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CATENARY VARIATION, SOIL FERTILITY STATUS AND SUBSISTENT FARMING IN A PART OF AKWA IBOM STATE, NIGERIA.

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Abstract

Five slopes located in Itu, Akwa Ibom State, with evidence of recent cultivation were sampled along their lower, middle and supper segments. Soil samples at two layers - surface and sub-surface were collected from each segment and analysed for particle size distribution and the exchangeable cations. The aim was to establish the relationships between slope forms and the soil found on them, with a view to examining the implications of these relationships to the subsistent farming economy of Itu. The slopes varied in length from 54. 35m to 126m and inclination from $10^{0}20^{1}$ to $25^{0}30^{1}$. On all slopes coarse sand content was at the surface than in the subsurface while fine sand content was higher in the subsurface than in the surface. Percentage clay and silt was higher at the surface soil than subsurface soil. Generally the soils were sandy in texture. Analysis of variance showed that the soil particle sizes indicated varying levels of statistical significance among the slopes and segments, but with clay being the most varied. The exchangeable cations showed no significant variation. It was observed that no slope facet in Itu was suitable for cultivation in terms of nutrient levels. Changes in soil texture,

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structure and depletion of the nutrients occur throughout the slope length irrespective of segments. Variation in clay was probably responsible for the low cation exchange capacity, Nutrient depletion was cyclic in consonance with cultivation patterns. Since the population of Itu is basically agrarian, intensive extension services would be needed to modify the subsistence culture.

1. Introduction

Itu Local Government Area in Akwa Ibom state is of relatively higher relief than the others parts of the State. Undulating hills, low lying areas and flood plains, characterise the landscape.

Erosion scars are many while actively retreating slopes are initiated following each rainy season due to surface soil exposure as slopes are cleared for cultivation. As population increases in the area, more pressure is brought on the land as demand for farm lands grows. Hence more marginal areas are cultivated thus making the hill slopes increasingly prone to erosion. The erosion problem is much aggrevated by slash-and-burn method which destroys the vegetal cover and soil organic matter such that the exposed soil becomes loose and friable (Kinnel et al, 1990). These affect weathering and soil formation on the slopes and also the effectiveness of denudational processes on the surface and subsurface materials. However, there is dearth of information on the catenary relationships between the slopes and the weathered materials and their effect on soil fertility status, considering that farming is the major occupation of the people.

This study seeks to establish the relationship between slope forms and the soils found on them with a view to examining the implications of the relationship to the subsistence farming economy of Itu area, Akwa Ibom State.

2. Materials and Methods

Five slopes with evidence of recent cultivations located respectively at (1) Obot Okpoto in Use Ikot (2) Obot Ifiok in Okopedi, (3) Ntiat Itam, (4) Ntak Inyang, and (5) Ekim Itam were selected for the study using the Calabar SE topographical map. Erosional activities, in addition to biological and physical weathering were observed to characterize the slopes under study. On each location, elevation, slope length and slope angle were measured. The profile of each slope seemingly fell into three major segments as upper slope, middle slope and lower slope.

Details of the slope morphology were described:

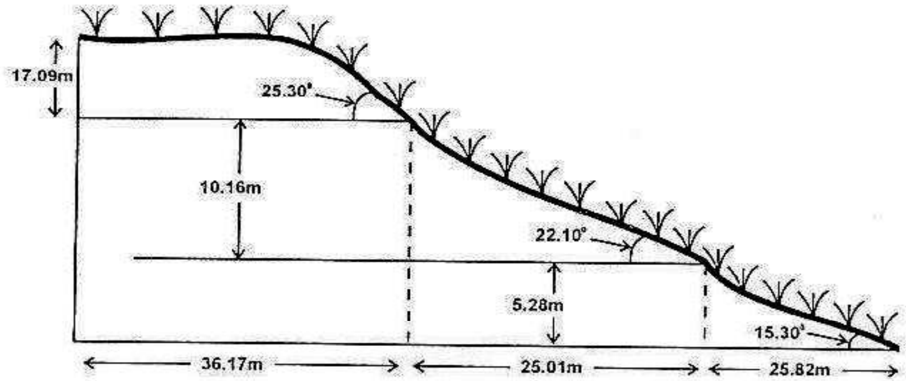

Fig. 1: External morphology of slope 1.

