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Research article

PHYTOGEOGRAPHIC CHARACTERISTICS ALONG CATENA SEGMENTS IN ITU LOCAL GOVERNMENT AREA, AKWA IBOM STATE, SOUTH-SOUTHERN NIGERIA

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ABSTRACT

Slope-induced variation in soil properties is widely recognised as a determinant of plant distribution, yet how this variation shapes woody and herbaceous species composition in the secondary forests of south-southern Nigeria remains poorly documented, leaving land managers without a local basis for conservation planning along catena landscapes. This study examined the phytogeographic characteristics of plant species along catena (slope) segments in Itu Local Government Area, Akwa Ibom State, Nigeria, with the objective of determining species composition, diversity, and whether density varies significantly across the upper, middle, and lower slope segments. An experimental design was adopted across the Ebu Afaha, Mbak, Afaha Ikot Udoe, and Oku Iboku communities: four toposequences were delineated with the aid of ArcGIS and a Geographic Positioning System, each divided into upper, middle, and lower slope segments, and a 20 m × 20 m quadrat (subdivided into 10 m × 10 m sub-plots) was established per segment, giving twelve quadrats in total; species data were analysed with descriptive statistics, the Shannon-Wiener diversity index, and one-way analysis of variance (ANOVA). Eighty-nine species (52 tree/shrub and 37 herbaceous) belonging to 59 families were recorded, with high overall diversity ($H = 3.9$) but low species evenness (0.03); tree/shrub density did not differ significantly along the catena as a whole ($F = 2.581$, $p = 0.079$), although the middle slope was significantly more diverse than the upper slope ($p = 0.030$). These results imply that catena position exerts a measurable, if spatially uneven, influence on woody species distribution in the study area, and that anthropogenic pressure rather than topography alone now drives much of the observed vegetation pattern. The study contributes new baseline phytogeographic data for the Itu catena and recommends erosion-control measures on the upper slope and stricter control of fuel-wood harvesting and illegal logging to conserve this species-rich ecosystem.

KEYWORDS

Phytogeographic characteristics, Catena segments, Species diversity, Slope position, Vegetation-soil relationship, Itu Local Government Area, Akwa Ibom State (Nigeria)

INTRODUCTION

Vegetation cover and soil properties are among the most closely coupled components of terrestrial ecosystems, and nowhere is this coupling more visible than along a catena — the association of soils that occur on a single slope and are linked, despite often sharing the same parent material, by the pattern of water movement across the landscape. As water and dissolved or particulate material move from the crest of a slope toward its foot, they redistribute nutrients, alter drainage and aeration, and modify the physical and chemical environment in which plants germinate, establish, and compete. Topography therefore acts as a silent architect of plant community structure, and understanding how it does so along different slope segments is fundamental to interpreting the vegetation patterns observed in any hilly or undulating terrain.

This relationship carries particular weight in the humid tropics, where high rainfall, intense weathering, and dense human settlement combine to make slope position a strong control on both natural soil fertility gradients and the intensity of human disturbance. In much of south-southern Nigeria, including Akwa Ibom State, catena landscapes support subsistence farming, fuel-wood collection, and logging, all of which interact with the natural soil-vegetation gradient in ways that are not yet fully documented for many local government areas. A clear understanding of how plant species composition and diversity change from the upper to the lower slope is therefore not only of academic interest but also of direct relevance to land-use planning, erosion control, and biodiversity conservation in the region.

A substantial body of research, reviewed in the following section, has established that soil physicochemical properties, microclimate, and drainage vary systematically along slope gradients, and that these variations are mirrored in plant community composition and productivity. This work spans temperate and tropical settings alike and provides strong theoretical grounds for expecting catena position to influence woody and herbaceous species distribution. However, much of this evidence derives from broad regional surveys or from ecosystems outside the coastal, swamp-forest transition zone typical of the Niger Delta fringe, and comparatively few studies have examined, at the scale of an individual local government area, exactly how tree/shrub and herbaceous species respond to the upper, middle, and lower segments of a single catena.

For Itu Local Government Area specifically, this gap is compounded by rapid change in land use: agricultural expansion, fuel-wood extraction, and logging are visibly altering the vegetation cover of the area's undulating terrain, yet no baseline phytogeographic inventory exists against which such change can be measured. Without such a baseline, it is difficult for local planners and conservation agencies to judge whether current land-use pressures are eroding species diversity, and where along the catena conservation effort would be most productively targeted.

This study therefore sets out to analyse plant species composition and diversity along the catenary structures of Itu Local Government Area, Akwa Ibom State, and to test the hypothesis that there is no significant variation in tree/shrub species density along the catena segments. Specifically, the study aims to (i) document the tree/shrub and herbaceous species composition of the study area; (ii) determine species diversity and evenness using the Shannon-Wiener index; and (iii) test whether tree/shrub species density varies significantly across the upper, middle, and lower slope segments of the catena.

