SOIL EROSION IN NIGERIA: THE VIEWS OF A GEOMORPHOLOGIST
BY
PROF. G.E.K. OFOMATA

Mr. Vice-Chancellor, Deputy Vice-Chancellor, Deans of Faculty, Colleagues, Ladies and Gentlemen

Soil erosion - which is simply a systematic removal of soil, including plant nutrients, from the land surface by the various agents of denudation occurs in several parts of Nigeria under different geological, climatic and soil conditions. But the degree of occurrence varies considerably from one part of the country to the other. Thus, while it is true to observe that soil erosion is one of the most striking features on the land surface of Southeastern Nigeria, especially in Omambala (Anambra) and Imo States, only rare occurrences of the phenomenon are recorded in some other States of the Federation. Equally varied are the factors responsible for the inception and development of erosion, as well as the types that exist in several parts of the country.

Again, the incidence of soil erosion in the country is not new, as it has formed a subject for serious consideration since the beginning of this century. For instance, the *Udi Forest Reserve* was created in 1922, followed by an *Anti-Erosion Plantation,* also at Udi, in 1928 (Sykes, 1940), all aimed at combating the nefarious effects of soil erosion. *This* awareness of the existence and, perhaps, danger of soil erosion was brought into greater relief by the general review of soil erosion in Nigeria by late Sir Dudley Stamp (1938). Stamp's review was followed by the special study of the phenomenon by Grove (1951 and 1952) in parts of the former Eastern and Northern provinces of the country. On our part (Ofomata, 1964, 1965, 1973, 1978, 1980, 1981a, 1981b, 1981c, 1982 and 1984a & b) we have studied the problem in some detail in parts of Southeastern Nigeria, while Ologe (1971 and 1973), Jeje (1978) and Sada and Omuta (1979) carried out related studies in parts of the Savanna Zone, Western Nigeria and Bendel State respectively.

In spite of these and similar studies, it could easily be said that erosion remained a localised problem which gained attention on an isolated and adhoc basis from the affected communities and the relevant Ministries of Agriculture. However, since the middle 1970s, soil erosion has continued to attract wider attention than before and has formed a topic for spirited speeches by former legislators, government functionaries and private individuals. The situation is that there is now some degree of general awareness of the problems of soil erosion in the country and some measures have been or are being taken to combat these problems. However, it would appear that in spite of some of these otherwise well-meaning attempts, our management strategy remains faulty.

In pursuance of these observations, I shall, in what follows, examine why the situation remains what it is. To achieve this objective, I shall outline the factors of soil erosion, the types of erosion and their operational mechanisms, the consequences of the phenomenon, existing control measures and recommended management strategies. The bulk of *my* illustrations will be taken from Southeastern Nigeria, where most of my studies have been concentrated.

FACTORS OF *SOIL EROSION*

Soil erosion is a major environmental problem in Nigeria and to be able to appreciate the full implications of the phenomenon, one should understand the factors responsible for its inception and development; one should also know the types of erosion that exist and the spatial distribution of those types.

Briefly, soil erosion can be regarded as merely a geomorphological process, 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 natural 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. Under such circumstances, soil formation is able to keep pace with the slow attrition, and

> *"the soil profile as a whole shifts downward and the thickness of the topsoil is maintained and, for most purposes, the soil under an undisturbed cover can be regarded as being in a steady state" (Grove, 1956).*

However, we know that .except for some of the forest reserves in the country, there is hardly any such soil under undisturbed cover. Man needs the soil for his cultivation and has to clear the ground (bush or forest) for farming. He also burns the grass and trees and has need to graze his animals. Each of these activities leads to exposing the soil to the elements and, invariably, to "accelerated" soil erosion and deterioration, depending on the existence of other favourable conditions. These other factors include climate, topographic disposition and lithology, especially the nature of surface materials.

Accordingly, *the factors* of soil erosion in Nigeria resolve into two components: physical (geologic or "natural") and anthropogenic (human or "accelerated"), dose study has, however, revealed that the human component in soil erosion is often exaggerated while the effects of the physical component are usually underestimated (Ofomata, 1965; .1978). This has often led to the rather simplistic view that soil erosion in the country is a result of the so-called "bad farming techniques". Accordingly, some workers have recommended the adoption of mechanisation in our agricultural practices, even when the censequences of this recommendation have not been evaluated on the basis of practical experience - and as if the episode of the East African Groundnut Scheme has been completely forgotten!

The physical factors of soil erosion could be divided into four climate, surface configuration (relief/slope), surface materials and vegetation. The relationship between climate and soil erosion is fairly well known and, for the humid tropics, rainfall constitutes the dominant sub-factor. Foumier (1960) has attempted an empirical consideration of this relationship but his outline serves only as a general guide in the attempt to correlate the two parameters.

Rainfall manifests itself in three different, though related, aspects. It gives rise directly to pluvial (splash) erosion as a result of the impact of raindrops on the ground surface. The erosive capacity of raindrops seems to result from three factors: the amount and intensity of rainfall, the diameter of the drops, and the velocity of the drops as they strike the soil, and a good account of the relationship between raindrop energy and erosion has been given by Hlison (1952). Rainfall also leads to infiltration where conditions are favourable, like where the underlying rocks and/or their associated weathered materials are porous and facilitate infiltration. The third aspect is that rainfall leads to runoff which is the central agent in the soil erosion system. Where unconcentrated runoff
gives rise to sheet wash (sheet erosion), while gullying results from concentrated runoff, provided that lithology is favourable.

The nature of surface materials influences the rate of infiltration and, thereby, of slumping and/or sliding. It also affects the nature and rate of surface runoff and, thereby, the nature and rate of incision (Ofomata, 1965, 1967).

Surface configuration (relief/slope) aids runoff, sheet erosion and gullying. The general tendency is for sheet erosion to be common over fairly uniform and gentle slopes, while gullying is expected to be more characteristic of steeper slopes. It is known, however, that gullying also takes place on very gentle slopes and is even more common on such gentle slopes than on very steep ones. For one thing, runoff requires such gentle slopes to be concentrated, and concentrated runoff is a prerequisite for gullying. Musgrave (1947) attempted to evolve an empirical equation relating erosion (rate of erosion) to rainfall and slope, while Zingg (1940) attempted an estimate of the relation between soil loss and slope.

The indirect effect of climate on soil erosion is through the medium of vegetation. Areas under effective cover of vegetation are more prone to sliding and slumping (provided that the gradient is steep enough) as they are characterised more by inflitration than by surface runoff, while bare surfaces encourage runoff and, thereby, sheet erosion and gullying.

The *human components* in soil erosion are connected mostly with agricultural practices and other land use activities. Agricultural practices in the humid tropics generally involve the destruction of vegetation by clearing the land for cultivation and by forest fires. These activities cause great change in the relative proportions of infiltration and runoff, with the dangers of erosion increasing with increased destruction of vegetation and, thereby, reduced infiltration and increased runoff (Ofomata, 1965: 45-47).

Of the other land use activities, surface mining, road building, urbanisation, industrialisation and general infrastructural development appear most important. Tire consequences of these activities for soft erosion have been discussed elsewhere (Ofomata, 1964, 1981c; Salbany, 1960). It suffices here to mention that these other land use activities help deprive the soil surface of its vegetation and also contribute directly to sliding (Ofomata, 1966), slumping, sheet erosion and gullying (Ofomata, 1981c).

Sail Erosion Model:

A little over 9 (nine) years ago, I embarked on the formulation of a soil erosion model for the humid tropics. I engaged in the exercise for two main reasons: (1) to further clarify the relative importance of the various factors of soil erosion in Southeastern Nigeria, and (2) provide a guide towards a uniform study of soil erosion in those parts of the world characterised by uniformly high temperatures, a generous annual rainfall and, hence, ideally under effective cover of vegetation. The hope in this second regard is that such a model would facilitate a comparative study and assessment of the soil erosion phenomenon in humid tropical areas, with local conditions introducing the necessary variants in the major components of the model

A general view of "model" is taken for the purposes of this exercise, in which a model is simply understood to be a representation of reality, a simplified and generalised statement of what seem to be the most important characteristics of a real-world situation; "... an abstraction from reality which is used to gain conceptual clarity — to reduce the variety and complexity of the real world to a level we can understand and dearly specify" (Lee, 1973).

The basic assumption in the exercise is that each factor of erosion is capable of being considered on its own as well as in conjunction with other factors. The various relationships between the factors of soil erosion and the phenomenon of erosion are given in Pig. 1 as the graphical version of the So»'l *Erosion Model,* Its relevance for the humid tropics is emphasized by the fact that rainfall is the principal element of climate considered. We believe that it is possible to modify the model to fit other climatic environments, like dry zones, where wind action should be emphasized, or cold regions, where glacial and periglacial effects would be paramount.

The model is self-explanatory. Briefly, potential erosion of the environment has both physical and human components; each component is itself made up of a number of constituent factors which interact in different ways and at varying degrees to produce different types and rates of erosion from one part to the other of the humid tropics. Rainfall is a major factor in the observed relationships. Direct relationships are shown by solid lines while indirect connections are shown by pecked lines. The *erosion rates* box represents only an attempt at a general indication of what is expected from certain soil erosion components acting either singly or in combination with other components.

Of the various factors of soil erosion recognised, only population density, surface configuration (relief), rainfall, vegetation and surface materials have been isolated as critical to the development of the soil erosion phenomenon and used as the parameters for formulating the model.

The methodology is entirely mine and straight forward. Six maps of the eastern States of Nigeria showing population density (x,), relief (x^), rainfall (xg), vegetation (xA surface materials (x_5), and type of erosion (y)- on a scale of 1:1 million - were gridded into 1cm squares (Figs. 2-7). The factors were observed at 3 levels. Each category of the variable concerned was entered in the appropriate square. The information contained in all the six maps was then coded onto another map (Fig. 8) in which each square now has six entries, each entry representing the category of each variable appropriate for that square. For example, the entry in square T17 is 322313. This means that in that square, the class of population density is 3, of relief 2, rainfall 2, vegetation 3, surface materials 1, and type of soil erosion 3.