SLOPE 1 (Fig. 1)

Among the processes acting on the entire slope, rill erosion was dominant. Physical and biological weathering was also observed in the area. A part of the slope was under cultivation. The surrounding plain was liable to flooding yearly, thereby destroying the talus formed during the dry season. The sampled slope profile was 87m in length. The entire profile was divided into three major parts based on the break of slopes along the profile. The height of the three parts range from 5.28m to 17.09m, with inclination varying from 15°30ᴵ to 25°30ᴵ. The upper most part of the slope was convex in shape, the middle steep and straight, while the lowest part had a concave shape spreading out to an almost level surface.

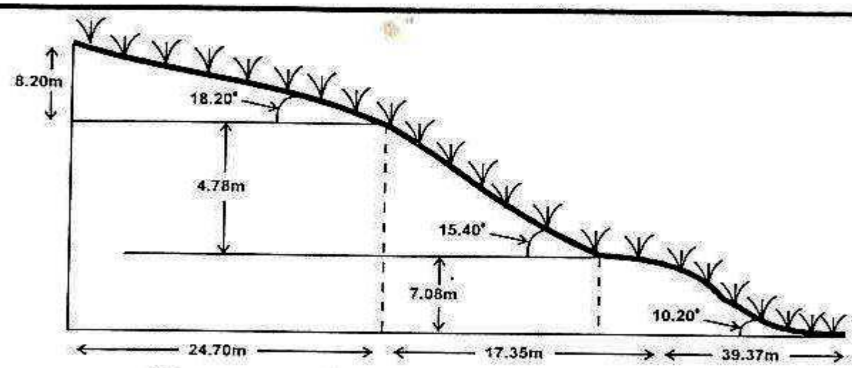

Fig. 2: External morphology of slope 2.

SLOPE 2 (Fig. 2)

Gully erosion was dominant on this slope. The entire slope was also influenced by mechanical and biological weathering. A part of the slope was thickly vegetated. The entire length of the slope profile was 84m. Divided into three parts, their height ranged from 4.78m to 8.12m while inclinations varied from 10°20ᴵ to 15°40ᴵ. The upper slope was concave and the lower slope was undulating.

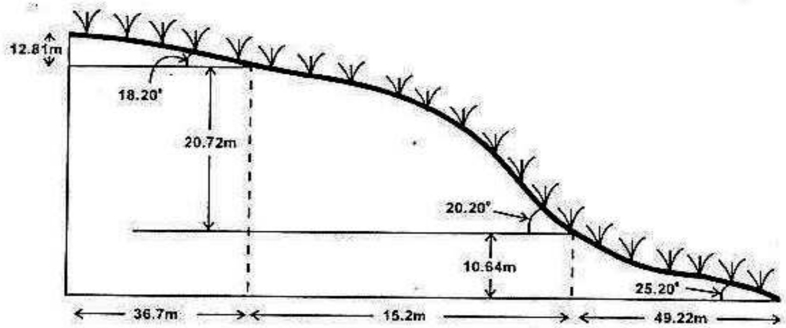

Fig. 3: External morphology of slope 3.

SLOPE 3 (Fig. 3)

The entire slope was cultivated. There was indication of seasonal stream at the foot of the slope. Sheet erosion was the dominant process on the slopes, although biological and mechanical weathering may have provided the eroded materials. The sampled profile was 126m long. Based on the breaks of slope, the lower, middle and upper parts ranged from 10.64m to 20.72m in height with inclinations of 18°20' to 25°20'. The upper slope was gentle while the middle was associated with convexity. The lower slope was steep.

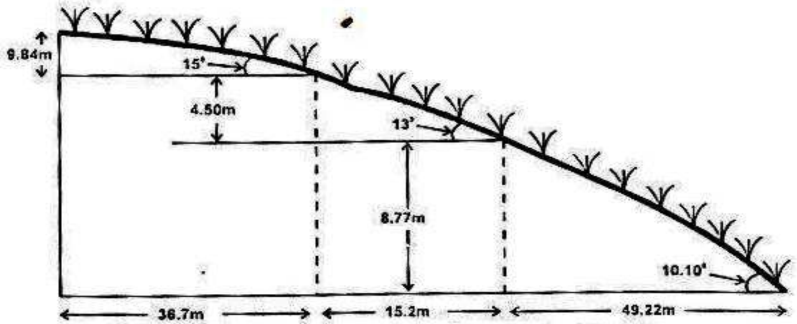

Fig. 4: External morphology of slope 4.