LITERATURE REVIEW

Global Evidence on Soil-Vegetation Relationships

Globally, soil factors play a significant role in the growth, functioning, abundance, and distribution of plant species within an ecosystem. Soil volumetric water content, electrical conductivity, acidity (pH), nitrogen, phosphorus, and sulfur are all closely related to plant distribution, and soil is understood to play a central role in the formation and heterogeneity of habitats, thereby driving changes in vegetation structure and plant diversity (Rodrigues, Jhonathan-de, Walnir, Rubens & Andreza, 2018). Soil itself is a multilayer porous medium, either formed in place through the weathering of underlying rock or deposited by agents of transportation such as water, wind, and ice (Esu, 2010; Eneyo, 2026a), and its formation is a dynamic process that develops wherever there is continuous interaction between air, water, parent material, and organisms (Jenny, 1941). Vegetation and soil, in turn, display a circularly causal relationship, each supporting and protecting the other (Tunçay, Dengiz, Bayramin, Kilic & Baskan, 2019; Idoga & Azagaku, 2005; Brant, Pivec, Venclová, Soukup & Holec, 2006; Jamieson, Gordon, Cochrane & Patterson, 2004; van der Maarel, 2004).

Topography-induced microclimate differences can cause significant changes in plant growth and soil properties, which in turn drastically affect the structure and function of ecosystems and the relational impacts between soil and vegetation (Zhang, Liu, Zhao, Li, Zhao, Li, Chen, Chen, Han & Huang, 2018; Begum, Bajracharya, Sharma & Sitaula, 2010; Khormali, Ayoubi, Foomani, Fatemi & Hemmati, 2007; Moorman, Cambardella, James, Karlen & Kramer, 2004; Tsui, Chen & Hsieh, 2004). Because these relationships are multidirectional and interact across scales, a multivariate approach is generally required to identify the vegetation and soil properties that sustain them, rather than relying on any single soil or climatic variable in isolation.

Regional and African Evidence

Within Africa, and West Africa in particular, empirical work confirms that these globally observed patterns hold, while also revealing distinctly regional dynamics. Essoka and Jaiyeoba (2008), working on toposequences developed over granitic-gneiss material in the rainforest region of Cross River State, recorded that downslope transportation and deposition of organic residues are common along such toposequences, and that the trend of available phosphorus is irregular across both the surface and slope positions, as is the general pattern of distribution of exchangeable calcium, magnesium, potassium, and sodium across catena segments. Despite this irregularity, soil continues to perform an important role in nature, supplying nutrients for plant growth and habitat for millions of micro- and macro-organisms (Eni, Iwara & Offiong, 2011; Rodriguez-Iturbe, 2000).

Regional studies of slope position and vegetation structure further indicate that the relationship is not always linear or symmetrical between slope segments. Aweto and Iyamah (1993), studying a swamp forest in south-western Nigeria, reported no marked variation in vegetation structure along a catena except close to the river bank, where trees were shorter and less dense — a finding that anticipates the pattern this study later confirms for Itu. Similarly, Pickering and Green (2009) found that vascular plant distribution was influenced by topographic position relative to a catena's summit, while Aweto (1976), working in a swampy forest, attributed low tree density in the lower slope to the prolonged effects of waterlogging on plant growth and vigour. Taken together, these African and comparative international studies establish that slope position shapes vegetation not through a single uniform gradient but through a combination of drainage, nutrient redistribution, and, increasingly, human disturbance.

Local Research Gap

Notwithstanding this substantial body of theoretical and empirical work, there remains inadequate knowledge regarding the specific relationships between edaphic factors, plant distribution, and diversity at the local scale in south-southern Nigeria, and Itu Local Government Area in particular has not, to the knowledge of the present authors, been the subject of a dedicated phytogeographic inventory along its catena segments. How slope position affects soil physicochemical properties in the secondary vegetation of such hilly, human-influenced regions remains poorly understood (Runhong, Yuanfang, Han, Shichu, Yong, Hongrun & Wanqing, 2020), and this uncertainty is compounded locally by ongoing agricultural encroachment and fuel-wood extraction, whose combined effect on catena-scale species diversity has not been quantified for the area. The present study therefore addresses this gap by providing an empirically grounded, quadrat-based inventory of tree/shrub and herbaceous species composition and diversity across the upper, middle, and lower slope segments of the Itu catena, and by statistically testing whether density varies significantly along that gradient.

METHODOLOGY

Study Area

Itu Local Government Area, Akwa Ibom State, Nigeria, is located within the coordinates of latitudes 5°10'0" N and 7°59'0"E and between longitudes 5°16'67' N and 7°9'833'E, as shown in Figure 1. It occupies a land mass of approximately 606.10 square kilometres and is one of the local government areas of southern Nigeria. The vegetation of the area along its west and southern axis is swamp forest and moist lowland forest, and the topography is highly undulating, with some areas as high as 120 ft above sea level (Figure 2). Dominant vegetation includes trees (*Elaeis guineensis*), bamboo (*Bambusa africana*), plantain and banana (*Musa spp*), and guinea grass (*Panicum maximum*), while the soils of Itu are characterised by sandy erosion and muddy bank root biotopes (Fasona & Omojola, 2005; Eneyo, 2026a).