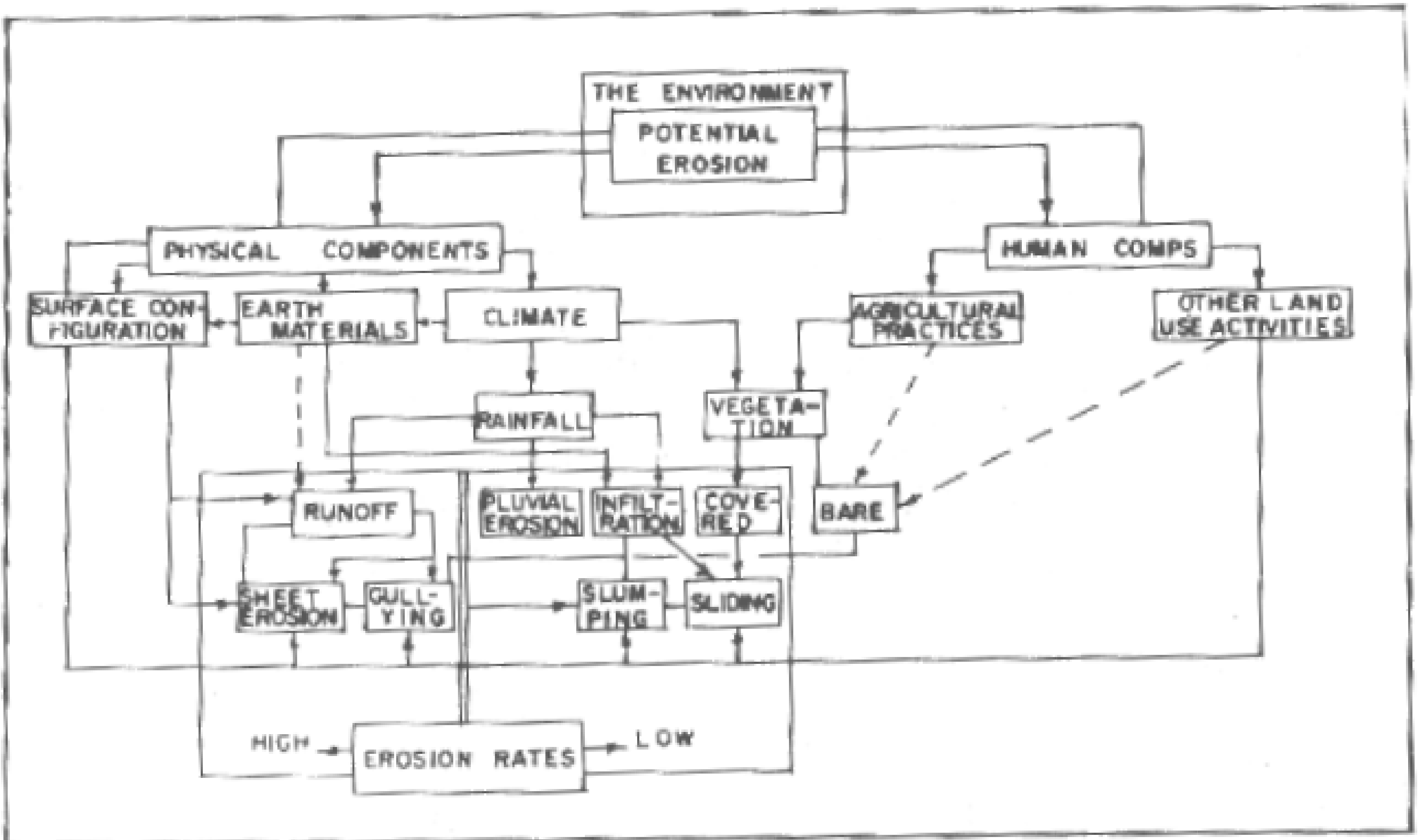


FIG I : SOIL EROSION MODEL (HUMID TROPICAL AREAS)

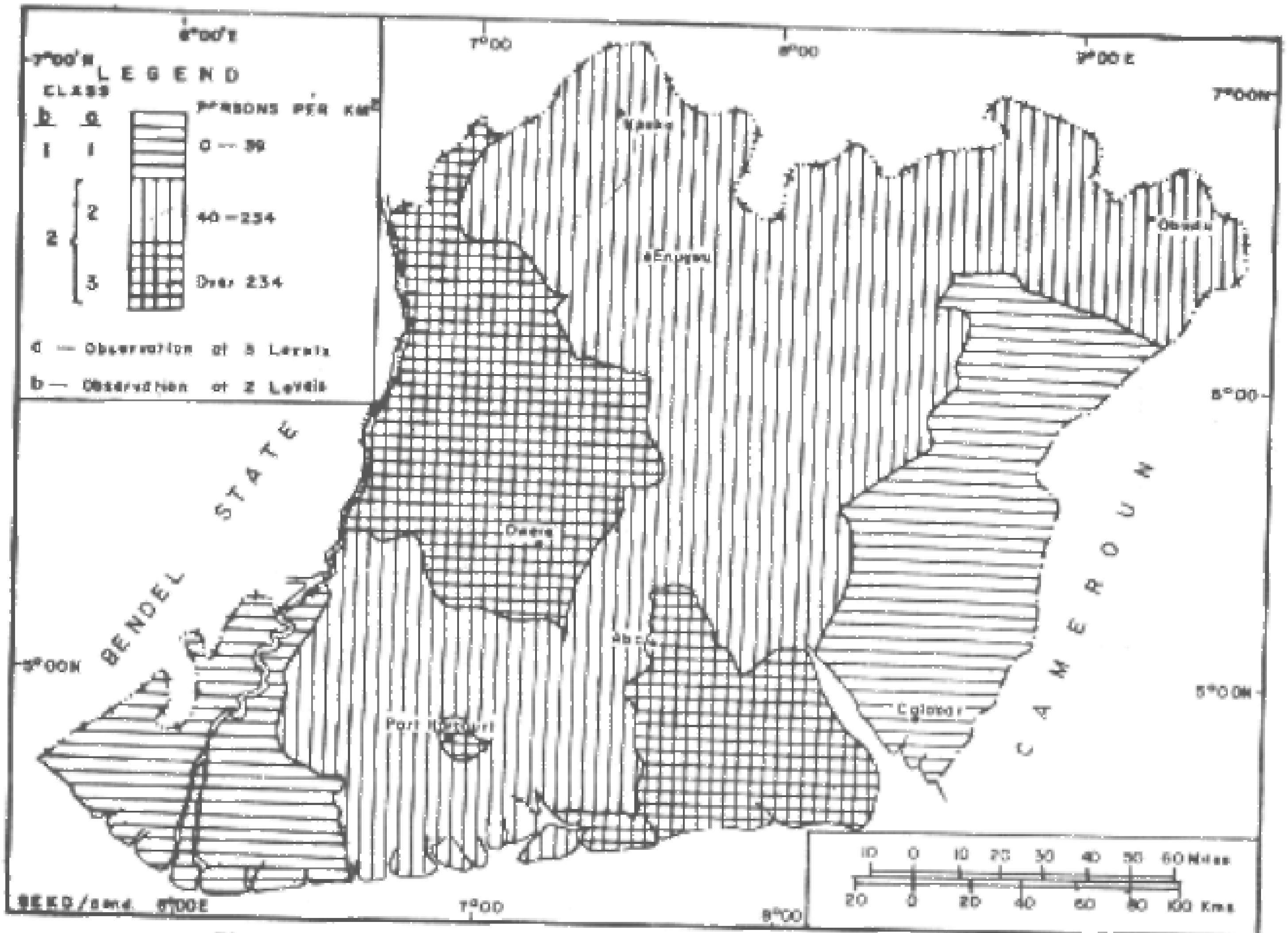


Fig. 2 : SOUTHEASTERN NIGERIA : POPULATION DENSITY(X1)

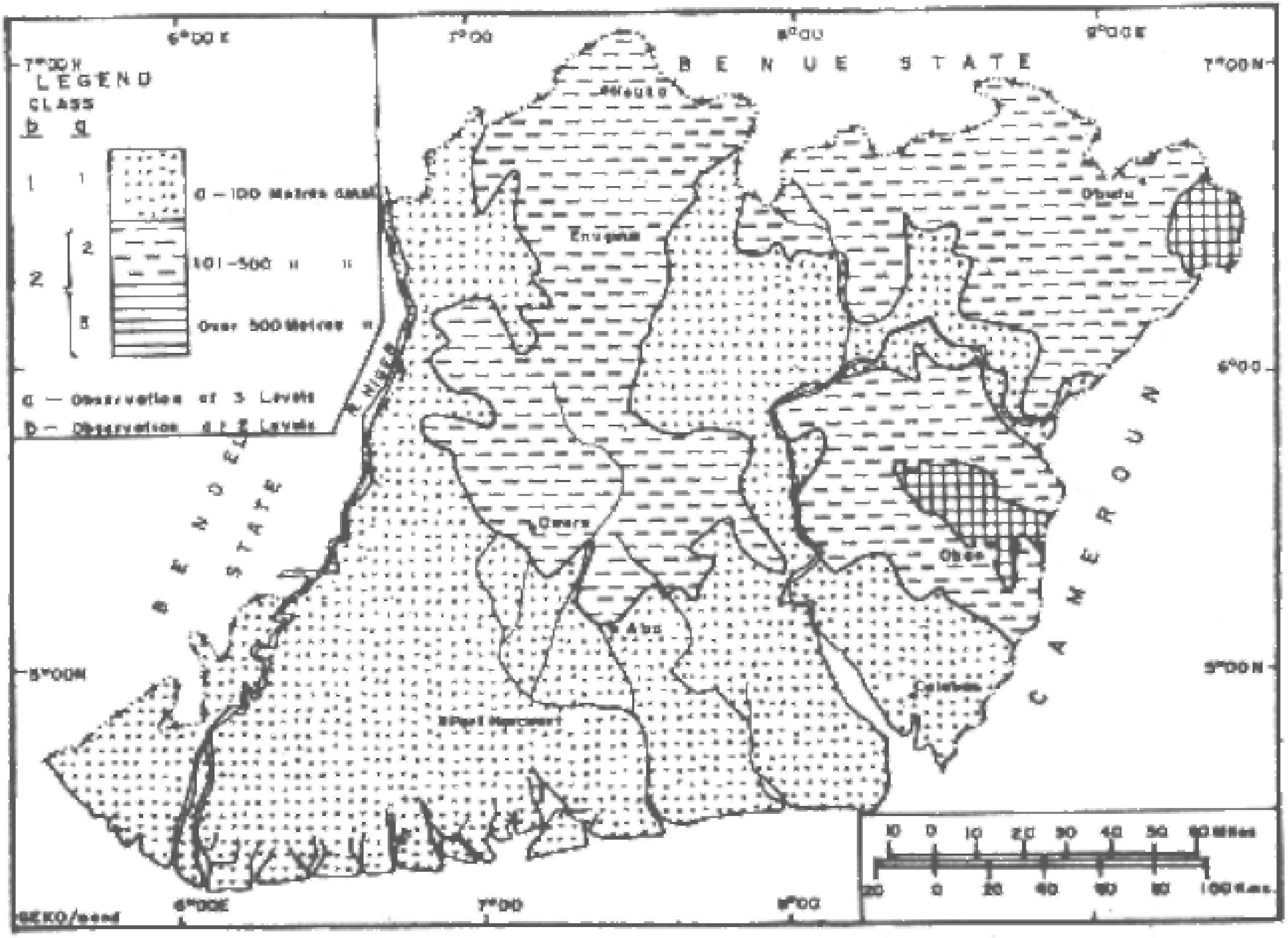


Fig.3: SOUTHEASTERN NIGERIA: RELIEF (X_2)

