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MAN'S ROLE IN THE EVOLUTION OF THE PHYSICAL ENVIRONMENT IN THE FOREST ZONE OF NIGERIA

ABSTRACT

The evolution of the physical environment in the forest zone of Nigeria is a result of both physical and anthropogenic factors. But existing literature on the subject seems to overstress man's action.

Man's contibution in the evolution centres on his agricultural activities, and an important result of man's action in this sphere is manifest in soil erosion for which the forest zone of Nigeria, and particularly southeastern Nigeria, is well known. However, the spate of soil erosion in the area is a consequence, not only of man's action, but also of the existence of other favourable conditions, such as climate, topographic disposition and the nature of surface materials.

The other ways in which man has affected the evolution of the physical environment in the forest zone of Nigeria are the various activities connected with his settlement on the land and include surface mining, road building, industrialisation and urbanisation. To obviate the nefarious consequences of man's action in these spheres of his endeavour, there is need to make the operations more rational, not by discontinuing the efforts, but by modifying them so as to save the Nigerian forest zone from total destruction. Accordingly, careful management of the zone is required, and this calls for a comprehensive national land-use policy, including an efficient management of the forests.

INTRODUCTION

The evolution of the physical environment in the forest zone of Nigeria results from a number of factors which, for convenience, could be grouped into physical and anthropogenic factors. The physical factors include some of well-known processes of geomorphological action, notably climate and climatic change, and tectonic activities, mainly uplift. The anthropogenic component of the evolution centres on the agricultural activities of man as well as various other activities connected with his settlement on the land, and include surface mining, road building, industrialisation and urbanisation. However, existing literature on the subject seems to over-emphasise man's action often to the total neglect of physical factors (Ofomata, 1978).

The paper reviews some of the major areas of man's impact on the physical environment

in relation to the part played by physical factors in the evolution. The aim is to ensure that while taking appropriate cognisance of man's role, one does not lose sight of the importance of associated physical factors.

MAN'S ROLE IN THE EVOLUTION OF THE PHYSICAL ENVIRONMENT

Man's role in the evolution of the physical environment here centres on his agricultural activities, and an important result of his action in the agricultural sphere is manifest in *soil erosion* for which the forest zone of Nigeria, and particularly southeastern Nigeria, is well known (Ofomata, 1982, 1983. See also Fig. 1). Under natural conditions and undisturbed vegetative cover, soil formation is able to keep pace with the slow attrition characteristic of routine geomorphological processes, whereby the surface layer of weathering rock is loosened and carried away by wind or running water and a lower horizon in the soil is exposed. Under such conditions, transport of material downslope or in the direction of the wind usually goes on intermittently, and each movement is so slight that erosive processes are very slow and appear to be continuous. Thus for most purposes, the soil under an undisturbed cover can be regarded as being in a steady state.

However, we know that except for some of the forest reserves in the country, there is hardly any such soil under undisturbed cover. The actual situation es that man continually clears the ground (bush or forest) for farming, burns the grasses, shrubs and trees and has need to graze his animals. The consequence of man's action in these ways is to expose the soil to the elements, leading to accelerated soil erosion and deterioration. Nevertheless, our experience of the subject leads to the conclusion that the spate of soil erosion in the forest zone of Nigeria is a consequence, not only of man's action, but also of the existence of other favourable conditions, such as climate, topographic disposition and the nature of surface materials (Ofomata, 1965, 1967a, 1978). This is why we have always opposed the rather simplistic view held by some workers that soil erosion in Nigeria es a result of the so-called «bad farming techniques». Such workers have usually recommended the adoption of mechanisation in our agricultural practices, even when the consequences of this recommendation have not been avaluated on the basis of practical experience.

An attempt to outline a soil erosion model for the humid tropics, based entirely on the experiences of Southeastern Nigeria, once more brought the importance of the physical factors to the fore. The results reveal that, allowing for interferences from single, two-factor and three-factor interactions among the variables, surface configuration accounts for about 26 per cent of variations in the type of soil erosion, against 14 per cent by rainfall, 3 per cent by surface materials, and almost zero per cent (actually 0.1 and 0.2 per cent respectively) by each of population density and vegetation. This revelation lends support to our earlier observation on the relationship between erosion and relief in the area and the underlying influence of lithology (Ofomata, 1967a). The paramountcy of rainfall and surface configuration as factors of soil erosion in this region was clearly established by these results, but this paramountcy seems to be valid only for lower classes of soil erosion (the non-gully types). Further analysis reveals that population density and surface configuration have a positive correlation with soil erosion, while rainfall, vegetation and surface materials have a negative correlation phenomenon. The regression lines between soil erosion (y) and population density (x_1), surface configuration (x_2), rainfall (x_3), vegetation (x_4) and surface materials (x_5) are given by the following equations:

$$Y = 0.5x_1 + 1 \quad \text{(i)}$$
$$Y = 1.5x_2 \quad \text{(ii)}$$
$$Y = -1.5x_3 + 5.5 \quad \text{(iii)}$$
$$Y = -1.5x_4 + 6 \quad \text{(iv)}$$
$$Y = -0.5x_5 + 3 \quad \text{(v)}$$

To a large measure, these equations would accord with what is expected under existing circumstances. However, contrary to equation (iii), one would normally expect a positive correlation between soil erosion and rainfall in the environment of southeastern Nigeria. The negative relationship existing between the two parameters here is a result of the influence of lithology (Ofomata, 1967a).

The model is given graphically in Fig. 2. An obvious implication of the model is that the

phenomenon of soil erosion is a system made up of complex interacting components. Like the environment itself, any changes in any one of its components will affect the other components of the soil erosion system and, thereby, the entire system itself. Another implication is that any action aimed at combating the menace of the phenomenon must equally be aimed at its various components for meaningful results. That is why, for instance, an adequate knowledge of the environment is advanced by the author as a necessary condition for fighting the menace of soil erosion (Ofomata, 1981a, 1983a).

No one could reasonably deny the possible contributions human activities make to the development of soil erosion. Nor could it be contended that different methods of land use and the level of technology of land users necessarily affect the soil diffenrently. Rather, what is being emphasised is that in areas inhabited by the same group of people with similar methods of land use and at the same level of technology, it is reasonable to assume that any differences in the nature and type of soil erosion have to be explained largely in terms of extra-human factors. Consequently, we are of the view that the most important of the factors to explain soil erosion in the forest zone of Nigeria are not human; that the main contribution of man to the inception and subsequent development of the various forms of erosion in the zone seems to be the complication of an already existing situation or, at best, to act as an additional incentive to set off a more serious situation in an environment whose physical characteristics are totally disposed to the evolution of the worst types of erosion.

The other ways in which man has affected the evolution of the physical environment in the forest zone of Nigeria are the various activities connected with his settlement on the land and include surface mining, road building, industrialisation and general infrastructural development (Ofomata, 1981b). The various mining activities include exploitation of lead and zinc, limestone, building stone, clay, marble, iron ore, salt, coal, crude oil and natural gas. Apart from coal which is mined mainly through the adit method, and crude oil and natural gas exploited by drilling, the rest of the mining activities are carried out mainly by surface mining. Surface mining in Nigeria (which is essentially area strip-mining) causes dereliction of the land. Undisturbed, unweathered rock strata are broken and brought to the surface, where the material is subject to rapid weathering, especially under the climatic conditions prevalent in the forest ecosystem. Mineral nutrients that were once slowly leached and recycled are now subject to rapid chemical weathering. Elements that are necessary to plants in small amounts become toxic when released in great amounts. These micronutrients are carried away in high concentrations by rainfall and by runoff from the stripped slopes, causing reduced water quality downstream. It is estimated that dissolved solids derived from stripped sites can be as much as twelve times greater than from unmined sites, and sulphites can be as much as fifty times greater (Collier, 1962).

Additional problems ensue from the highly unstable composition of the spoil. The mixture of soil and rock that makes up the overburden is often so deposited that the outer slope of the spoil tipped is steeper than the original gradient. Water seeping into and percolating through the spoil wets the clays and shales. The «activity» of such clays and the weight of the water-laden spoil combine under the force of gravity to cause serious landslides. Water flowing down steep slopes carries with it tonnes of sediment that are washed far down-stream. It is estimated that sediment yields from spoil banks may be as great as one thousand times the amount of those coming from undisturbed, forested slopes, and the erosion rate may be as high as five to ten times as great.

Central to the problem is, of course, that strip-mining starts with total removal of the vegetation covering of an area before trenches are cut. Consequently, it is usually a bare surface, devoid of vegetation, that is exposed to climatic elements as a result of strip-mining. This accelerates the rates of geomorphological and pedologic processes, leading to some of the consequences outlined in the preceding paragraphs.