SLOPE 4 (Fig, 4)

The whole slope was vegetated with grass, consequent to repeated removal of the secondary bush. At the foot, there was a dry channel carved by surface runoff. The dominant process was sheet erosion. The slope was convex almost along its entire length. The profile length was 108m. Inclinations along the breaks of slope varied from 10°10' to 15°20', with heights ranging from 4.50m to 9.54m.

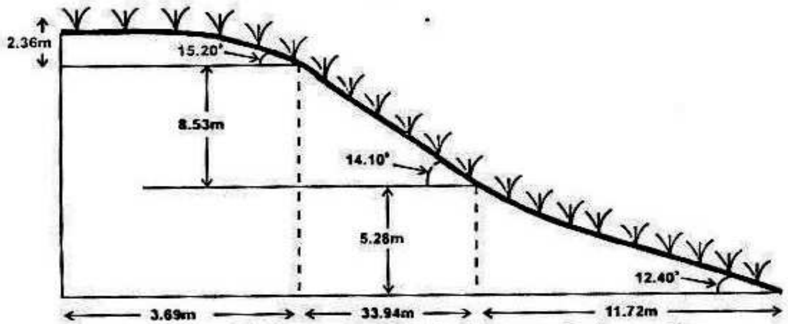

Fig. 5: External morphology of slope 5.

SLOPE 5 (Fig. 5)

This slope was under cultivation at the time of observation. The profile was 54.35m long divided into three parts along breaks of slope. These parts ranged 2.58 to 8.53m in height and 12°40' to 15°20' in

inclination. The upper part of the slope was associated with convexity, middle slope was steep but the lower slope was gently sloping.

Soil analysis was performed on the basis of the identified slope segments. Consequently soil samples for the surface layers (0-15cm) and for the sub-surface layers (15-30cm) in each segment of slope were collected at each location. A total of 30 samples, 15 in each layer, were obtained for laboratory analysis.

Particle size distribution (percentage coarse sand, fine sand, silt and clay) were obtained by the Bouyoucos (1962) method. Exchangeable cations were extracted by total elemental digestion; concentration of potassium, magnesium and calcium were determined by atomic absorption spectrophotometry while sodium was by flame photometry. The determination of exchange acidity, a component of cation exchange capacity was by extraction with barium acetate and titration with NaOH. Effective cation exchange capacity (ECEC) was determined through the summation method (IITA 1980). Percentage base saturation (BS) was determined by the formula:

$$BS = \frac{\text{cation} \times 100}{\text{ECEC}}$$

Analysis of variance (ANOVA) was used to examine the significant difference in the physical and chemical properties of the surface and subsurface soil from the different slope segments. The percentage coefficient of variation was used to assess variability within samples. The coefficients were classified as: 0-25% (low); 26-50% (moderate) and above 50% (highly variable).

3. Results

Results of the laboratory analysis are presented in Table 1. Values of coarse sand content for slope 1, 3, 4, and 5 were higher at the surface than in the sub-surface. The coefficients of variation were low for the surface and sub-surface. Only slope 2 had higher coarse sand values in the sub-surface than at the surface layers and with very high variability.

Table 2 shows that fine sand values were higher in the sub-surface than on the surface layers for slopes 1, 3, 4 and 5, with low coefficient

Table 1: Variability of % Coarse Sand on Slopes in Itu

Slope Number	Surface Layer (SL)			Sub-Surface Layer (SSL)		
	X̄	SD	CV (%)	X̄	SD	CV (%)
1	49.27	6.12	12.56	45.32	7.56	16.68
2	13.67	8.58	62.77	18.63	16.6	89.1
3	56.51	11.15	19.73	45.0	3.83	8.51
4	42.45	9.67	22.78	36.6	3.7	10.22
5	35.49	3.29	9.27	30.51	3.65	11.96
ANOVA	**			*		

** Significant at the 1% level;
* 5% level

Table 2: Fine Sand Content of Soil Materials on Slopes

Slope Number	Surface Layer (SL)			Sub-Surface Layer (SSL)		
	X̄	SD	CV (%)	X̄	SD	CV (%)
1	32.73	9.19	128.09	42.01	13.27	31.59
2	39.39	4.47	11.35	37.76	1.68	4.45
3	32.49	6.81	20.96	44.07	3.93	8.92
4	47.95	9.66	20.15	54.47	2.76	5.07
5	44.51	1.79	4.02	51.10	3.45	6.75
ANOVA	**			N.S.		