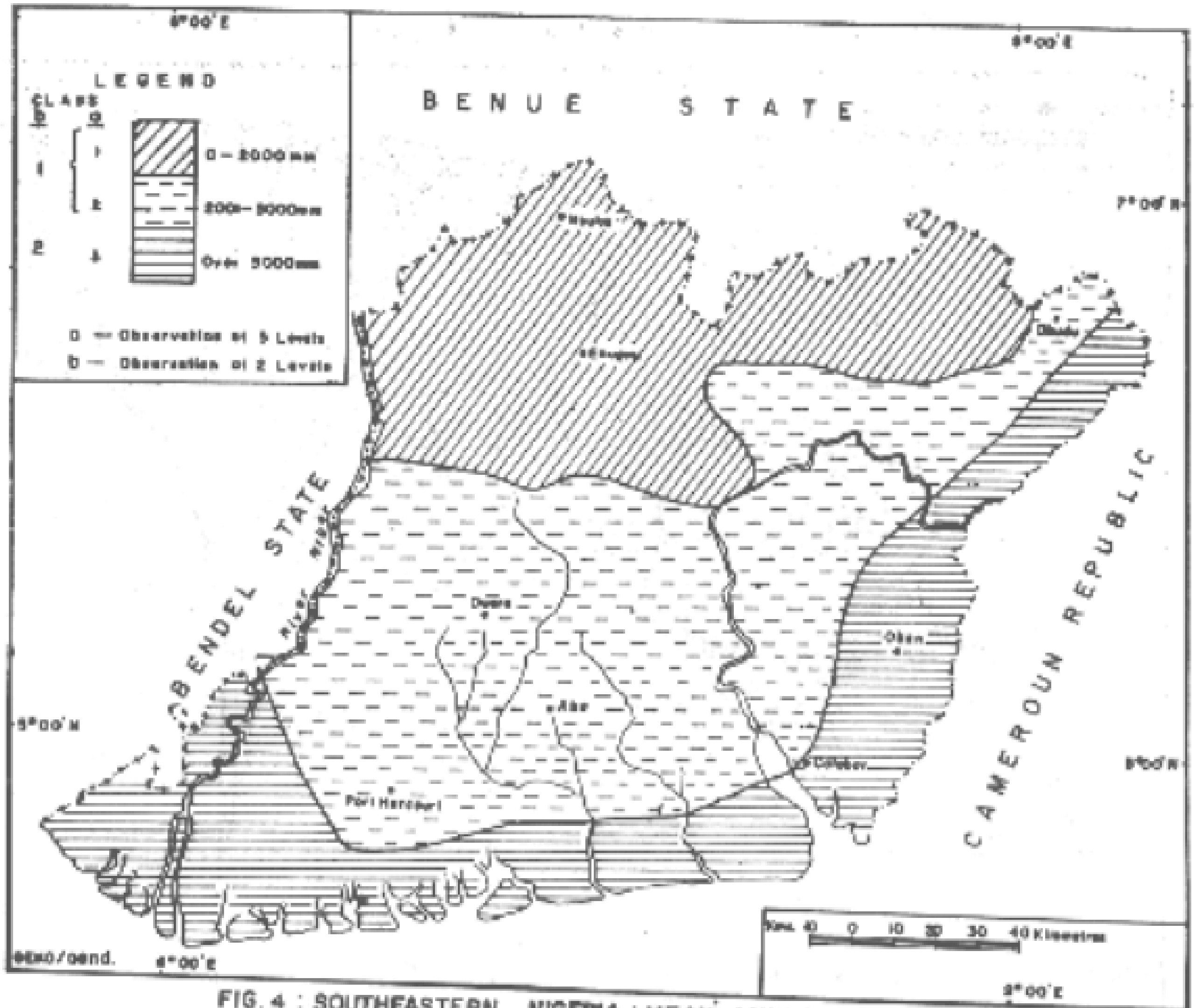


FIG. 4 : SOUTHEASTERN NIGERIA : MEAN ANNUAL RAINFALL (X_3)

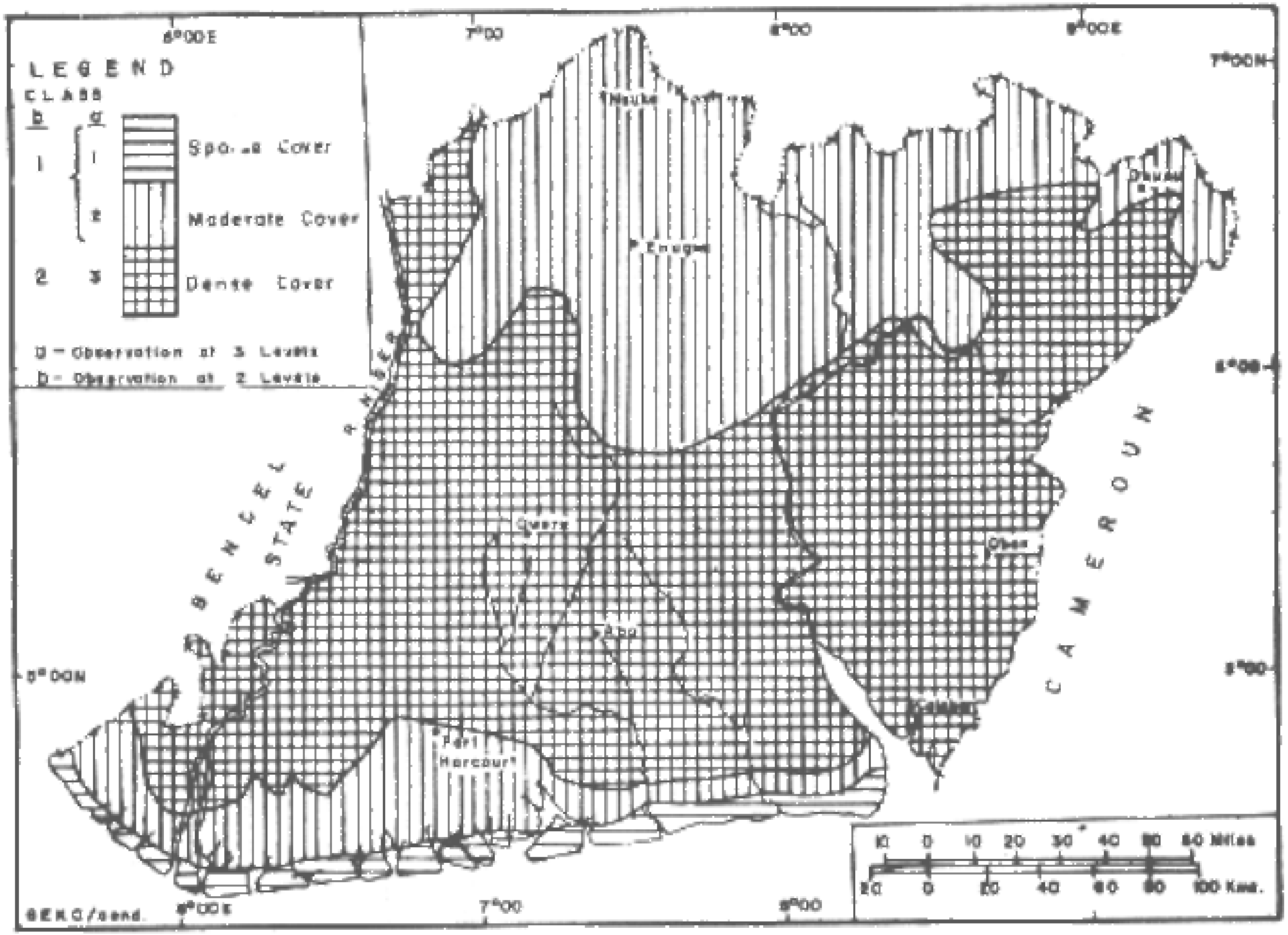


Fig. 5: SOUTHEASTERN NIGERIA: VEGETATION (X_4)

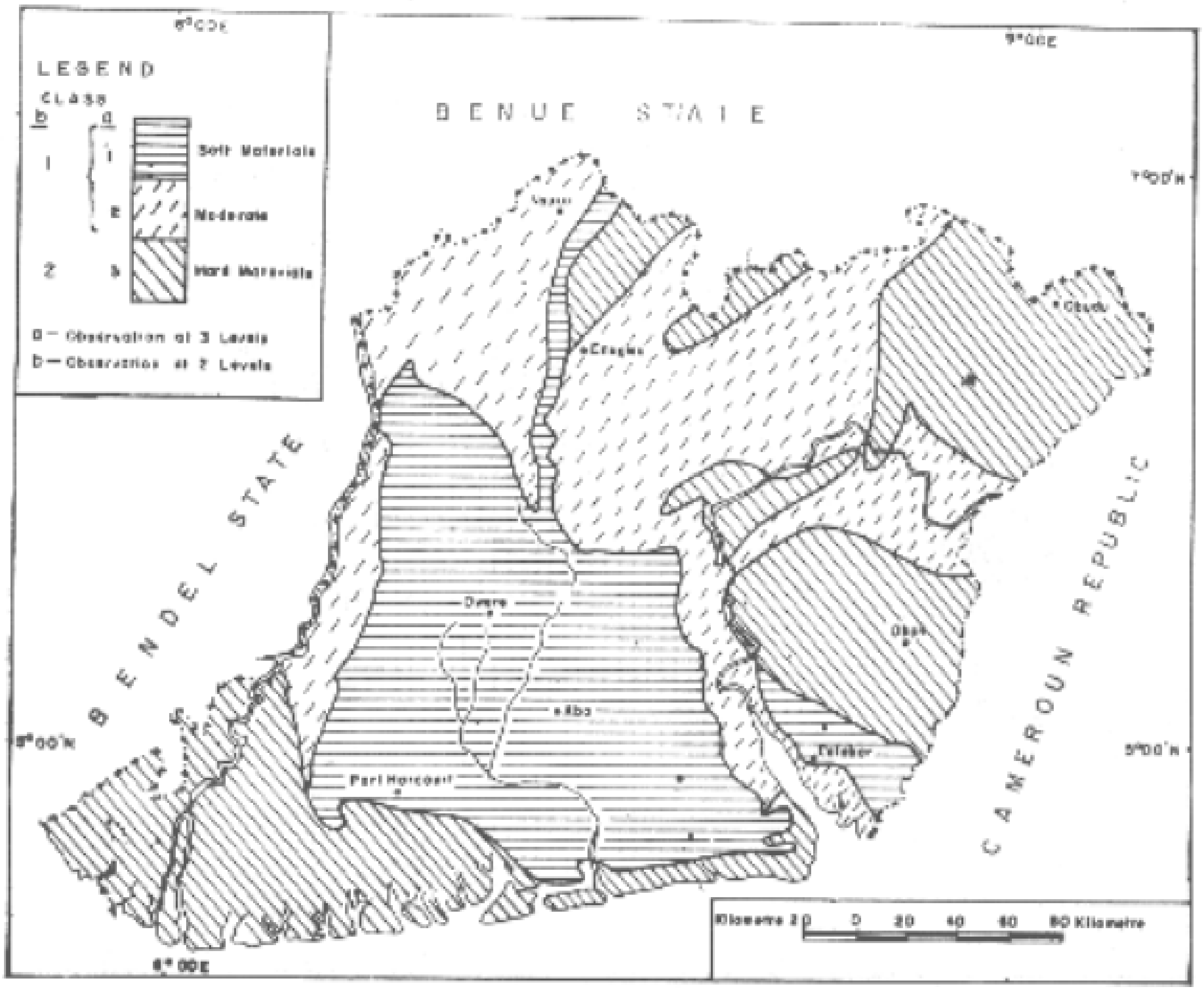


FIG.6 : SOUTHEASTERN NIGERIA : SURFACE MATERIALS (X_5)