A further effect of strip-mining is the alteration of the groundwater regime. The level of water tables, once deep in the underlying rock strata, is often brought to the surface, producing free-flowing water at the newly created surface. Large quantities of water that would have been taken up by trees and lost to the at-

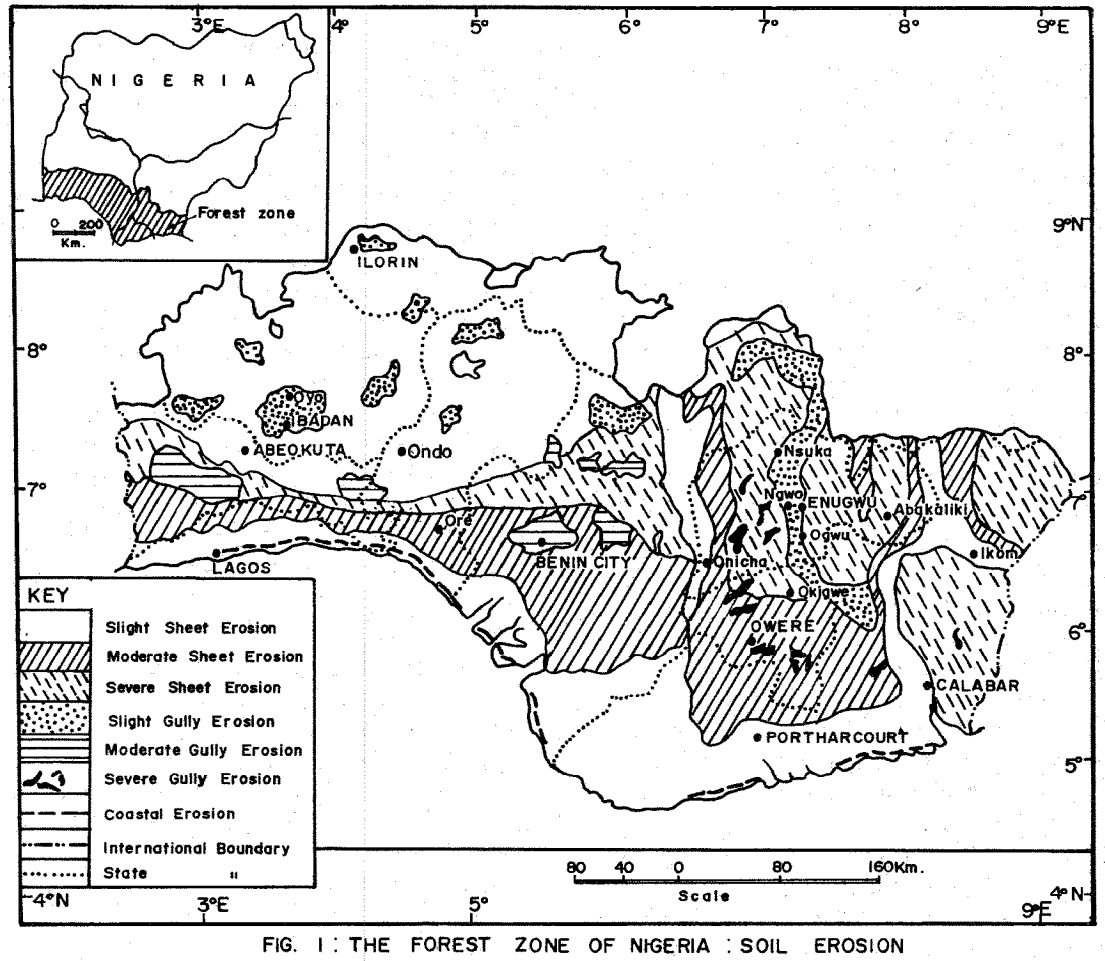

FIG. 1 : THE FOREST ZONE OF NIGERIA : SOIL EROSION

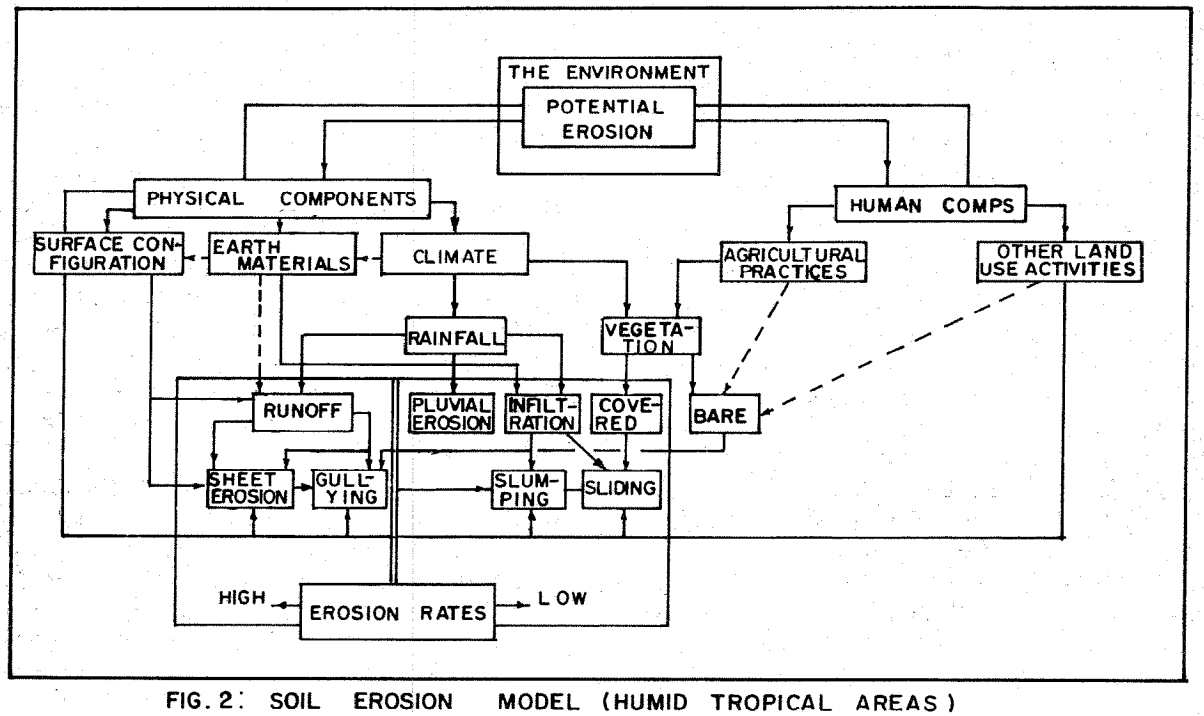

FIG. 2: SOIL EROSION MODEL (HUMID TROPICAL AREAS)

mosphere through evapotranspiration are added to the amount of runoff. Thus, during the periods of heavy storms, water flows from strip-mine sites with great force, intensifying the height and damage from flash floods and washing out stream channels and narrow flood plains below.

The search for oil also involves the destruction of a lot of forest. In addition, the use of explosives in Seismic Surveys disturbs the rivers and seas, and results in the destruction of marine lives.

The easiest suggestion to make in order to limit the consequences of the modification of the environment as a result of strip-mining, is not to mine at all. It is recognised, however, that this is an impossible proposition, since the products of such strip-mining activities are necessary for the overall development of the country. In this case, the alternative suggestion is to formulate and enforce extensive reclamation regulations, incorporating slope reduction, backfilling, levelling and burying of toxic materials and revegetation. Revegetation on many spoils is virtually impossible because of the acidic and toxic composition of the overburden material, the extremely unstable slopes, and severe environmental conditions. Even though toxic materials are covered, water moving through the material still carries a concentration of toxic elements. Again, even where revegetation seems to succeed, the plant cover established is usually inferior to the original cover. Whatever the extent of success achieved through revegetation, the «new» plant cover would require some long-term management; otherwise, it would soon degenerate, re-exposing the materials to erosion. It is important, in all efforts at revegetation, that a grassy cover is maintained until the natural succession can take over.

No land use change has been more absolute and final in modifying the forest zone of Nigeria than *industrialisation and urbanisation*, which are a «climax type» in the human succession. In these processes, natural vegetation is destroyed by man and replaced by ecologically permanent areas of bare concrete, asphalt and steel. Fumes from factories, coke ovens and smelters may destroy the vegetation of surrounding areas. Even after the process has ended, or the cause eliminated, many years are required before the vegetation begins to return. Pollution of streams by sewage, industrial wastes and siltation eliminates oxygen-demanding fish like trout; these are replaced by carp and bullheads which are able to adapt to polluted conditions. Dam construction (for power and other uses) drowns terrestrial communities and converts part of the river community to deep lake conditions.