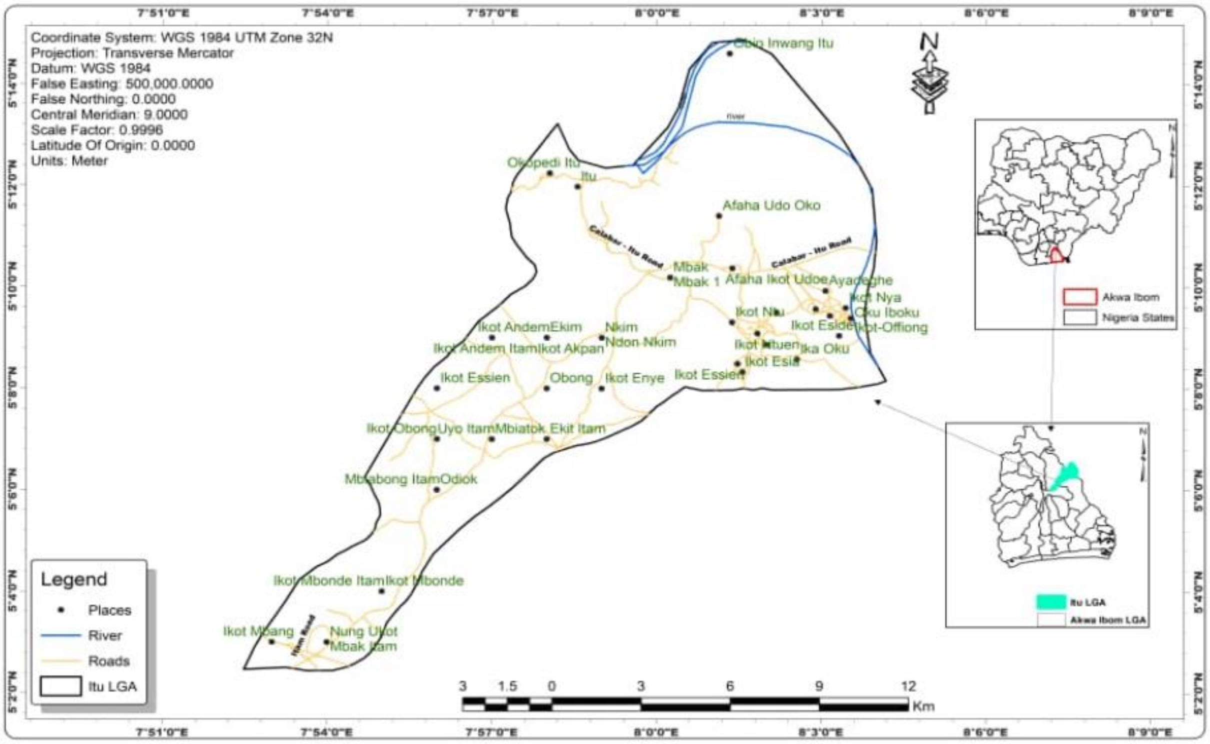

Figure 1. Akwa Ibom State and Itu Local Government Area showing communities
Source: GIS Unit, Department of Geography and Environmental Science, University of Calabar, Calabar