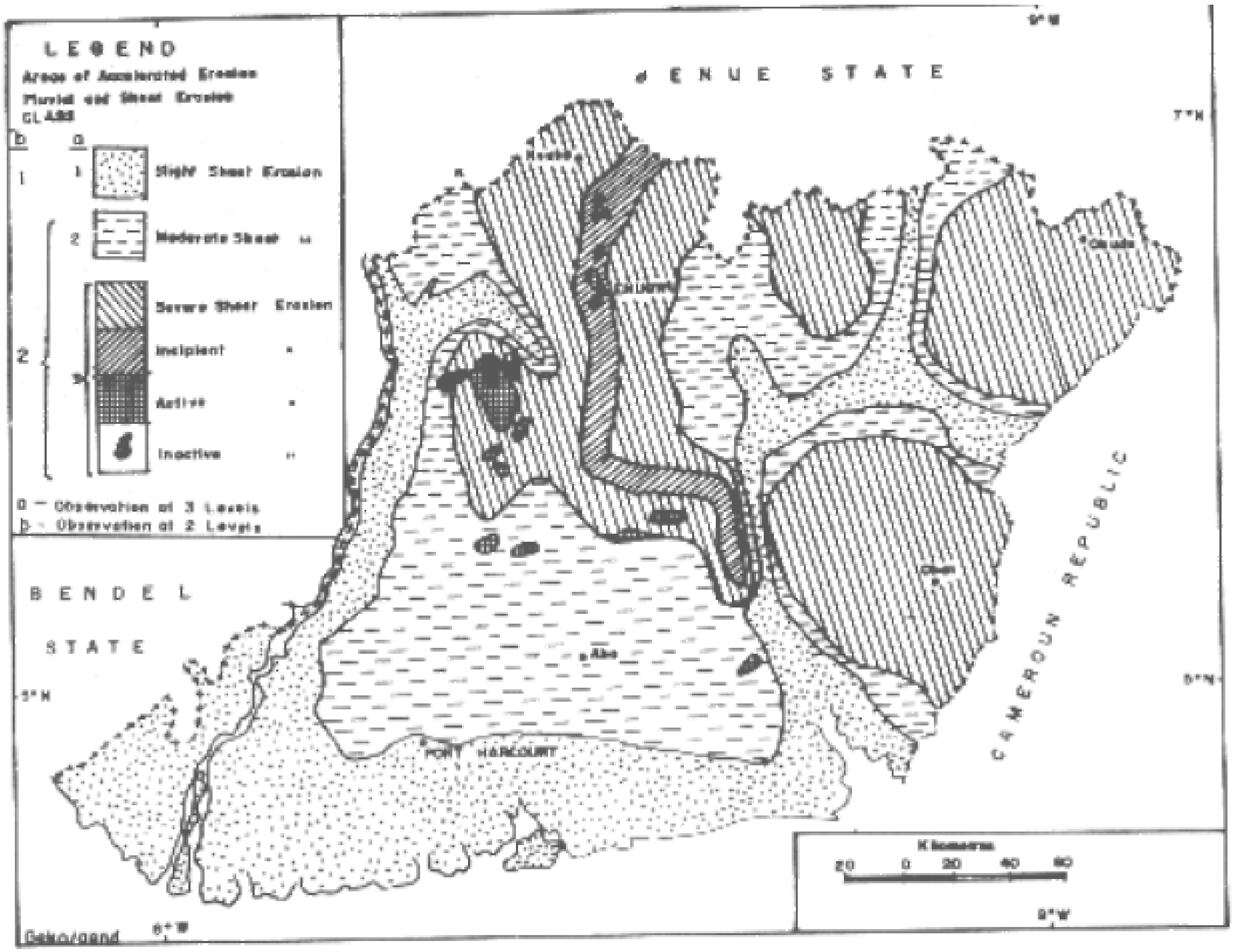
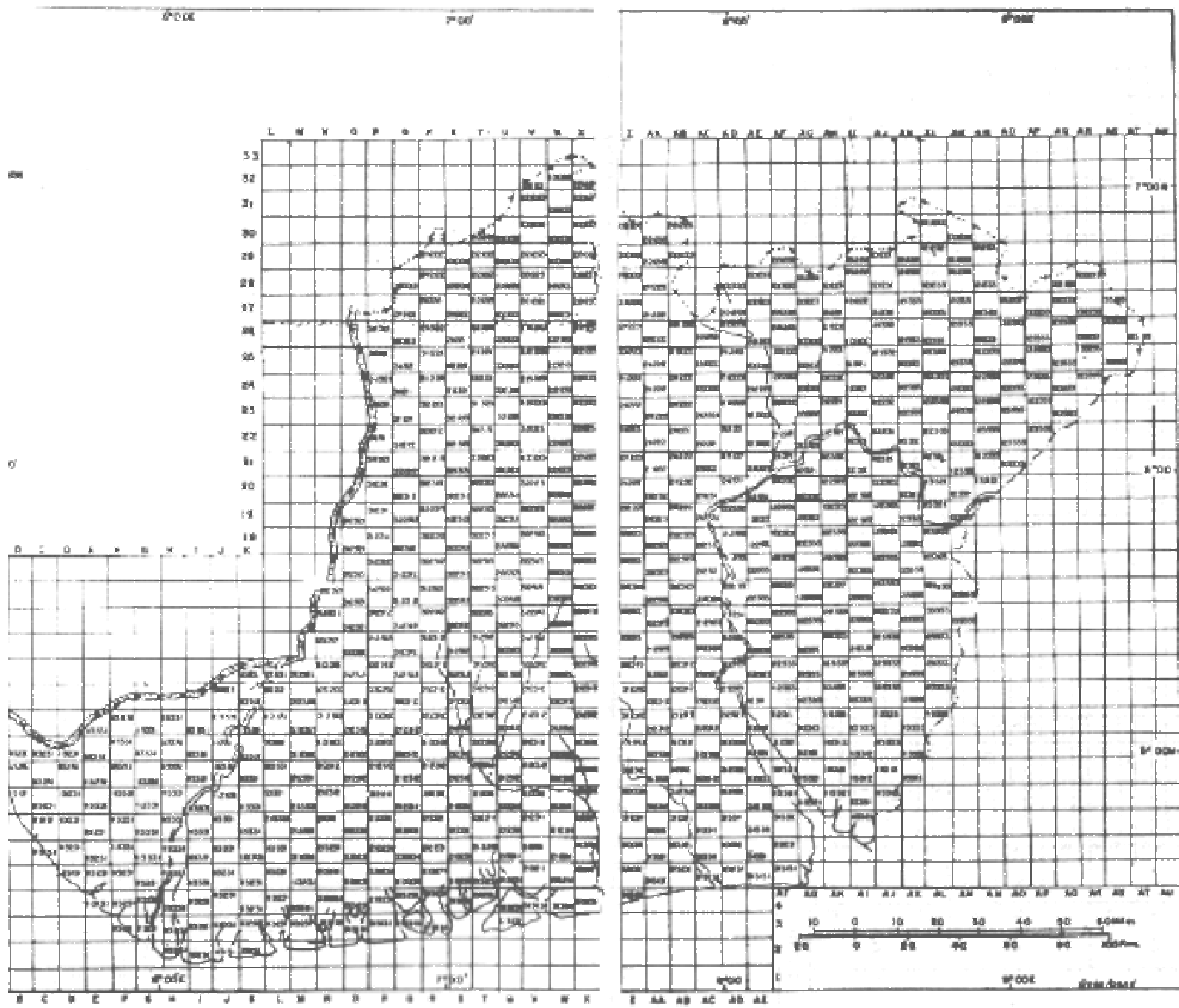


Fig. 7 : SOUTHEASTERN NIGERIA : TYPES OF EROSION (Y)



6 CODED SOIL EROSION VARIABLES IN SOUTHEASTERN NIGERIA.

Table I : OBSERVED FREQUENCY AT THREE LEVELS

			X_1 1									2									3									
			X_2 1			2			3			X_2 1			2			3			X_2 1			2			3			
			X_3 1	2	3	X_3 1	2	3	X_3 1	2	3	X_3 1	2	3	X_3 1	2	3	X_3 1	2	3	X_3 1	2	3	X_3 1	2	3	X_3 1	2	3	
X_4 1	X_5 1	Y 1																							1					1
		2																												
		3																												
	2	Y 1																												
		2																												
		3													1															1
	3	Y 1			12									5									11							28
		2																												
		3																												
2	X_5 1	Y 1											3	4							2		3							12
		2											1											3						4
		3													11									2	1					14
	2	Y 1		3		1						3	5								4									16
		2			1	7						19	7		3	2					2									41
		3	1			2	1					9	3		52	5									5					78
	3	Y 1		1	34	1						1	9	14									4							64
		2		1		3						2			2															9
		3				7	4			1	4				16								1							33
3	X_5 1	Y 1		3	1								14	3							2	6	11							40
		2			5								49			5					1	40			4					104
		3		1	1								2	1		15					1	1		4	28					54
	2	Y 1		10	11			2					10								5	7	1							48
		2		3			2	3				2	5		1						3	4								23
		3		1			5	3					5			7								1	1					13
	3	Y 1		5	45							1	7	4		2														54
		2		3		2	2						2																	9
		3		5	11	11	32	23		2	11		1			4														100
TOTAL			1	36	121	34	46	33		3	15	37	123	31	86	38					20	59	31	10	39					763

Table 2 : OBSERVED FREQUENCY AT TWO LEVELS

			X_1 = 1							X_1 = 2							
			X_2 = 1			X_2 = 2				X_2 = 1			X_2 = 2				
			X_3 = 1		X_3 = 2	X_3 = 1		X_3 = 2		X_3 = 1		X_3 = 2	X_3 = 1		X_3 = 2		
X_4 = 1	X_5 = 1	Y = 1	0	(0)	0	0	(0)	0	0	17	(24)	7	0	(0)	0	24	24
		Y = 2	0	(1)	1	11	(11)	0	12	42	(42)	0	85	(85)	0	127	139 (163)
	X_5 = 2	Y = 1	4	(16)	12	1	(1)	0	17	10	(44)	34	0	(0)	0	44	61
		Y = 2	2	(36)	34	15	(19)	4	55	2	(3)	1	18	(18)	0	21	76 (300)
X_4 = 2	X_5 = 1	Y = 1	13	(25)	12	0	(2)	2	27	44	(59)	15	0	(0)	0	59	86
		Y = 2	5	(11)	6	7	(13)	6	24	113	(114)	1	66	(66)	0	180	204 (290)
	X_5 = 2	Y = 1	5	(50)	45	0	(0)	0	50	8	(12)	4	2	(2)	0	14	64
		Y = 2	8	(19)	11	49	(85)	38	104	3	(3)	0	2	(2)	0	5	109 (463)
TOTAL			37	(158)	121	83	(131)	48	289	239	301	62	173	(173)	0	474	763

The next step was to obtain the class frequencies. This was achieved t»y counting the number of times each six digit figure occurs in Fig. 8. This information is recorded in Table 1. A look at Table 1 shows that it is disconnected, and some of the class frequencies were rather low, such as would create problems for a meaningful analysis. To overcome this problem, two levels of each factor were merged to give 1 able 2.

As one of the aims of the research is to be able to predict the type of erosion based on the factors in operation, the sums of squares and the degrees of freedom due to these factors and their interactions were calculated and displayed in the ANOVA Table — Table 3.

Since the sum of squares due 10 the individual factors, two-and three-factor interactions accounted for well over 97% of the total variation atttributable to the response variable, the four- and five-factor interactions were confounded with the error component of the observations.

TABLE 3: ANOVA TABLE

S. V.		d.f.	SS	SS/TSS	Test
Population density	(x_1)	1	0.28	0.001	x_1^2 = 0.656
Relief	(x_2)	1	85.90	0.264	x_2^2 = 201.26**
Rainfall	(x_3)	1	44.48	0.137	x_3^2 = 104.22**
Vegetation	(x_4)	1	0.60	0.002	x_4^2 = 1.406
Surface Materials	(x_5)	1	9.47	0.029	x_5^2 = 22.19** 43%
x_1x_2		1	1.61	0.005	x_{12}^2 = (3.77)
x_1x_3		1	30.29	0.093	x_{13}^2 = 70.97**
x_1x_4		1	3.32	0.010	x_{14}^2 = 7.78**
x_1x_5		1	27.83	0.086	x_{15}^2 = 65.21**
x_2x_3		1	11.09	0.034	x_{23}^2 = 25.98**
x_2x_4		1	0.57	0.002	x_{24}^2 = 1.34
x_2x_5		1	10.17	0.031	x_{25}^2 = 23.83**
x_3x_4		1	0.41	0.001	x_{34}^2 = 0.96
x_3x_5		1	14.72	0.045	x_{35}^2 = 34.49**
x_4x_5		1	4.72	0.015	x_{45}^2 = 11.06** 75%
$x_1x_2x_3$		1	6.71	0.021	x_{123}^2 = 15.70**
$x_1x_2x_4$		1	10.61	0.033	x_{124}^2 = 34.83**
$x_1x_2x_5$		1	6.70	0.021	x_{125}^2 = 15.68**

$x_1x_3x_4$	1	3.71	0.011	x^2_{134} = 6.68**
$x_1x_3x_5$	1	13.53	0.042	x^2_{135} = 31.66**
$x_1x_4x_5$	1	2.45	0.008	x^2_{145} = 5.73*
$x_2x_3x_4$	1	9.97	0.031	x^2_{234} = 23.33**
$x_2x_3x_5$	1	6.80	0.021	x^2_{235} = 15.91**
$x_2x_4x_5$	1	8.07	0.025	x^2_{245} = 18.88**
$x_3x_4x_5$	1	2.68	0.008	x^2_{345} = 6.27* 97%
Error, made up of four and five – factor interactions	737	8.55		
Total	762	325.24		

S.V. stands for source of variation;

d.f. stands for degree of freedom:

SS = Sum of Squares;

TSS = Total Sum of Squares.

x^2_1 is the computed value for the effect of the factor x_1, etc.

x^2_{12} is the computed value for the effect of the two-factor interaction between x_1 and x_2, etc.

x^2_{345} is the computed value of the effect of the three-factor interaction between x_3, x_4 and x_5, etc.