Human settlement in a rural setting is perhaps the least culpable process in modifying the natural rainforest ecosystem. However, human settlement of an area from past to present has undergone a form of visible succession. The first group of people to live in or penetrate a region, generally known as pioneers, are hunters and trappers, who, apart from harvesting animals and wild fruits, leave little mark on the land. They are followed by subsistence farming or grazing culture, the stage at which most rural groups in Nigeria still exist today; these are capable of completely changing a natural ecosystem. Some plants and animals may be destroyed, the succession set back to an earlier and more economically productive stage, and new succession introduced. If the land is too poor or abused to support human society economically, the land at this stage may revert back to natural vegetation. Traces of old settlements and abandoned land can be found in most parts of the forest zone of Nigeria.

However, the situation is different with industrial and urban settlements which, as has been mentioned earlier, are the climax stages of human succession. The tremendous growth of suburban settlements onto fertile farmland properly indicated the nature of this succession. But as there are successional trends in the various later stages of forest development, so there are successinal trends in the stages of urban development. The urban community begins as a small central core and grows outward into the surrounding countryside until, eventually, this outward expansion or invasion of an urban community takes over the surrounding countryside.

Initially, the centre of the city is the most desirable place to be located. However, because all residents and their associated establishments cannot locate there, a sorting process takes place, resulting in the segregation of both functional units and social units based on socio-economic status and culture. As the city

grows, the pressure for other central locations forces outward expansion. This expansion (or invasion) does not take place at equal rates because of resistance or competition from land-use functions, people and transportation facilities. As one zone exerts pressure on the adjacent outer zone, it eventually replaces this outer zone. At the same time, the outer zone tends to invade the next to colonize a new site. Thus, one successional stage replaces another.

A close look at existing or recently established urban and industrial complexes would reveal how the process being discussed would affect the forest zone. It is easy to observe that the destruction of forests accompanying the process is total and irreversible and the forest is replaced, permanently, by bare soil surface, often covered by concrete, asphalt or steel. The consequences of such total forest removal include flooding and soil erosion, which are causing increasing concern in most urban and industrial locations. These and related consequences are sufficently well known to require no further elaboration here.

Areas of this gradual encroachment of the urban zone on surrounding rural countryside include Enugwu, which has expanded to the surrounding area of Okunano, some 8 km. on the Enugwu-Ogwu road; Ngwo, 5 km. on the Enugwo-Onicha road; Nike, about 9 km. away, and Emene, some 13 km. on the Enugwu-Abakaliki road; Owere; Ibadan City, which has expanded in the last decade to engulf such villages as Apata, about 6 km. on the Abeokuta road, Ojoo, 7 km. on the Oyo road, and Manatan, 4 km. on the Iwo road (Areola and Ofomata, 1978). Lagos has also expanded beyond the island to absorb such mainland settlements as Mushin, Ikeja, Isolo and Agege.

The quarrying of building materials such as sand, clay, gravel and «red earth» is one of the major causes of forest clearance and land degradation in the rural hinterlands of most of the forest zone of Nigeria. This practice is widespread and, because there has been a tendency to take these materials for granted, little attention has been given to their evaluation, exploitation or utilisation. There are no laws or regulations whatsoever concerning the earth material quarrying activities, in contrast to the regulations enacted for large-scale mineral operations. Thus, the exploiter may dig anywhere he chooses as long as he has the consent of the land owner.

In many rural areas and along the motorways, builders seldom bother to seek permission from the land owner. The quarrying of earth materials results in large-scale clearance of vegetation. For example, along with road construction, it has been largely responsible in recent years for the extensive land clearance of the Lagos, Benin and Ondo forest regions. Entire interfluves or broad valley sides may be completely cleared and quarried. The exposed pits and earth dumps are often subjected to intense erosion by concentrated storm runoff. The exposed land surface soon hardens under the intense heat of the sun so that the reforestation of such lands is very slow. Close to big towns and villages, some of these pits have become the dumping ground for scrap metal and household refuse (Areola and Ofomata, 1978).

Road construction is another area in which the impact of man on the Nigerian rainforest ecosystem is readily felt. Man's activity here goes beyond a stretch of road and includes, often more forcefully, the adjacent land excavated for red earth, or so-called «laterite», for road filling and surfacing. As with the case of industrialisation and urbanisation, road building represents another area of land use that is complete and final in its impact on the rainforest ecosystem.