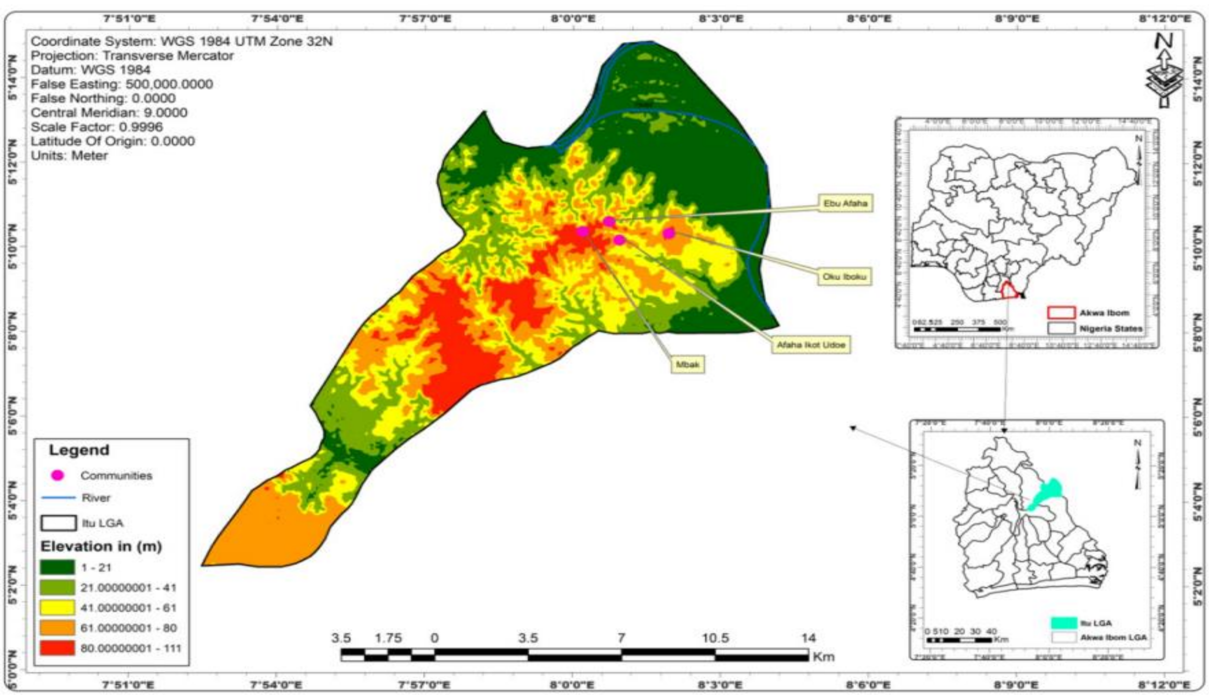

Figure 2. Elevation map of Itu Local Government Area showing the sampled communities
Source: GIS Unit, Department of Geography and Environmental Science, University of Calabar, Calabar

The climate of Itu is tropical, with an average of 2,409 mm of annual precipitation and mean air surface temperatures ranging between 25.5 and 28.3°C. Relative humidity is usually high throughout the year, averaging

80%. Itu Local Government Area has a projected population of 163,200, and the major occupations of the people are farming, fishing, and trading — occupations that place direct and continuing pressure on the catena vegetation examined in this study.

Research Design

An experimental research design was adopted for this work because the research variables required direct field measurement and observation for the identification and delineation of the soil catena, rather than reliance on secondary records. Discrete data on plant species composition along the toposequence — a nominal-scale measurement — were accordingly collected first-hand from the four communities of Ebu Afaha, Mbak, Afaha Ikot Udoe, and Oku Iboku.

Data Collection

Purposive sampling was used to identify areas of undulating topography within the study area, while ArcGIS software was used to map and delineate four major toposequences from the identified communities, located between 61 and 111 metres above sea level. A Geographic Positioning System (GPS) was used to record the coordinates of these areas. Each toposequence was further divided into three segments — the upper slope, middle slope, and lower slope — which constituted the sampling points for the vegetation parameters. A 20 m × 20 m quadrat was established per slope segment, giving twelve quadrats in total across the four toposequences. Tree/shrub and herbaceous species data were obtained from the established quadrats, which were further subdivided into 10 m × 10 m sub-plots to ease the identification and enumeration of plant species.

Data Analysis

The vegetation data were analysed using descriptive statistics — tables, frequencies, percentages, and averages — alongside the Shannon-Wiener diversity index, which was used to determine plant species diversity, richness, and evenness, and is given as:

$$\text{Shannon Index D} = -\sum_{i=1}^{s} \mathrm{p_i}\,(\log iPi)$$

Where: D = the value of Shannon-Wiener's Diversity Index; *Pi* = the proportion of the *i*th species; *Logi* = the natural logarithm of *Pi*; S = the number of species.

A one-way analysis of variance (ANOVA) was then used to test and analyse the variation in tree/shrub species density across the three slope segments, in line with the study's stated hypothesis. The formula is:

$$\mathrm{F} = \frac{MST}{MSE}$$

Where: F = ANOVA coefficient; MST = mean sum of squares due to treatment; MSE = mean sum of squares due to error. Where the ANOVA indicated a significant difference, a Post Hoc Test of multiple comparisons was applied to identify which specific slope segments differed from one another.

RESULTS

Tree/Shrub and Herbaceous Species Composition in the Study Area

The vegetation composition and tree/shrub species density recorded in the study area are presented in Tables 1 and 2. A total of eighty-nine (89) species of trees/shrubs and herbs, with one thousand and eighty-eight (1,088) occurrences, were recorded across the twelve quadrats. Of these, fifty-two (52) tree/shrub species accounted for four hundred and forty-four (444) occurrences, while thirty-seven (37) herbaceous species accounted for six hundred and forty-four (644) occurrences across the catena segments. The species recorded spanned fifty-nine (59) families in total, indicating a taxonomically broad community rather than one dominated by a small number of related plant groups.

Among the tree/shrub species, twenty-six (26) species were classed as abundant, four (4) species as common, ten (10) species as occasional, and twelve (12) species as rare in the study area (Table 1). Among the 37 herbaceous species, 25 species were found in abundance, 4 species were common, 7 species were occasional, and 1 species (*Sesamum indicum*) was rare. This distribution shows that, while the study area supports a considerable number of species overall, a comparatively small subset of species account for most of the recorded occurrences.