For the algebraic expression of these quantities, refer to Onukogu (1984).

*implies significance at 5% level of error, where $x^2\ (1, 0.95) = 3.84$ is the value of the chi-square statistic with one d.f. and 5% level of error.

**implies significance at 1% level of error, where $x^2\ (1, 0.99) = 6.63$.

Based on the above tests, we propose the model:

$$
\begin{aligned}
Y_{ijkstu} = Y_{ijkst}(&M_u + x_{2(ju)} + x_{3(ku)} + x_{5(tu)} + x_{12(iju)} \\
&+ x_{13(iku)} + x_{14(isu)} + x_{15(itu)} + x_{23}(jku) + x_{25(jtu)} \\
&+ x_{35(ktu)} + x_{45(stu)} + x_{123(ijku)} + x_{124(ijsu)} \\
&+ x_{125(ijtu)} + x_{134(iksu)} + x_{135(iktu)} + x_{145(istu)} \\
&+ x_{234(jksu)} + x_{235(jktu)} + x_{245(jstu)} + x_{345(kstu)} \\
&+ E_{ijkstu}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)
\end{aligned}
$$

where

Y_{ijkstu} is the observed frequency for the uth type of erosion (y) arising from the ith level of population density (x_1), jth level of relief (x_2), kth level of rainfall (x_3), sth level of vegetation (x_4), and tth level of surface materials (x_5).

M_u is a constant for the uth level of erosion.

$x_{2(ju)}$ represents the mean effect of the jth level of relief (x_2) at the uth level of erosion (y), etc.

$x_{12(iju)}$ represents the interaction between the ith level of population density (x_1), jth level of relief (x_2) at the uth level of erosion (y), etc.

$x_{123(ijku)}$ represents the interaction between the ith level of population density (x_1), jth level of relief (x_2) and kth level of rainfall (x_3) at the uth level of erosion (y), etc.

As can be observed from the sum of squares of the various factors, the model accounts for over 97% of the total observed variation and, therefore, can be used to give a good prediction of erosion in the area under study.

A general regression model for the data could be written as follows:–

$$Y_{ijkstu} = Y_{ijkst}\ (M_u + b_{1u}x_{1(iu)} + b_{2u}x_{2(ju)} + b_{3u}x_{3(ku)} + \ldots\ldots\ldots + b_{13u}x_{13(iku)} + b_{14u}x_{14(isu)} + \ldots\ldots + b_{125u}x_{125(ijtu)} + \ldots + E_{ijkstu} \quad (2)$$

where M_u is a universal constant for the uth level of erosion and b_{mu} (m=1,2,3,4,5) are coefficients representing the rate of change of a particular factor with respect to the type of erosion.

After estimating the coefficients, we have the model as shown below:

$$\begin{aligned} Y_{ijkst1} = Y_{ijkst}\ (&0.32 - 0.09x_{1(i1)} + 0.27x_{2(j1)} - 0.045x_{3(k1)} - 0.068x_{4(s1)} \\ &-0.058x_{5(t1)} + 0.035x_{13(ik1)} - 0.046x_{14(is1)} + 0.062x_{15(it1)} \\ &-0.064x_{23(jk1)} - 0.045x_{25(jt1)} - 0.07x_{35(kt1)} - 0.03x_{45(st1)} \\ &+0.078x_{123(ijk1)} - 0.065x_{124(ijs1)} - 0.066x_{125(ijt1)} + 0.047x_{134(iks1)} \\ &+0.038x_{135(ikt1)} - 0.04x_{145(ist1)} + 0.033x_{234(jks1)} - 0.003x_{235(jkt1)} \\ &-0.042x_{245(jst1)} - 0.012x_{345(kst1)} + E_{ijkstu}) \quad (3) \end{aligned}$$

and

$$Y_{ijkst2} = Y_{ijkst}\ (0.49 + 0.15x_{1(i2)} - 0.15x_{2(j2)} + 0.147x_{3(k2)} + 0.006x_{4(s2)}$$

$$
\begin{aligned}
&-0.057x_{5(t2)} - 0.16x_{13(ik2)} + 0.015x_{14(is2)} - 0.093x_{15(it2)} \\
&-0.03x_{23(jk2)} - 0.08x_{25(jt2)} + 0.007x_{35(kt2)} + 0.03x_{45(st2)} \\
&-0.016x_{123(ijk2)} + 0.065x_{124(ijs2)} + 0.002x_{125(ijt2)} - 0.037x_{134(iks2)} \\
&-0.038x_{135(ikt2)} + 0.061x_{145(ist2)} - 0.095x_{234(jks2)} \\
&-0.06x_{235(jkt2)} - 0.042x_{245(jst2)} + 0.012x_{345(kst2)} + E_{ijkstu}) \ldots\ldots\ldots\ldots (4)
\end{aligned}
$$

This 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 ^e variables, relief accounts for about 26% of variations in the type of soil erosion, against 14% by rainfall, 3% by surface materials, and almost zero percent (actually 0.1% and 0.2% 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, 1967). Further analysis reveals that the single factors together contribute about 43% of the variations in soil erosion; up to two factor interactions contribute about 75%, while up to three factor interactions contribute about 97% of variations in soil erosion.

It is clear from equation (3) that, at the first level of erosion, only relief (x_2) has a positive correlation with soil erosion, while all the other independent variables have a negative correlation with the phenomenon. In many respects, this observation is contrary to what is expected in the environment of Southeastern Nigeria where, in addition to relief (x_2), population density (x_1) and rainfall (x_3) are also expected to have a positive correlation with soil erosion. A possible explanation for the existing relationships may be that man's impact is not yet sufficiently felt at this level of erosion, while the observed relationship between rainfall and soft erosion at this level is attributable to the influence, of lithology (Ofomata, 1967).

At the second level of erosion, equation (4) reveals that population density x_1 rainfall (x_3) and vegetation (x_4) all have positive correlations with soil erosion while relief (x_2) and surface materials (x_5) have a negative correlation with erosion. This observation accords with what is expected in the environment of Southeastern Nigeria, except in the case of relief (x_2) and vegetation (x_4) However, it would appear that the paramountcy of relief (x_2) as a factor of soil erosion in the area is optimal for the lower class of erosion while, at the second level of erosion, the influence of lithology becomes more important. The positive correlation between vegetation and soil erosion would appear insignificant when one considers the magnitude of the anticipated increases.

An obvious implication of the model (Fig. 1 and equation 1) is that the phenomenon of soft 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 die 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 later in the discussion as a necessary condition for fighting the menace of soil erosion.

No one could reasonably deny the possible contributions human activities make to the development of soil erosion, and we have discussed aspects of these contributions already. Nor could it be contended that different methods of land use and the level of technology of land users necessarily affect the soil differently. 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 Nigeria are not human; that the main contribution of man to the inception and development of the various forms of erosion in the country is essentially one of complicating and accelerating an inherent problem rather than provoking it, given that the environment is one whose physical characteristics are totally disposed to the evolution of the worst types of erosion. However, man's role is a more recent and. easily decipherable phenomenon than that of geologic erosion, which Is why his role readily attracts attention.

TYPES OF *EROSION*

The types of erosion in Nigeria would be better appreciated if we consider them under the two broad subheadings of *actual erosion* and *potential erosion.* The import of this approach is to ensure that while we engage in activities aimed at combating existing forms of erosion, we do not lose sight of the great potentialities of the problem that could erupt any time under inadequate management strategies. Thus, while tackling what is, we guard against that which is likely to be!

Actual Erosion

Fig. 9, which is an outline map of soil erosion, shows the general state of actual erosion in the country and is based on the current state of our knowledge on the subject.

The gully types are the more obvious forms of erosion in the country, mainly because of the remarkable impression they leave on the surface of the earth. They are also a visible manifestation of the physical loss of the land due to erosion. Good examples of gullies are widespread in Nigeria, especially in the Agulu-Nanka (Plate 1), Obioma, Nsuka, Alo, Nnobi, Nnewi, Olu, Ozuitem, Abiriba, Ohafia, Uruala, Amucha and Uyo areas of Southeastern Nigeria. Other examples, but on a much smaller scale, exist on the Jos Plateau, especially in Heipang (Plate 2), around Zaria, in Ankpa and at Auchi. Yet, gully erosion is only one aspect of the soil erosion phenomenon, and one which has affected the smallest area of land in the country. In the particular case of Southeastern Nigeria, active gully erosion presently affects only about 0.60% of the total land area, while all types of gully erosion occupy a little less than 2%. The situation is worse in Omambala and Imo States, where comparable figures are 1.90% (active) and 5.40% (all types).

Much more pernicious and highly detrimental to agriculture is sheet erosion which often goes on unnoticed due to its gradual, constant and uniform action, but which finally results in a. complete removal of arable parts of the soil. Through this action of sheet erosion, the topsoil is gradually swept clear of its finer elements and plant nutrients, and only coarse, infertile materials are left behind (See Table 4).