The construction of a road implies complete removal of all vegetative cover along the zone occupied by the road, as well as on adjacent land exploited for earth materials. The chief source of concern is that road building in Nigeria seems to be undertaken with no consideration of geomorphological factors, nor of the possible consequences of such landscape modification (Ofomata, 1965; 1966). It would appear that the road builders take only their projcts into consideration and are normally not interested in any problem that may arise as a result of their activities. A look at most of the roads will authenticate this observation.

One obvious consequence of such road-building activities is road-side erosion, which is widespread on most of the roads. The removal of vegetation from the roads and adjacent areas exposes the land to the vagaries of climatic elements. In rainforest areas, the chief elements are rainfall and accompanying rainwater runoff. Consequently, most roads are marked by intensive erosion emanating from the concentration of water in roadside draina-

ge channels, most of which have turned into gullies, threatening the roads and constituting a danger to motorists. It would be useless citing examples of such cases, as on most roads they are plainly visible to any casual observer. However, to put the situation in its proper perspective, a few cases may be necessary. Some interesting examples are easily observed on both sides of the Nsuka-Enugwu road, especially at Umulumgbe, Abo, Ngwo and the Milliken Hill. Other notable examples occur on the Onicha-Owere road (especially near the Idemili River bridge), some sections along the Benin-Ore road, and in several places along the Calabar-Ikom road.

Several school compounds and market places also reveal examples of the impact of man's activities in the Nigerian rainforest ecosystem. The results, in most cases, are similar to those observed on most of our roads, as well as on industrial and urban sites.

SUMMARY AND CONCLUSIONS:

In this paper, we have purposely concentrated on exposing man's role in the evolution of the physical environment n the forest zone of Nigeria. This is strictly in keeping with the title of the paper and to emphasise aspects of the increasing part played by man as a geomorphological process in the evolution should not be minimised —as a man's action seems only to complement or dramatise these processes. Some of the geomorphological processes have been examined elsewhere (Ofomata, 1967b, 1972, 1980a&b, 1983b) and it is clear that man's role is a more recent and easily observable phenomenon, which is one of the reason why it readily attracts attention.

The need to emphasise the points raised in this paper is at least to enable us appreciate the urgency of rectifying some of the damage done to the Nigerian forest ecosystem and to be more careful in further destruction of the forests, even for the necessary and laudable efforts of expanding our agricultural operations, of establishing new towns and industries, or to construct new roads and introduce new infraestructural development to improve the general socio-economic status.

The suggestion being made is not to discontinue these efforts but rather to make them more rational so as to save the forests from total destruction. Thus, what is required is careful managment or our forests while continuing the attempt to improve the status of the population. This makes it necessary, as soon as possible, to establish effective conservation and management policies so that the benefits associated with forests could be fruitfully realised. Apart from lumber and pulp, other benefits that could be realised include the maintenance of watersheds; oxygen production; their function es reservoirs for a variety of plant species, fish and wildlife; the recreational opportunities and aesthetic pleasure they afford mankind.

Careful management of the forests could assure us of the opportunity to benefit from these values in virtual perpetuity. This management would include preservation of trees of mixed species and ages as much as possible to discourage losses from pests, disease and fire; logging on a long-term rotation basis for the best quality of lumber; reafforestation; and careful protection of the soil. These effort at conserving the forest will continue to face increasing demand for agriculture, housing, industrial and urban establishments, roads or other necessary infrastructures. However, these demands could be met without disturbing our forests unnecessarily if careful management measures are adopted. In the caso of those activities of man which make tota forest removal inevitable, the least that could be done in pursuit of prudent management is to ensure adequate vegetative cover of adjacent lands, such as sides of roads paved with asphalt, surroundings of urban and industrial sites covered by concrete or asphalt surfacing, maintenance of properly positioned road-side channels and reclamation (through reafforestation and other means) of mined sites and sites from which earth has been removed for one purpose or another.

The forests are theoretically known to constitute a renewable resource, but it is equally well known that once disturbed, a forest hardly ever attains its previous climax nature. This is even more so in the case of road building, urbanisation and general infrastructural development, which entail permanent destruction.

Only a comprehensive national land-use policy, including careful management of the forests, will alleviate the situation. Without this, and as has been noted elsewhere (Ofomata, 1981b), Nigeria may soon discover that it has improved the circumstances of one generation rather well, but at the detrimental expense of the next.

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