 | 1.95 |
| | Lower Stream segment | 75 | 1.66 | 1.06414 | .12 | 1.42 | 1.90 | . 86 | 10.00 |
| | Total | 150 | 1.51 | .78394 | .064 | 1.38 | 1.63 | .86 | 10.00 |

*Source: Computer Analysis*

**Table 2:** Analysis of Variance of the Effect of Urban Development Factors on the Width of Flooding in River Ajilosun Drainage Basin.

| Variable | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Percentage of urban development | Between Groups | 30042.998 | 1 | 30042.99 | 38983128.595 | ***.000 |
| | Within Groups | .114 | 148 | .001 | | |
| | Total | 30043.11 | 149 | | | |

Note: *** significant at 0.05 alpha level
*Source: Computer Analysis*

**Table 3:** Methods of Waste Disposal Adopted by the Respondents in River Ajilosun Drainage Basin

| Segment of the river | | methods of waste disposal: use of dustbin | indiscriminate dumping/open space | designated dumping site | communal sanitary land | along drainage channel | inside Ajilosun river | Total |
|---|---|---|---|---|---|---|---|---|
| Upstream | Count | 24 | 4 | 15 | 6 | 14 | 5 | 68 |
| | % | 16.2% | 2.7% | 10.1% | 4.1% | 9.5% | 3.4% | 45.9% |
| Downstream | Count | 24 | 5 | 20 | 9 | 13 | 9 | 80 |
| | % | 16.2% | 3.4% | 13.5% | 6.1% | 8.8% | 6.1% | 54.1% |
| Total | Count | 48 | 9 | 35 | 15 | 27 | 14 | 148 |
| | % | 32.4% | 6.1% | 23.6% | 10.1% | 18.2% | 9.5% | 100.0% |

*Source: Computer Analysis*

the drainage and in the city of Ado-Ekiti as a whole reduces effective distance covered to the point of location of the facilities. The direct effect of this situation is that householders particularly those along the river course resort to using the river/stream channels for disposing their wastes. 27% of the respondents claimed that they discharged their household waste either along or directly inside River Ajilosun channel (Table 3). 27.7% of them do so because of the perceived advantage of the closeness of the river to their residence (homes). Such practices have tended to cause serious ecological problems for the physical and human environment downstream of the drainage basin. Such problems require paying proper attention to organized spatial location of the city and the drainage basin.

## 5.0 Summary and Conclusion

So far, the paper has demonstrated how urbanization in Ado-Ekiti and particularly in River Ajilosun drainage basin impacted on the lower reaches of the basin. Urban growth and development have caused extensive deforestation in the headwaters of the drainage basin. The haphazard location of buildings and human occupation of the flood plains have intensified the frequency of occurrence of flooding, erosion and other concomitant environmental hazards particularly in the lower reaches of the basin. It is therefore being suggested that planting of shrubs and creeping grasses should be planted around homes in the upstream segment of the basin. Also urban agriculture should be encouraged in the flood plains of the headwater areas of the basin. This should be done in addition to ensuring effective monitoring of urban development across the entire Ado-Ekiti city. In this respect an onus is resting on agencies such as the Town Planning Authority, Ministry of Environment, Waste Management Board, Ministry of Works and Transport and the Capital and Urban Development Authority.