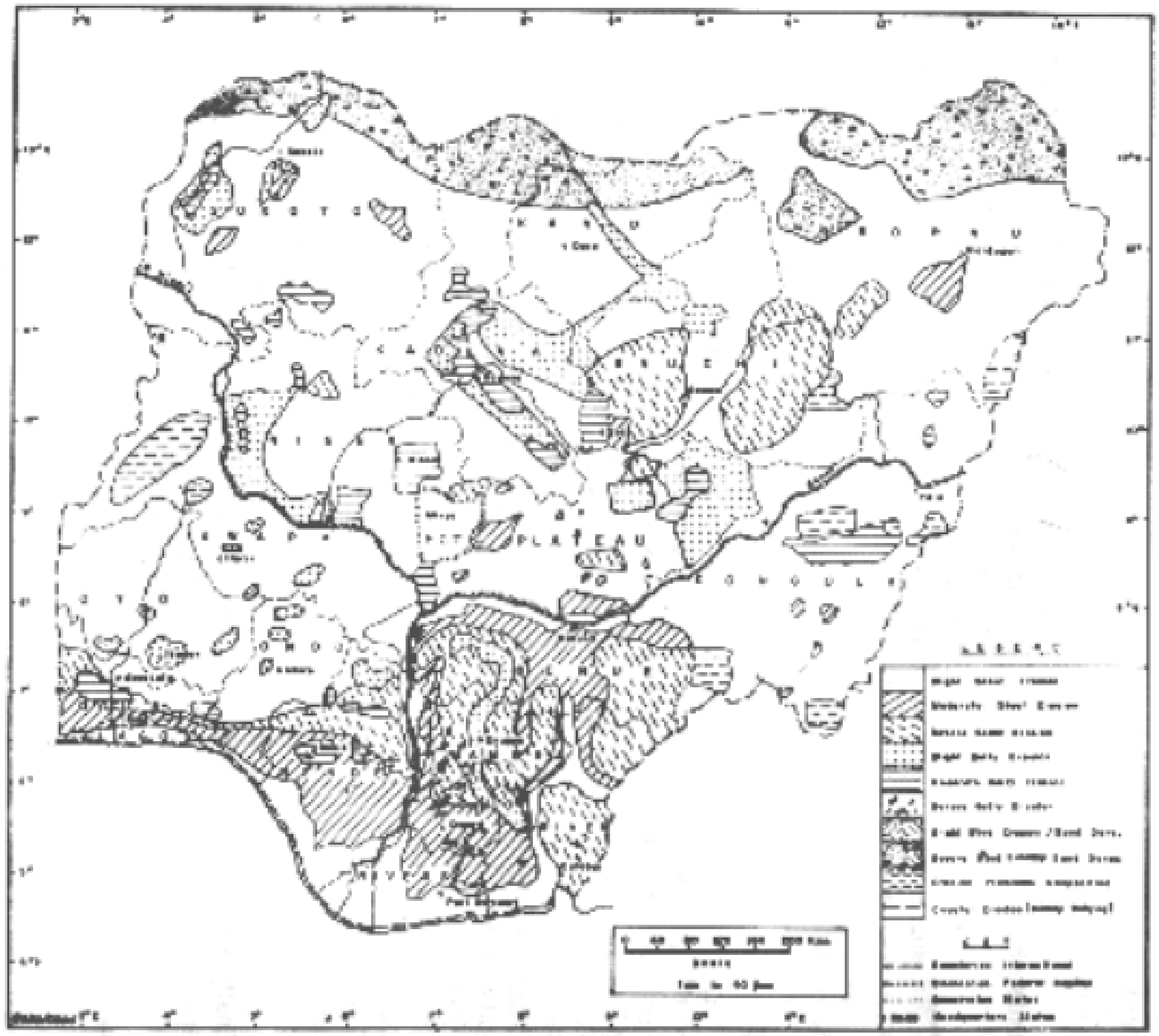


Fig. 9 SOIL EROSION MAP OF NIGERIA

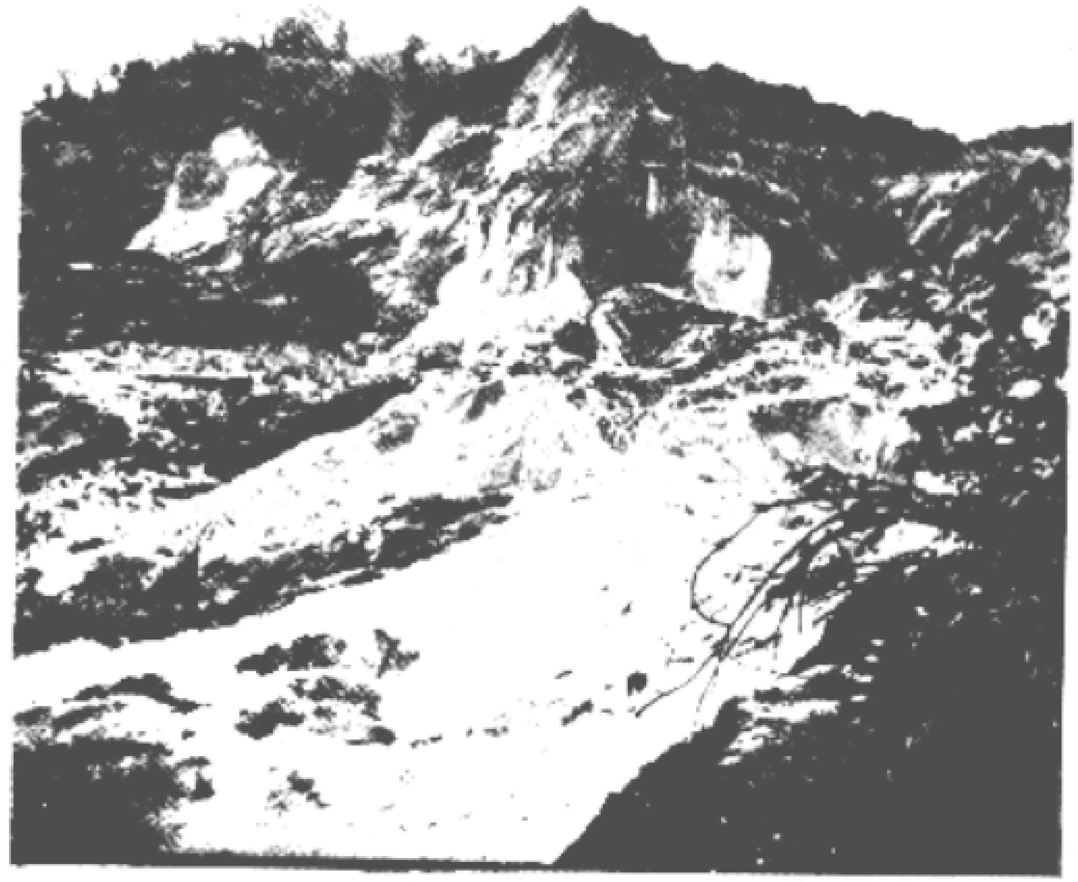


Plate 1: Gully Erosion at Agulu, Eastern Nigeria

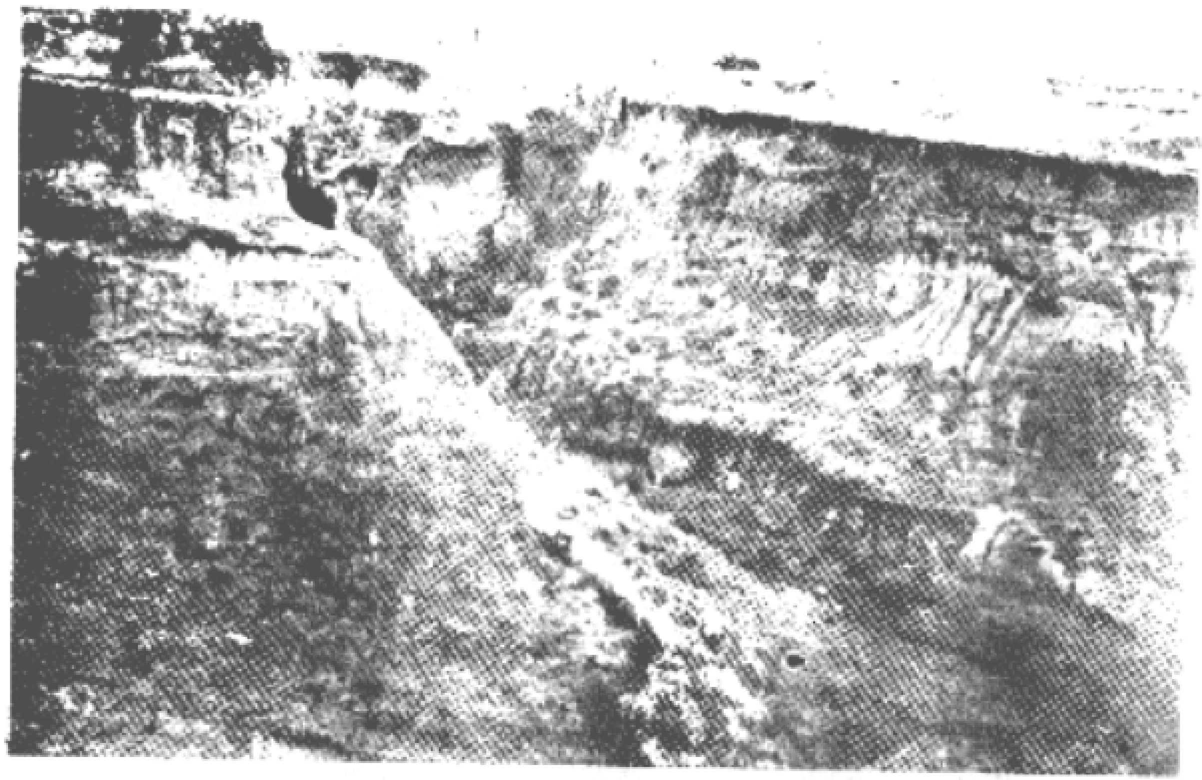


Plate 2: Gully Erosion at Heipang, Jos Plateau, Nigeria

Table 4: Granulometrical Composition of Typical Soil Samples in Omambala State

Sample		Fine Sand %	Medium-grained sand %	Coarse Sand %	Clay & Silt %
N62/1A (Nsuka)	(a)	26.95	46.13	7.63	19.3
	(b)	26.5	42.7	8.75	21.9
	(c)	24.0	40.15	10.05	25.2
N62/111A (Udi)	(a)	12.8	63.6	18.8	4.2
	(b)	13.2	65.8	16.92	3.9
	(c)	17.27	49.85	17.10	14.9
N62/IVA (Agulu/ Nanka)	(a)	14.2	56.0	21.95	7.85
	(b)	10.85	56.05	22.90	9.50
	(c)	9.75	39.0	20.65	30.1
N62/IVB (Agulu)	(a)	18.50	54.45	12.30	14.0
	(b)	14.45	48.0	24.10	13.05
	(c)	10.25	43.45	21.80	23.55

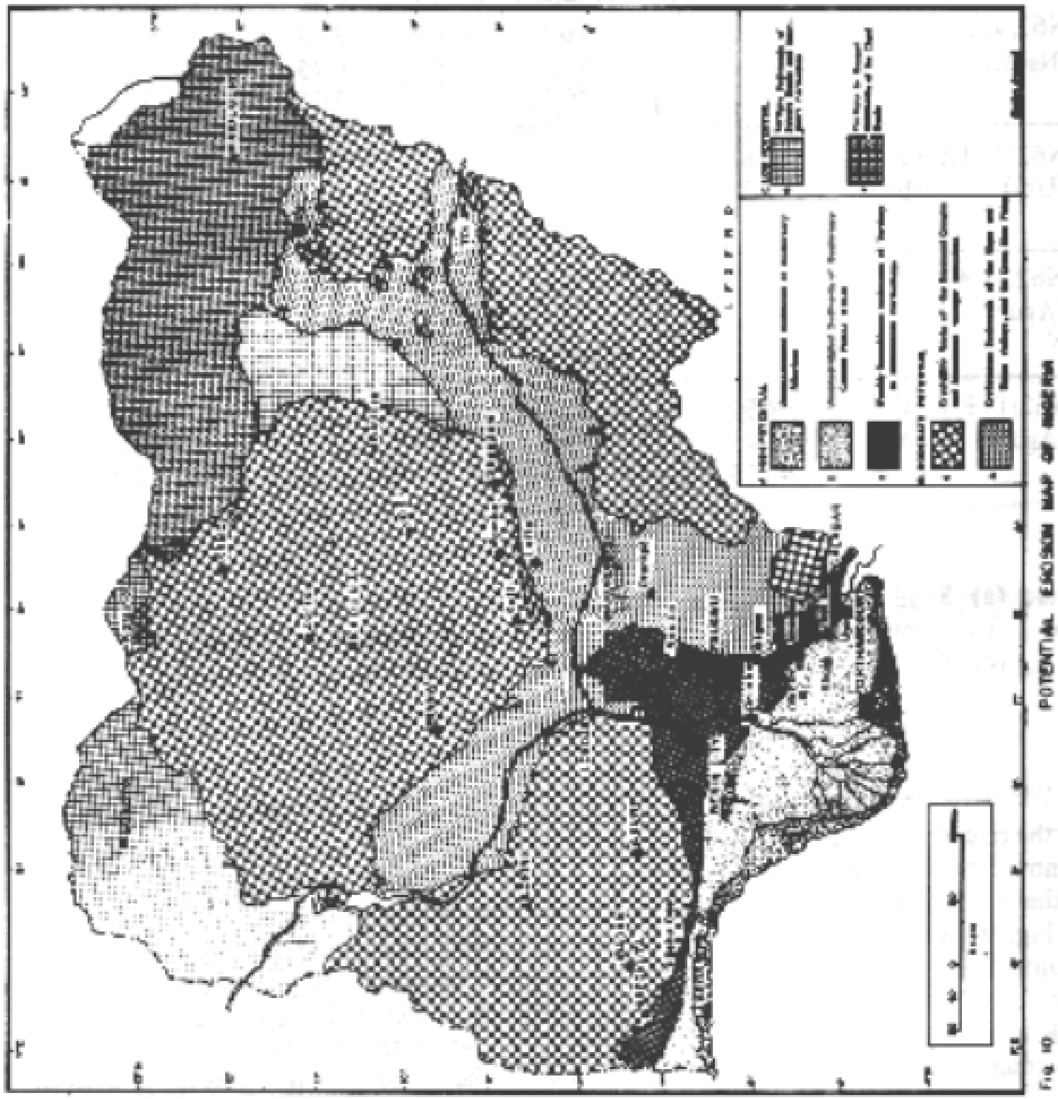
Note: (a) Signifies that sample conies from the surface.
(b) Signifies that sample comes from a depth of some 10 cm beneath the surface.
(c) Signifies that sample comes from a depth generally of over 1.2m.