Table 1. Plant species composition in the study area

S/N	Scientific names	Common name	Family	Lifeform	FRQ	A	C	O	R
1	*Rauvolfia vomitoria*	Poison devil pepper	Apocynaceae	Tree	14	X			
2	*Alstonia boonei*	Stool wood	Apocynaceae	Tree	14	X			
3	*Coco nucifera*	Coconut tree	Arecaceae	Tree	4	X			
4	*Anarcadium occidetalis*	Cashew nut	Anacardiaceae	Tree	2			X	
5	*Eleais guineensis*	Palm tree	Arecaceae	Tree	78	X			
6	*Cassia sp*	Candle bush	Fabaceae	Shrub	28	X			
7	*Bambusa vulgasis*	Bamboo	Bambusae	Shrub	18	X			
8	*Alchornea cordifolia*	Christmas bush	Euphorbiaceae	Tree	22	X			
9	*Dacryodes edulis*	Bush pear	Burseraceae	Tree	2			X	
10	*Magifera indica*	Mango	Anacardiaceae	Tree	5	X			
11	*Ficus exasperate*	Sandpaper tree	Moraceae	Tree	20	X			
12	*Neuwbodia leavis*	Boundary tree	Bynoiaceae	Shrub	38	X			
13	*Annona musicata*	Soursop	Anonaceae	Shrub	1	X			
14	*Ficus sur*	Sandpaper	Moraceae	Tree	4	X			
15	*Spondias moubin*	Hog plum	Anacardiaceae	Tree	18	X			
16	*Gmelina aborea*	Gmelin	Lamiaceae	Tree	14	X			
17	*Chrysophilum albidum*	Star apple (udara)	Sapotaceae	Tree	1				X
18	*Azadirachta indica*	Neem tree	Meliaceae	Tree	1				X
19	*Baphia nitida*	Camwood	Fabaceae	Tree	9	X			
20	*Albizia zygia*	Nongo	Fabaceae	Tree	28	X			
21	*Heavea brasilensis*	Rubber tree	Rubiaceae	Tree	6	X			
22	*Melicia excels*	African teak	Moraceae	Tree	2			X	
23	*Ceibax bombax*	Cotton tree	Malvaceae	Tree	5	X			
24	*Cola nitida*	Kolanut	Sterculiaceae	Tree	2			X	
25	*Haura crepitans*	Sandbox paper	Euphorbiaceae	Tree	1				X
26	*Anthonota macrophylla*	Africa rosewood	Caesalpinaceae	Tree	7	X			
27	*Pertaclethra macrophylla*	Africa oil bean	Fabaceae	Tree	4	X			
28	*Anthocleista vogelii*	Velvet bush willow	Gentianaceae	Tree	13	X			
29	*Funtumia elastica*	West African rubber tree	Apocynaceae	Tree	16	X			
30	*Pycnanthus angolensis*	African nutmeg	Myristicaceae	Tree	6	X			
31	*Munsanga cecrepiodes*	Umbrella tree	Urticaceae	Tree	11	X			
32	*Ceiba buenopozenes*	Cotton tree	Malvaceae	Tree	4	X			
33	*Sterculia taefecantha*	African tragacanth	Sterculiaceae	Tree	2				X
34	*Raphia Africana otedoh*	Raffia palm	Arecaceae	Tree	3		X		
35	*Persea American*	Avocado pear	Lauraceae	Tree	1				X
36	*Tectona glandis*	Teak	Lamiaceae	Tree	2			X	