** Significant at the 1% level; N.S. = Not Significant

of variation in all layers except for slope 1 which varied moderately. Slope 2 presents a converse situation with higher fine sand values at the surface than in the sub-surface layer, with low variability for both layers.

In Table 3, slopes 1, 2, and 5 have higher clay content at the surface than for sub-surface layers. Moderate coefficients of variation were observed in all the layers of slope 1. In sloe 2, low variability was observed in all layers while moderate and low coefficients were observed in the surface and sub-surface layers respectively for slope 5.

Table 3: % Clay Contents of Soil Materials on Slopes

Slope Number	Surface Layer (SL)			Sub-Surface Layer (SSL)		
	X̄	SD	CV (%)	X̄	SD	CV (%)
1	9.6	4.0	41.6	6.27	3.06	48.80
2	41.53	4.62	11.12	28.87	5.05	10.56
3	7.33	3.38	46.11	7.33	3.38	46.11
4	6.2	2.0	32.26	1.87	1.15	16.74
5	14.8	6.0	40.54	13.47	3.06	22.72
ANOVA	***			***		

*** Significant at the 1% level

While slope 3 had similar values of clay at the surface and sub-surface layers with moderate coefficients of variation. Slope 4, on the other hand, had slightly higher values in the surface than at the surface.

As indicated in Table 4, silt fraction was higher at the surface layers than in sub-surface with respect to slopes 1, 3, and 4. Variability is low at the surface on slope 1, moderate on slope 2, and high on slope 4. Slope had similar mean values at the surface

Table 4: Variability of Silt on Slopes in Itu

Slope Number	Surface Layer (SL)			Sub-Surface Layer (SSL)		
	X̄	SD	CV (%)	X̄	SD	CV (%)
1	8.4	2.0	23.81	6.4	3.46	54.06
2	15.4	5.29	34.35	14.73	15.26	103.59
3	5.4	0.0	0	5.4	2.83	52.41
4	3.5	2.0	58.82	2.07	1.15	55.56
5	4.2	3.69	70.19	4.73	3.06	64.69
ANOVA	*			N.S.		

** Significant at the 1% level; N.S. = Not Significant and sub-surface, and high sub-surface variability. Sloe 5, indicate higher values in the sub-surface layer than at the surface layer. Coefficient of variation for all layers were higher.

(iii) Table 5, categorizes exchangeable cations as observed on the upper, middle and lower slopes. On the upper slopes, calcium had the

Table 5: Chemical Properties of Materials on Slopes

Properties	Upper Slope			Middle Slope			Lower Slope		
	$\bar{X}$	SD	CV	$\bar{X}$	SD	CV	$\bar{X}$	SD	CV
Ca(meg/100g)	2.32	1	43.10	3.0	2.28	0.84	3.96	4.72	120.45
Mg(meg/100g)	0.96	0.59	61.4	0.84	0.43	51.19	1.84	1.40	76.80
K(meg/100g)	0.29	0.08	27.59	0.29	0.07	24.13	0.31	0.08	25.81
Na(meg/100g)	0.10	0.05	50	0.08	0.05	62.5	0.07	0.03	42.86
EA	3.26	1.86	57.05	2.06	0.96	46.60	2.21	1.46	66.06
ECEC	6.93	2.01	29	6.28	2.14	34.08	8.39	5.60	66.75
BS	60.64	9.29	15.32	64.7	7.54	27.11	67.05	22.98	34.27

EA = Exchange acidity; BS = Base Saturation ECEC = Effective Cation Exchange Capapcity

highest values with a moderate coefficient of variation, followed by magnesium while values for potassium and sodium were low. Magnesium showed high variability, sodium moderate variability while potassium was the least variable.

On the middle slopes, calcium maintained the highest values with high variability. The values of magnesium, potassium and sodium were similar to those obtained on the upper slope. However, sodium and magnesium vary highly while potassium shows low variation.