Wind erosion occurs more generally and more frequently in the extreme northern parts of-the country, but is limited in both time and space in other parts. Some of the materials removed by the wind reach the southern parts of the country by way of dust-laden winds - the North Easterly Trades - especially during the period of the harmattan.

Pig. 9 also reveals that sheet erosion is the most widespread type of erosion in the country, and that every part of Nigeria is affected by one form of erosion or the other. The figure further reveals that erosion in four States - Borno, Kaduna, Kano and Sokoto - is a result of the combined effect of wind and water action, while the other parts of the country are affected by erosion due mainly to the action of running water.

Potential Erosion:

A potential erosion map of Nigeria is embodied in Fig. 10. The map reveals that ill part of the country are susceptible to erosion of varying types and degrees. Generally, three degrees of susceptibility to erosion could be identified: high susceptibility; moderate susceptibility, and low susceptibility. The map is adapted and modified from a preliminary "Map of Nigeria showing erosion susceptibility", produced by the Geological Survey of Nigeria as GSN 2215.



The three major categories of susceptibility are based on the underlying geology of the areas, and subdivided into seven classes.

A, Areas of *High Susceptibility* to erosion are subdivided into three, as follows:

1. Areas of unconsolidated sediments of Quaternary alluvium, abandoned beach ridges, meander belts, back and fresh water swamps, and mangrove swamp formations of the coastline, subject mainly to severe coastal erosion, essentially gullying.
2. Areas of unconsolidated sediments of the Quaternary. Coastal Plains Sands, meander belts, back and fresh water swamps, and Sombreiro deltaic plain formation of the coastal plain. Generally, it is an area of low relief and affected by moderate to severe sheet erosion and varying degrees of gullying.
3. Areas of weakly consolidated sediments of the Tertiary to Cretaceous Lignite formation, the

Bende-Ameke and Imo Clay-Shale groups, the False-bedded sandstones, the Upper and Lower Coal Measures. The area is subject mainly to severe sheet erosion and gullying, with the highest concentration of severe gully erosion in the country. The famous Agulu-Nanka gullies are located in this area; so are most of the other menacing gullies in Omambala and Imo States.

B. Areas *of Moderate Susceptibility to erosion* fall into two groups:

4. Areas of crystalline rocks of the Pre-Cambrian to Paleozoic Basement Complex, and its associated younger intrusive igneous rocks, They are generally areas of high relief, subject mainly to severe sheet erosion and gullying, with gullying concentrated in the mantle of weathering, or on mine spoils around Jos.
5. Areas of well to moderately consolidated Cretaceous Sediments of the Niger and Benue valleys and the Cross River Plains. They are generally of low to moderate relief and subject mainly to moderate sheet erosion and localised slight to moderate gullying. The gullying component if an aspect of routine geological erosion, and is concentrated mainly along the river valleys.
6. C. Areas of Low *Susceptibility to erosion* also fall into two groups:
7. Areas of weakly consolidated Tertiary Sediments of Sokoto Basin and the Kerri-Kerri formation, subject mainly to wind erosion, with some sheet erosion and isolated cases of slight to moderate gullying.
8. Areas of unconsolidated Tertiary to Recent Sediments of the Chad **Basin,** of generally low relief and subject mainly to wind erosion and some sheet erosion.

This is only a brief outline of potential erosion in Nigeria and further study is necessary to update the information available to us on the subject.

CONSEQUENCES OF SOIL EROSION

No matter the type of soil erosion in any given location, the *consequences,* in terms of what is relevant to soil conservation, are two-fold: general decrease in soil fertility (as a result of the action of sheet and/or wind erosion), and diminution of cultivable land as a result of the occurrence and expansion of gullies. The latter consequence has wider implications which include displacement of population following loss of residential houses and farm crops (Ofomati, 1964**,** 1973), changes in the topography and hydrology of affected areas, and disruption of roads, such as at Ngwo Agu (Plates 3 and 4) and at Agulu (on the Agulu-Ogbu road).

This brief mention of the consequences of soil erosion leads us to a consideration of erosion control measures in the country.

Plate 3: A gully cuts through to the middle of a road, Ngwo Agu, near Enugwu, Nigeria (9 June 1982)

Plate 4: A gully (plate 3) completely cuts off a road at Ngwo Agu, near Enugwu, Nigeria.
(20 September, 1982)

EXISTING S OIL CONSERVATION MEASURES

The need to arrest the wasteful trend in soil loss has been widely recognised and various soil conservation measures have been taken at various levels to deal with me problem. These measures have been mostly curative and preventive. On the curative side, the two lines of action depend on whether the type of erosion involved is gullying, sheet or wind erosion. On gullies, the attempt has always been to prevent as much runoff as possible from reaching the gullies, as well as to stabilise the slopes. A combination of afforestation, ridging, contour ploughing, bunding, the construction of side-drains leading to soak-away pits (sumps) and the construction of concrete structures and drainage channels has usually been applied. On sheet erosion, the emphasis is co reducing the extent of bare soils in any area and by planting such areas to grasses, such as bahama grass and shrubs, such as *Acioa barteri*, as well as other local varieties. Wave-bedding is also important to either of the above measures. In the case of wind erosion, emphasis is again on limiting the extent of bare soils and providing wind breaks (trees, shrubs^ etc.) to check the process.

On the preventive side, where the incidence of erosion is either not known or not yet serious, a number of measures are taken in addition to the above simple curative devices to check the inception of soil erosion. These other measures include limitation of the extent of forest degradation by evolving a system of cultivation which will always ensure that the ground surface is under effective cover of vegetation; controlling the extent and timing of bush burning; adaptation of contour ploughing; introduction of inter and multiple cropping and effective use of cover crops; zoning and controlling the use of pastures.

Most of the methods outlined above have been employed to combat the soil erosion menace in various parts of the country, but, so far, there is no clear indication of success from these efforts. On the contrary, the attempts seem to have failed, at least in large measure. This creates a rather disturbing situation that calls for a reassessment of our erstwhile soil conservation measures and emphasises the need to formulate a co-ordinated and sustained management strategy to deal with the- problem.

RECOMMENDED MANAGEMENT STRATEGIES

It should be clear by now that soil erosion is a disastrous form of environmental degradation and, for greater effectiveness, the best way to tackle it is to treat it as a vital component of the broad issue of environmental resource management in the country. An important objective of this management is to plan towards an improvement of the overall quality of the country's human environment, and such apian has greater chances to succeed if it is undertaken from the local level upwards

One of the reasons usually given for the failure of previous soil conservation measures in the country is that the farmers do not co-operate in the attempts, but are rather passive and apathetic to any plans aimed at combating soil erosion. They are accused of unwillingness "to adopt the procedures deemed necessary to heal the land". Infact, the ills of soil erosion are easily blamed on the so-called "bad farming techniques" of the affected communities. We know, however, that this is not all the story, nor infact its most important aspect. But, without going into the merits and demerits of such reasoning, we are of the view that the main reasons for the observed failures could be summarised under three broad headings: lack of communication between the Government and the people; inadequate knowledge of the environment, and exploitative excesses of the people.

Usually, the Government or its agencies/representatives hardly elicit the confidence of the local people in their erosion control efforts. This is an unfortunate state of affairs because we know that it is neither wise nor desirable to make plans for conserving the soil without fully involving those who are using, and *who* will continue to use the same soil. It should also be realised that before any reasonable fanner could be attracted to change his methods of cultivation, he must first be convinced of the need to change and be satisfied that the new methods to be adopted would lead to better results, usually translated to mean greater crop yields and, thereby, higher income. The fact that these requirements and assurances have never been guaranteed by our erstwhile soil conservation efforts reveals a lot about what has been wrong in the past and indicates possible positive steps to take in future projects. The least that could be said here is that the local people are as concerned as anybody else interested in the problem and should form part of any soil conservation movement? in their various localities. My personal experience with the people of Agalu in their erosion control efforts justifies this assertion!

Even more serious is the regrettable fact that our soil conservation efforts have so far not been based on in adequate knowledge of the environment. It should be dear that our soil conservation measures cannot succeed when we are still ignorant of tropical soils, tropical agriculture and tropical forestry. A salient aspect of the situation is illustrated by the fact that we do not exactly know the cover crop*, shrubs and plants best suited for effective conservation of our soils. At least, it is lick of this vital knowledge that has led to the utilisation, of cashew ties *(Anacardium occidentale)* as part of the soil conservation efforts in the vicinity of Agulu-Nanka gullies of Omambala State and elsewhere, when it is clear that these trees are unsuitable for such purposes, as they neither hold the soil in place nor encourage the thriving of undergrowths to form a protective cover for the soils. The same state of mind leads to the usually haphazard and adhoc construction of concrete structures and improperly located drainage channels as means to control/prevent gullying, but which end up creating more problems than they were intended to solve. Gullies usually intensify their activities in the wake of the building of such structures, contrary to expectation, but which will not surprise any one familiar with the dynamics of gullying. The examples of Ngwo and along the New Opi-9th Mile Corner road bear eloquent testimony to this observation.

On the exploitative excesses of the people, there is need for effective regulation to govern the conduct of human activities, especially in connection with agricultural, mining, industrial and related practices. For instance, there should be a limit to the extent and timing of bush burning, which remains an important aspect of the agricultural practices of the people. Rush burning should be confined to the beginning of the dry season (or end of the rains), as such an activity in the middle of the dry season is dangerous. It is equally important to restrict cultivation near gully edges. It is suggested that cultivation should not be allowed within a radius of 0.5 to 1 km, or at conveniently shorter distances from the edges o£ existing gullies, in order to give soil conservation measures a chance to succeed. In the same way, free movement of animals has to be regulated so that pasturage does not disrupt what is expected to be gained through controlled cultivation. Equally, the movement of the herds of the cattle Fulani should be controlled. In this regard, effort should be made to demarcate grazing grounds to avoid indiscriminate grazing at all times and in all places. Some form of schedule of use of the demarcated zones should be. worked out in such a way as to avoid unnecessary hardship for the herdsmen and their herds, while ensuring maximum protection for the land. In those parts of the country, such as the Agulu-Nanka area, where foot-paths (over steep gully slopes) are still used to fetch water from the gully depths, effort should be made to provide the communities with pipe-borne water. This is the only way to minimise, if not completely halt, the frequent use of such foot-paths, as this latter practice aids expansion of the gullies through headward erosion and lateral extension.

The easiest suggestion to make in order to limit the consequences of the modification of the environment arising from mining is not to mine at all. It is recognised, however, that this is an impossible proposition, since the products of such 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, back-filling, levelling and burying of toxic materials, and revegetation. Revegetation on many mine 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.

Road building, urbanization and industrialization are all areas of land use that are complete and final in their impact on the environment (Ofomata, 1981c). The complete removal of vegetation associated with these activities leaves bare surfaces behind, a direct consequence of which is soil erosion. Road-side erosion constitutes a major threat on most of our roads, notably on both sides of the Nsuka - Enugwu road (especially at Umulumgbe, Abo, Ngwo and Milliken Hill), the Onicha-Owere road, some sections' of the Benin-Ore road, and in several places along the Calabar-Ikom road. It is time that our road builders begin to think about the consequences of their action and take geomorphological. factors into account while executing their projects, which constitute a major modification on the surface of the earth. For one thing, road-side drainage channels should be properly located and routinely maintained to avoid such costly and nasty experiences as those of Ngwo Agu. Revegetation of bare areas along the road and where earth had been dug for road filling and surfacing is equally recommended.