S/N	Scientific names	Common name	Family	Lifefor m	FRQ	A	C	O	R
37	*Teminelia superba*	Limba or Afara	Cobretaceae	Tree	3		X		
38	*Terminelia catapa*	Country almond	Combretaceae	Tree	2			X	
39	*Juglans regia*	Persia walnut	Juglandaceae	Tree	2			X	
40	*Antidesima lucinatum*	Antidesima	Phylathaceae	Tree	1				X
41	*Allabrakia floribunda*	Tallow tree	Clusiaceae	Tree	7	X			
42	*Boerhia leavis*	White broom weed	Rubiaceae	Shrub	1				X
43	*Futunima africana*	Rubber tree	Apocynaceae	Tree	2			X	
44	*Ricinodendron heudeticolic*	Ricinodendron	Euphorbiaceae	Shrub	2			X	
45	*Harungana madagascarensis*	Dragon’s blood tree	Hypericaceae	Tree	1				X
46	*Uapaca acuminate*	Uapaca	Phyllanthaceae	Tree	3		X		
47	*Mitragyna ciliate*	False abura	Rubiaceae	Tree	1				X
48	*Raphia hookeri*	Raphia palm	Arecaceae	Tree	2			X	
49	*Draceana aborea*	Dragon tree	Asparagaceae	Tree	3			X	
50	*Irvingia gabonensis*	Bush mango	Irvinginceae	Tree	1				X
51	*Tetraptera tetrapleura*	Soup perfume	Fabaceae	Tree	1				X
52	*Oxystigma mannii*	Spicy cedar	Fabaceae	Tree	1 (444)				X
53	*Chromoleana odorata*	Siam weed	Asteraceae	Herb	137	X			
54	*Axomopus compresus*	Carpet grass	Poaceae	Herb	5	X			
55	*Mimosa pudica*	Sensitive plant	Fabaceae	Herb	20	X			
56	*Amaranthus spinose*	Spiny amaranth	Amaranthaceae	Herb	45	X			
57	*Panicum maximum*	Guinea grass	Poaceae	Herb	80	X			
58	*Urena labota*	Caditto	Malvaceae	Herb	16	X			
59	*Brachiaria deflex*	Elephant grass	Poaceae	Herb	33	X			
60	*Boerhavia diffusa*	Red spidering	Nyctaginaceae	Herb	8	X			
61	*Larpatea aesthes*	Stringing herb	Peperaceae	Herb	6	X			
62	*Peperomia pellucid*	Silver plant	Urticaceae	Herb	3				
63	*Spermacole ocymoides*	Ezecma plant	Rubiaceae	Herb	7	X			
64	*Saccharum octicinanum*	Sugar cane	Andropogonem	Herb	2				
65	*Eleusine indica*	Bull grass	Poaceae	Herb	8	X			
66	*Larpater ovalifolia*	Striging nettle	Urticaceae	Herb	3				
67	*Sida acuta*	Broom weed	Malvaceae	Herb	47	X			
68	*Andropogon tectorum*	Giant blue-stem grass	Poaceae	Herb	27	X			
69	*Chrysopogon aciculatus*	Love grass	Poaceae	Herb	22	X			
70	*Calapogonium mucunoides*	Calapo	Poaceae	Herb	18	X			
71	*Phyllanthus amarus*	Egg woman	Euphorbiaceae	Herb	20	X			
72	*Caladium bicolin*	Devils cocoyam	Araceae	Herb	29	X			
73	*Euphorbia heterophylla*	Spurge weed	Euphorbiaceae	Herb	20	X			

S/N	Scientific names	Common name	Family	Lifeform	FRQ	A	C	O	R
74	*Spigelia enthelmia*	Warm weed	Potaliaceae	Herb	7	X			
75	*Centrosema pubescens*	Blue cento	Fabaceae	Herb	8	X			
76	*Tithonia diversifolia*	Mexican sunflower	Asteraceae	Herb	4	X			
77	*Imperata cylindrical*	Speargrass	Poaceae	Herb	13	X			
78	*Commelina beghalensis*	Wandering jew	Commelinaceae	Herb	6	X			
79	*Zea mays*	Maize	Maydeae	Herb	37	X			
80	*Cyperus spp*		Cyperaceae	Herb	2			X	
81	*Cleome rutidosperma*	Consumption weed	Corpparidaceae	Herb	2			X	
82	*Croton lobutus*		Euphorbiaceae	Herb	3		X		
83	*Sesamum indicum*	Beni seed	Pedaliaceae	Herb	1				X
84	*Ageratum conyzoides*	Goat weed	Asteraceae	Herb	4	X			
85	*Canna indica*	Canna lily	Cannaceae	Herb	2			X	
86	*Alternanthera sessilis*	Khallei weed	Amaranthaceae	Herb	2			X	
87	*Costus afer*	Bush cane	Costaceae	Herb	3		X		
88	*Indigofera hinsituta*	Indigo	Fabaceae	Herb	2			X	
89	*Kyllingo bulbosa*	Sedge	Cyparaceae	Herb	2 (644)			X	
				Total	1088	51	8	17	13

A = Abundant, C = Common, O = Occasional, R = Rare. Source: Authors' fieldwork analysis, 2024.

The Shannon-Wiener diversity index for the study area was calculated at H = 3.9, indicating high overall species diversity, while species evenness was calculated at 0.03, a markedly low value indicating that abundance is concentrated in relatively few species rather than being spread evenly across the recorded community.

Table 2. Trees/shrubs density of species encountered along the catena

S/N	Scientific names	Common name	Family	Lifeform	Upper slope	Middle slope	Lower slope
1	*Rauvolfia vomitoria*	Poison devil pepper	Apocynaceae	Tree	7	2	5
2	*Alstonia boonei*	Stool wood	Apocynaceae	Tree	5	5	4
3	*Coco nucifera*	Coconut tree	Arecaceae	Tree	0	3	1
4	*Anarcadium occidetalis*	Cashew tree	Anacardiaceae	Tree	0	1	1
5	*Eleais guineensis*	Palm tree	Arecaceae	Tree	14	34	44
6	*Cassia sp*	Candle bush	Fabaceae	Shrub	8	10	10
7	*Bambusa vulgasis*	Bamboo	Bambusae	Shrub	5	5	7
8	*Alchornea cordifolia*	Christmas bush	Euphorbiaceae	Tree	6	5	13
9	*Dacryodes edulis*	Bush pear	Burseraceae	Tree	0	5	2
10	*Magifera indica*	Mango	Anacardiaceae	Tree	0	2	2
11	*Ficus exasperate*	Sandpaper tree	Moraceae	Tree	7	6	7
12	*Neuwbodia leavis*	Boundary tree	Bynoiaceae	Shrub	3	18	17
13	*Annona musicata*	Soursop	Anonaceae	Shrub	0	0	1
14	*Ficus sur*	Sand paper	Moraceae	Tree	1	0	1
15	*Spondias moubin*	Hog plum	Anacardiaceae	Tree	3	8	7
16	*Gmelina aborea*	Gmelin	Lamiaceae	Tree	0	5	6
17	*Chrysophilum albidum*	Star apple	Sapotaceae	Tree	0	0	1