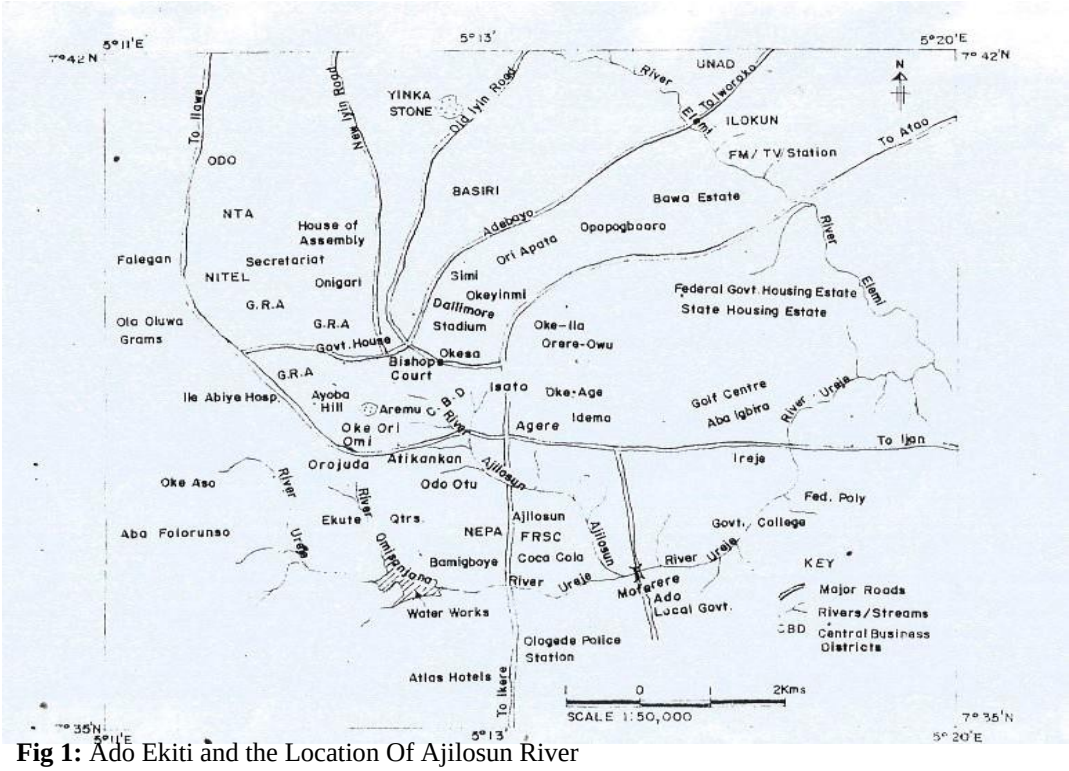


**Fig 1:** Ado Ekiti and the Location Of Ajilosun River
Source: Topographical Map of Ado Ekiti, sheet 244, SW, 1966

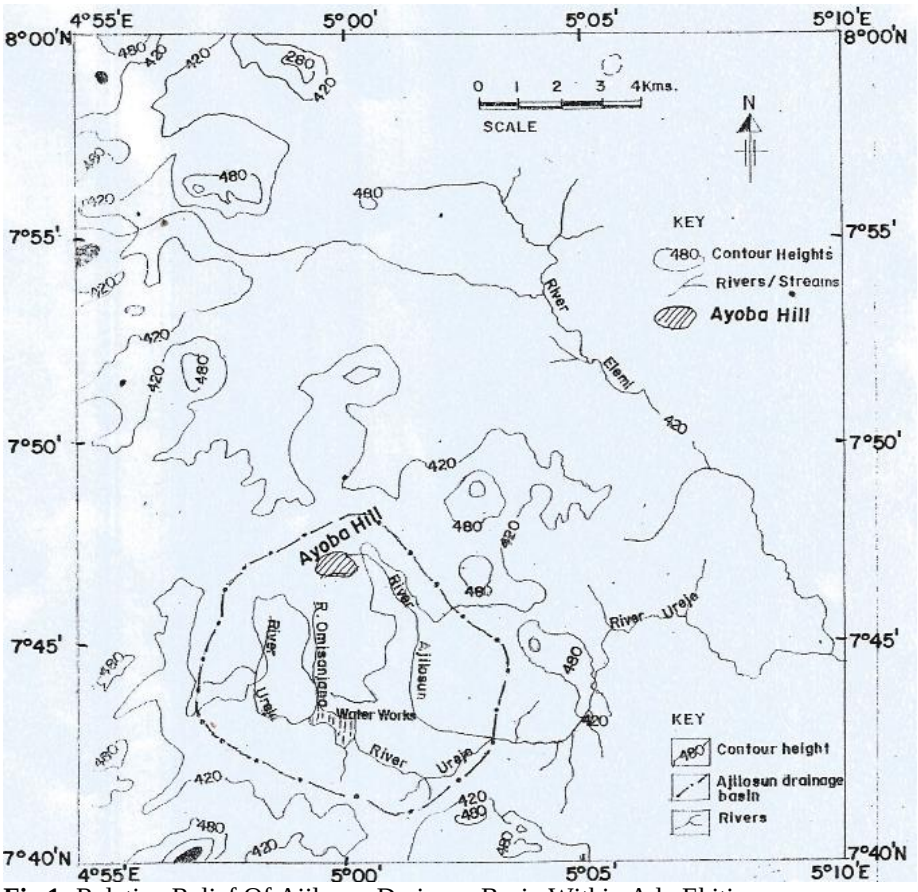


**Fig 1:** Relative Relief Of Ajilosun Drainage Basin Within Ado Ekiti
**Source**: Topographical Map of Ado Ekiti, sheet 244, SW, 1966