Finally, the loss due to erosion and increasing demand made on the land by agriculture, urban growth, industrialisation and other human activities make the need for integrated landscape planning urgent. What is required is the creation of a forum where thought should be harmonised and an adequate strategy formulated to conserve our land resources through a co-ordinated and sustained land-use programme. For maximum effect, we believe that this should be done within the broader issue of environmental resource management in *the* country, an important aspect ,of which is effective soil conservation. Because of the ramified nature of environmental issues and the need for integrated approach in dealing with such issues, we recommend, as we have done elsewhere (Ofomata, 1980 and 1981 a), the establishment of a *National Environmental Protection Council* (or *Commission),* preferably headed by an executive chairman, to advise on and oversee the various uses and abuses of the environment. The *National Committee on Soil Conservation* (established in 1978) should constitute an important arm of the proposed *Council* and it is strongly recommended that the *Committee* be enabled to function effectively through the provision of adequate funds and necessary infrastructural facilities.

When I first made the recommendation in 1980 for the need to establish the *Council,* I commended the initiative already taken by Government to establish a 'National Co-ordinating Committee on Human Environment', but pointed out that the initiative was not enough, since environmental challenges in Nigeria require a more capable, authoritative and independent body to deal with them effectively. At the 1981 Conference (in Kano) where I repeated the suggestion (Ofomata, 198la), the then Minister of State in the Federal Ministry of Housing and Environment gave an indication that Government was about to establish an *Environmental Protection Agency* in the country. Some months later, one heard that an Environmental Protection Agency *Bill* was with (or on its way to) the 1979-83 National Assembly. No details were available to some of us, but from what one heard about the content of the *Bill,* there was enough room for speculation on the adequacy of the *Environment* covered by the proposals. There would appear to have been an overplay of pollution in relation to other environmental hazard such as erosion, flooding and desertification. In any case, the *Bill* never materialized before the last regime was shown the way out. However, the issue remains topical. But for *the* meantime, one can do no more than commend for serious consideration some important aspects of the *Press Release* issued in Kaduna 3n February 27, 1982, at the a Symposium held under the auspices of the Association of Geosciendsts for International-Development (AGID) and the Inter-Union Commission on the Ltthosphere (ICL) on *Erosion and Desertific tion in Nigeria,* viz :

1. The Environmental Protection Agency should consist of four main divisions: Desertification, Inland Erosion, Coastal and Riverine Erosion, and Pollution. Each division should consist of technical experts mainly drawn from the areas of the country affected by these problems and their functions shall be to produce policy guidelines and plans. They snould be empowered and duly funded to execute remedial projects against these hazards.
2. The Federal (Military) Government should encourage and fund research into these problem. For this purpose, the country should be zoned around individual universities and other centres of research so that each can concentrate on the problem as it occurs around it. The researches into all these forms of environmental degradation - soil erosion, coastal and riverine erosion, flooding, desertification and pollution - should be interdisciplinary involving geologists, geographers, hydro-graphic and land surveyors, geophysicists, economists, sociologists, soil scientists and conservationists.
3. A National Working Committee should be formed to mobilize Government involvement and financial support for coordinated programmes to arrest erosion, Hooding and desert encroachment now threatening the lives and property of people and hindering development in various parts of the country.

CONCLUSION

I have tried in the above sections of the Lecture to outline the state or soil erosion in Nigeria and indicate what I consider appropriate strategy for soil erosion management in the country. A lot remains to be done by way of research to update current information on the subject with a view to tackling the problems posed by erosion more systematically.

There is need for consorted plan to conserve the soil, and effective soil conservation must be based on an adequate knowledge of the environment. We are of the considered opinion that necessary information on the subject can only be procured through combined action by pedologists, agriculturists, geographers, engineers, foresters and other specialists in soil morphology, soil physics, ecology, land use, oil and nature conservation. An integrated research programme is what is required and Nigeria can boast of competent people in these areas to carry out its feasibility and other studies aimed at effective soil conservation in the country. If for any reason there is proven need to use foreign consultants in specific aspects of such studies, our advice is that they should be made to work with competent Nigerians who are knowledgeable not only in their specific fields of interest, but also, and perhaps more importantly, about the Nigerian environment. The point being made here is so obvious that we consider further elaboration unnecessary .

There are many people who still believe that constraints to development and growth in Africa are only economic, social and political, not ecological. Such people would want to explain the problem of soil erosion along these lines also. However, our experience on the subject leads to the conclusion that physical factors are perhaps more important in the evolution of the soil erosion phenomenon in tropical areas than has hitherto been recognised, while the part played by man has tended to be over emphasised. Thus, it would appear that most of our efforts in dealing with constraints to development and growth in Africa are based on an inadequate knowledge of the environment. The success of future soil conservation measures in Nigeria, as in Africa as a whole, will depend on how soon and how well we fill this information gap. Our scientists have to find quick and satisfactory answers to such questions as the lithological composition of areas affected by soil erosion, the nature and effect of rain-water runoff, the type of shrubs and trees best suited for conserving our soils, the reaction of the soils to various conservation devices, etc. It is urged that future studies of the phenomenon should take these points into account while evaluating the factors responsible for the increasingly disturbing soil erosion that plagues parts of Nigeria. Results from instrumented sample areas will, no doubt, make an important contribution to our knowledge of the subject and point the way to the most suitable soil conservation measures to take.

On 4ie various types of soil erosion, effort should be continued to control the gullies, but on well-established order of priorities! However, this particular type of soil erosion should not monopolise the attention of those to be engaged in the soil conservation exercise. Equal attention should be directed towards checking sheet wash, wind erosion and those human activities which lead steadily to continuous soil deterioration. Massive, but carefully planned afforestation would appear inevitable in this regard. So would the building of engineering structures; but their construction should be preceded by appropriate environmental impact studies. Again, it is of primary importance to elicit the confidence of the local people, who are as concerned as anybody else interested in the problem, who use and would continue to use the soils, and who should form part of any soil conservation movements in their various localities.

Finally, it must be emphasised that the management of soil erosion problems in Nigeria should no longer be undertaken on an adhoc basis. Soil conservation activities in the country should be co-ordinated and prosecuted in a sustained manner. Each unit of soil erosion should not be considered in isolation but must be seen as a component part of a higher unit which, invariably, is a drainage basin, and be treated within that context. Above all, our soil conservation efforts must be based on an adequate knowledge of the environment, and there can be no substitute for such knowledge.

Mr. Vice-Chancellor, Deputy Vice-Chancellors, Deans of Faculty, Colleagues, Ladies and Gentlemen, I thank you for listening!

REFERENCES

Collier, C.C. (1962): Influence of strip mining on the hydrological environment of parts of Beaver Creek Basin, Ky., 1955-1959. *U.S. Geol. Survey, Prof. Paper* No. 427-R

Ellison, W.D. (1952): "Raindrop Energy and Soil Erosion". ./own. *Experimental Agric. Vol.*. 20, pp. 81-97.

Foumier, F. (I960): *Climatet Erosion.* Univ. Presses, Paris.

Grove, A.T. (1951): *Land Use and Soil Conservation in parts of Onitsha and Owerri Provinces.* Bulletin No. 21, Geological Survey of Nigeria.

____________(1952): *Land Use and Soil Conservation on* the *Jos Plateau.* Bulletin No. 22, Geological Survey of Nigeria,

___________(1956); "Soil Erosion in Nigeria". In R.W. Steel and C.A. Fisher (eds.): *Geographical Essays on British Tropical Lands,* Philip, pp.. 77-111.

Jeje, L.K. (1978): "A preliminary investigation into Soil Erosion on Cultivated Hillsides in Parts of Western Nigeria' *Ceo-Eco-Trop.,* I, pp. 175-187.

Lee, C. (1973); *Models in Planning: an introduction to the use of quantitative models m planning,* Pergamon Press, Oxford.

Musgrave, G.W. (1947): "Quantitative Evaluation of factors in water erosion - first approximation". *Journ.. Soil and Water Conservation,* vol. 2, No. 3, pp. 133-138.

Ofomata, G.E.K. (1964): "Soil Erosion in the Enugu Region of Nigeria". *African Soils,* IX, No. 2, pp. 289-348.

_________(1965); "Factors of Soil Erosion in Enugu Area of Nigeria". *Nigerian Geographical Journal,* 8, pp. 45-59

————(1966): "Quelques observations sur l’'eboulement d'Awgu, Nigeria Oriental". *Bulletin* de *PIFAN.* Serie A, *XXVm,* pp. 433-443.

———(1967); "Some observations on relief and erosion In Eastern *Nigeria", Revue de*

Geomorph. Dynamise, XVU, pp. 21-29.
_______(1973); "Village erosion at Ozuitem, East Central State of Nigeria". *Ikenga.* 11, No. pp. 64-74.
________(1978); "Man as a factor of Soil Erosion in Southeastern Nigeria". *r^o-Eco-Trop.,* Vol. 1, pp. 143-154.
_________(1980); "Perspectives on Environmental Deterioration in Nigeria". *The Tropical Environment* Vol.1, pp. 6-19.
________1981a); "The Management of Soil Erosion Problems in Nigeria". Paper presented at the *24ih Annual Conference of the Nigerian Geographical Association,* Kano, April 6-10, 1981 (In Press).
———(1981b): "Actual and Potential Erosion in Nigeria and Measures of Control". Paper presented at the 9th Annual Conference of the Soil Science Society of Nigeria, Owere, December 6-10, 1981.
———(1981c); "Impact of road building, urbanization and general infrastructural development on the Nigerian rainforest ecosystem". *Land scape Planning,* 8,pp. 21--;9.
-——(1982); "Use and Misuse of Nigeria's Agricultural Land Resources". Chapter 3/2, pp. 119-130 of-F.O.C. Ezedinma *et at* (eds.): *Efficient Use of Nigerian Land Resources.* Federal Department of Agric. Land Resources, Kaduna.
______(1984a): "Erosion in the Forest Zone of Nigeria". Paper presented at the *27th Annual Conference of the Nigerian Geographical Association,* Univ. of Nigeria, Nsuka, March, 1984.
______(1984b): "The Impact of Man in the Evolution of the Physical Environment in the Forest Zone of Nigeria". *25lh International Geographical Congress,* Paris, Main Session *Abstracts,* Vol. l.Th.t.34.
Ojo G.J.A. (1973): "The Status of Environmental Management in Nigeria". - Paper presented at the *Conference on Environmental Resource Management m Nigeria,* University of Ife, July, 1973
Onukogu, I.B, (1984).. "An Analysis of Variance of Nominal Data". *StaHstica,* XLIV, No, l,pp. 87-
Sada, P.O. and G.E.D. Omuta (1979): "Auchi Urban Area - A preliminary report on Erosion and Environmental Problems and Planning". In P.O. Sada and G.E.D. Omuta *Ifds.): Spatial Perspectives in National Development.* Proceedings of the 22nd Annual Conference of the Nigerian Geographical Association, Benin, March 28 to April 1, 1979, pp. 130-152.
Salbany, A. (I960): "Aspects Ecologiques et Agronomiques de problemes de 1'erosion des sols en relation avec la construction d'ouvrages et installation". *Sols Africttins,* vol. 3, pp. 337-341.
Stamp, L.D. (1938): "Land utilisation and soil erosion in Nigeria". *Geographical Review,* 28, pp.32-45.
Sykes, R.A. (1940): "A History of and-erosion work at Udi". *Farm and Forest,*

Vol. 1, pp. 3-6.
Zingg, A.W. (1940): "Degree and length of land slope as it affects soil loss in runoff". *Agric. Engineering*, Vol. 21, pp. 59-64.