S/N	Scientific names	Common name	Family	Lifeform	Upper slope	Middle slope	Lower slope
18	*Azadirachta indica*	Neem tree	Meliaceae	Tree	0	0	1
19	*Baphia nitida*	Camwood	Fabaceae	Tree	3	4	2
20	*Albizia zygia*	Nongo	Fabaceae	Tree	9	10	0
21	*Heavea brasilensis*	Rubber tree	Rubiaceae	Tree	0	6	0
22	*Melicia excels*	African teak	Moraceae	Tree	0	2	1
23	*Ceibax bombax*	Cotton tree	Malvaceae	Tree	1	3	1
24	*Cola nitida*	Kolanut	Sterculiaceae	Tree	0	2	0
25	*Haura crepitans*	Sand box paper	Euphorbiaceae	Tree	0	1	0
26	*Anthonota macrophylla*	Africa rosewood	Caesalpinaceae	Tree	0	5	3
27	*Pertaclethra macrophylla*	Africa oil bean	Fabaceae	Tree	0	2	2
28	*Anthocleista vogelii*	Velvet bush willow	Gentianaceae	Tree	3	2	6
29	*Funtumia elastica*	West African rubber tree	Apocynaceae	Tree	3	11	2
30	*Pycnanthus angolensis*	African nutmeg	Myristicaceae	Tree	0	3	3
31	*Munsanga cecrepiodes*	Umbrella tree	Urticaceae	Tree	0	11	0
32	*Ceiba buenopozenes*	Cotton tree	Malvaceae	Tree	0	4	0
33	*Sterculia tragacantha*	African tragacantha	Sterculiaceae	Tree	0	2	0
34	*Raphia Africana otedoh*	Raffia palm	Arecaceae	Tree	0	0	3
35	*Persea American*	Avocado pear	Lauraceae	Tree	0	0	1
36	*Tectona glandis*	Teak	Lamiaceae	Tree	0	1	1
37	*Teminelia superba*	Limba or Afara	Cobretaceae	Tree	0	3	0
38	*Terminelia catapa*	Country almond	Combretaceae	Tree	0	2	0
39	*Juglans regia*	Persia walnut	Juglandaceae	Tree	0	1	1
40	*Antidesima lucinatum*	Antidesima	Phylathaceae	Tree	0	1	0
41	*Allabrakia floribunnda*	Tallow tree	Clusiaceae	Tree	1	2	4
42	*Boerhia leavis*	White broom weed	Rubiaceae	Shrub	0	0	1
43	*Futunima africana*	Rubber tree	Apocynaceae	Tree	0	2	0
44	*Ricinodendron heudeticolic*	Ricinodendron	Euphorbiaceae	Shrub	0	2	0
45	*Harungana madagascarensis*	Dragon’s blood tree	Hypericaceae	Tree	0	1	0
46	*Uapaca acuminate*	Uapaca	Phyllanthaceae	Tree	0	3	0
47	*Mitragyna ciliate*	False abura	Rubiaceae	Tree	0	1	0
48	*Raphia hookeri*	Raphia palm	Arecaceae	Tree	0	2	0
49	*Draceana aborea*	Dragon tree	Asparagaceae	Tree	0	0	3
50	*Irvingia gabonensis*	Bush mango	Irvinginceae	Tree	0	0	1
51	*Tetraptera tetrapleura*	Soup perfume	Fabaceae	Tree	0	0	1
52	*Oxystigma mannii*	Spicy cedar	Fabaceae	Tree	0	0	1
	TOTAL				79	201	164

Source: Authors' fieldwork analysis, 2024.

Variation in Tree/Shrub Species Composition along the Catena

The one-way ANOVA (Table 3) returned $F = 2.581$, $p = 0.079$, a probability value greater than the 5% (0.05) significance level, indicating no statistically significant variation in tree/shrub species density along the catena when the three slope segments are compared as a whole. The Post Hoc Test of multiple comparisons (Table 4) nonetheless showed that tree/shrub species distribution and density in the middle slope differed significantly from the upper slope (mean difference = 2.288, $p = 0.030$), but did not differ significantly from the lower slope (p = 0.107); tree/shrub density in the lower slope, in turn, did not differ significantly from either of the other two slope segments.