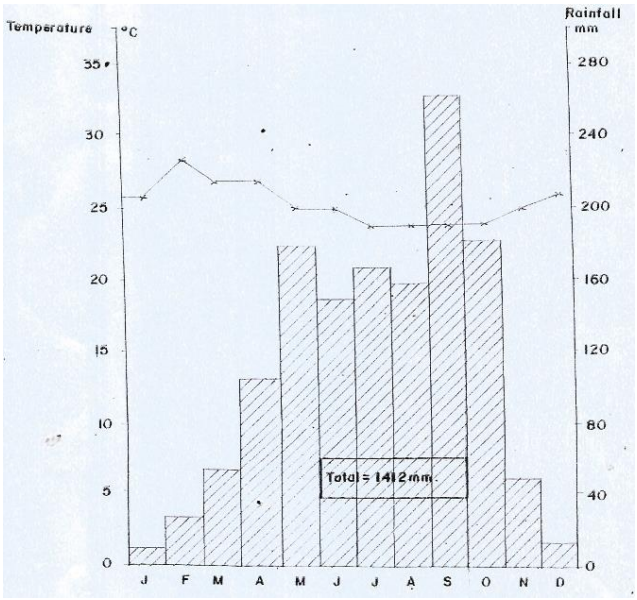


**FIG 3:** Temperature-Rainfall Relationship in Ado Ekiti

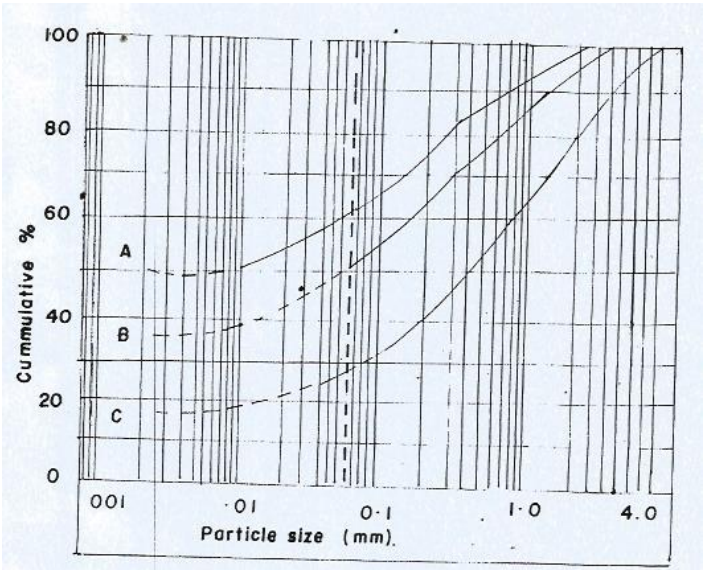


**FIG 4:** Particle Size Distribution Curve Of Charnokite Derived Soils

**A=** As received from the field chemically soaked for 48 hours
**B=** Air dried soil sample for 48 hours
**C=** Oven dried soil sample for 48 hours
Source: Adeduro, 1993

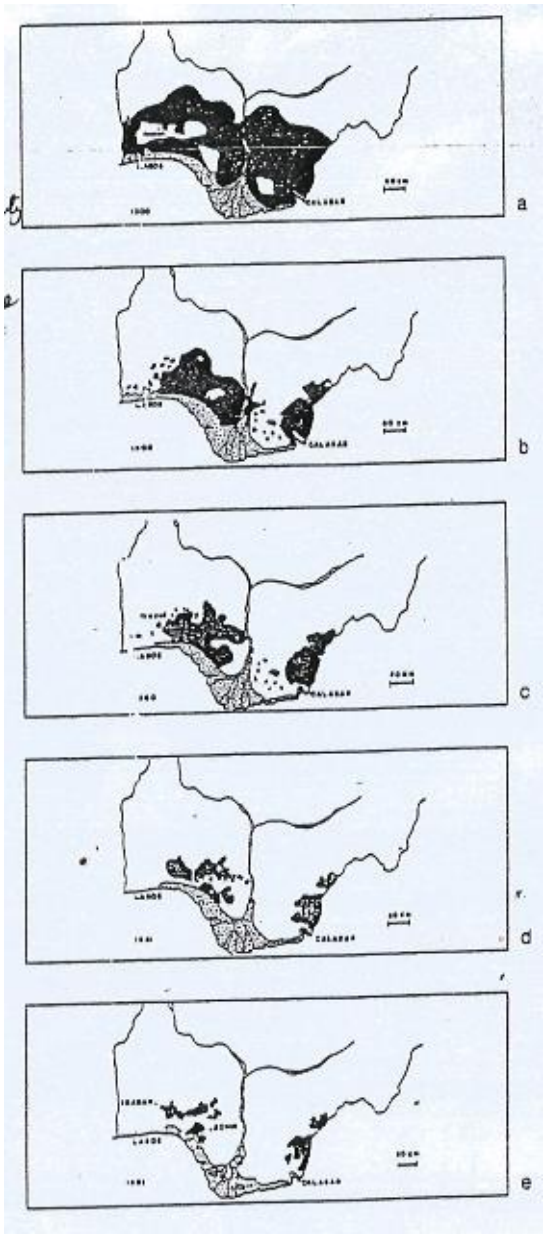


**FIG 5:** Systematic Destruction Of Rain Forest In Nigeria

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