On the lower slopes, the values indicate high concentrations of calcium, with high coefficients of variation (120.45%). This is followed by magnesium (1.84-1.40mg/100g) with a high variation (76.08%). P otassium and sodium values were low, with low to moderate variabilities. Generally, observations of exchangeable cations appear to be similar between the upper, middle and lower slopes. Although the lower slopes had slightly higher values, the differences were marginal. On the upper slopes, exchange acidity was higher than values in the middle and lower slopes. Variability was low on the upper slopes, moderate on the middle slopes and high on the lower slopes.

The values for effective cation exchange capacity (ECEC) was higher on the lower slopes than on the upper and middle slpes. The lower slopes show variation while the upper and the middle slopes were moderately varied. For base saturation higher values were observed on the lower slopes with a moderate coefficient of variation while values for middle slopes were slightly lower with a moderate variability.

4. Implications on Subsistent Farming

Cultivating the slopes in Itu play important role in changing particularly the soil texture in terms of coarse sand, fine sand and clay contents of the soils. Clay content are highly affected, irrespective of the horizons. Analysis of variance test (ANOVA) shows that among the slopes coarse sand fractions varied at a higher statistically significant level ($P<0.01$ ANOVA), than the sub-surface fractions ($P<0.05$ ANOVA). However, only the surface fine sand fractions varied significantly ($P<0.01$ ANOVA) while the sub-surface content was not significantly varied ($P<0.001$ ANOVA) both at the surface and in the sub-surface. Silt content showed the least significant variation (0.05 ANOVA) at only the surface layer.

Visual assessment of soil structure along the slopes showed that there existed a seasonal pattern of structural change as the slopes were cultivated (with mainly cassava and Okro). After each cultivation season structural changes resulting from settling were evident. If the slopes were allowed to fallow over a number of years, soil structure could improve while sheet wash and surface wash may be reduced, thus stabilizing soil nutrient levels. However, since cultivation is cyclic the processes of slope wash and settling are also cyclic. Therefore the resulting structural states are perpetuated showing a pattern of cyclic occurrence.

The chemical properties of soils showed no statistically significant differences among the slopes (and are not reported in this paper). However, it is assumed that the lower slopes have greater wetness and the soil are relatively "younger" being deposited materials from upper and middle slopes. Therefore cation requirements of plants could be more consistently satisfied here than on the middle and upper slope surface (Kleiss 1994). Since the soils have been frequently under cultivation and exposed to the weather, it seems obvious that weathering imputs have provided most of the exchangeable cations (Zabowski et al 1994). Therefore, proper soil management could increase the CEC levels and improve the soil nutrient status.

By the FAO (1976) standard, the low values of the effective cation exchange capacity could also be explained by the depletion of clay fractions consequent to cultivating the slopes. The low clay content here has serious agricultural implications in view of the importance of clay minerals in fixing the cation exchange capacity of soil (Sancherz, 1976). The base saturation values for all slope facets shows that the soils in question here were already low in nutrients and as such the contribution of the basic nutrient elements is very minimal. The study clearly shows that farming on slopes have adverse effects on the soils and is threatening the subsistence farming livelihood of Itu settlement and its environs. As soil quality deteriorates, food supply will decline and the people will turn to alternative means of sustainance or migrate to the nearby urban centres e.g Uyo; others may take to fishing as the farmlands are ravaged by erosion. Conservation and management of the hilly terrain of Itu need to be intensified to maintain the agrarian population and discourage rural - urban drift.

5. Conclusion

The major constraint to subsistent farming in Itu are chiefly soil and soil related which include low soil cation exchange capacity. Once the natural slope ecosystem is disrupted for agricultural production and as care is not usually taken in the clearance of the vegetation, there develop physical constraints on production as soil structural properties are disrupted. Consequently, when agricultural production is established on cleared slopes, it is difficult to sustain it beyond the first two years, moreso as fertilizer imputs are not substantial. Trees, in some form of agroforestry system or alley crapping may offer a sustainable solution to a subsistent agricultural production system.

The practice of mixed cropping with cover crops and other leguminous crops could arrest erosion on the slopes and conserve the soil nutrients. Terrace farming and strip cropping could be introduced and encouraged through extension services demonstrations. Hence the farmer could be made to participate in the practice.

To actualize the appreciation of such efforts basic education especially of the adult population is necessary. This is because the subsistence culture cannot be changed but modified to suit the changing times.

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