Table 3. ANOVA result of the variation in tree/shrub species composition along the catena

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	146.577	2	73.288	2.581	.079
Within Groups	4343.731	153	28.390		
Total	4490.308	155			

Table 4. Multiple comparisons of tree/shrub species composition and density across the catena

(I) id	(J) id	Mean Difference (I-J)	Std. Error	Sig.
Upper slope	Middle slope	-2.288*	1.045	.030
Upper slope	Lower slope	-1.692	1.045	.107
Middle slope	Upper slope	2.288*	1.045	.030
Middle slope	Lower slope	.596	1.045	.569
Lower slope	Upper slope	1.692	1.045	.107
Lower slope	Middle slope	-.596	1.045	.569

** Significant at the 5% alpha level.*

DISCUSSION OF FINDINGS

The absence of a statistically significant variation in tree/shrub species density along the catena when considered as a single gradient ($F = 2.581$, $p > 0.05$) is consistent with the findings of Aweto and Iyamah (1993), who similarly reported no marked variation in vegetation structure along a catena in south-western Nigeria, except near the river bank, where trees were shorter and tree density lower. This suggests that, at the whole-catena scale, the Itu toposequence behaves relatively uniformly in terms of tree/shrub stocking, and that the overall taxonomic richness recorded (89 species across 59 families) is not simply an artefact of sampling one particularly favourable slope segment.

At a finer scale, however, the middle slope stood out as significantly more diverse than the upper slope, a result that corroborates Pickering and Green (2009), who reported that vascular plant species distribution was influenced by topographic position relative to the catena summit, confirming that species composition and abundance are shaped by topographic attributes rather than occurring at random. This difference may reflect drainage conditions: the middle slope is typically well-drained and less prone to flooding than the lower slope, while the upper slope is more exposed to erosion and nutrient loss. This interpretation is consistent with Aweto (1976), who studied plant distribution in a swampy forest and recorded low tree density in the lower slope, attributing it to the prolonged effects of water-logging on plant growth and vigour — a mechanism distinct from, but complementary to, the erosion-driven pressure evident on the upper slope of the present study area.

The high overall diversity index (H = 3.9) alongside very low species evenness (0.03) indicates that, although the study area supports a large number of species, abundance is concentrated in relatively few of them, a pattern typical of secondary, human-influenced tropical vegetation rather than of an undisturbed climax forest. This interpretation is reinforced by direct field observation: heavy human encroachment on the sloping landscape, through agricultural activity and fuel-wood logging, was observed throughout the study area. This encroachment appears to be promoting eluviation and illuviation processes that affect vegetation composition, most likely by exposing land to erosion, which in turn disrupts the distinct plant species ecosystem — a probable consequence of overexploitation of the area's plant resources rather than of natural topographic controls acting alone. Read together, the statistical and observational evidence suggest that anthropogenic pressure is now interacting with, and in places overriding, the natural catena-driven gradient in shaping the vegetation of Itu Local Government Area.

CONCLUSION

This study set out to document plant species composition and diversity along the catena segments of Itu Local Government Area and to test whether tree/shrub species density varies significantly along that gradient. Eighty-nine species from 59 families were recorded, with high overall diversity but markedly low evenness, and no statistically significant variation in tree/shrub density was found across the catena as a whole, although the middle slope emerged as significantly more diverse than the upper slope. These findings confirm that topographic position continues to shape woody species distribution in the study area, but that this natural gradient is now overlaid by the effects of agricultural encroachment and fuel-wood logging, which together appear to be eroding the species-rich character of this catena ecosystem. The study contributes a baseline phytogeographic inventory for Itu Local Government Area against which future change can be measured, and underlines the practical relevance of catena-scale vegetation surveys for local conservation and land-use planning.

RECOMMENDATION

Based on the findings, terracing is recommended on the upper slope to control erosion, given the comparatively low nutrient status of that segment; the addition of organic manure and crop residue would further improve soil fertility there. The destruction of lush forest vegetation for fuel-wood harvesting and illegal logging should be controlled to preserve this species-rich ecosystem, and periodic monitoring of species composition along the catena is recommended to track the long-term impact of these anthropogenic pressures and to guide future conservation interventions by the relevant local government and environmental agencies.

DECLARATIONS

Ethical approval: Not applicable.

Informed consent: Not applicable.

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Conflict of interest: The authors declare no conflict of interest.

Data availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Aweto, A. O. (1976). Changes in soil characteristics associated with secondary succession in a part of the forest zone of south-western Nigeria. Postgraduate Students/Staff Seminar, Department of Geography, University of Ibadan.

Aweto, A. O., & Iyamah, C. C. (1993). Catenary variation of vegetation in a swamp forest in south-western Nigeria. International Journal of Environmental Studies, 43(2-3), 133–140.

Begum, F., Bajracharya, R. M., Sharma, S., & Sitaula, B. K. (2010). Influence of slope aspect on soil physicochemical and biological properties in the mid hills of central Nepal. International Journal of Sustainable Development World, 17, 438–443.

Brant, V., Pivec, J., Venclová, V., Soukup, J., & Holec, J. (2006). The influence of different soil vegetation covers on the volumetric water content in upper soil layers. Plant, Soil and Environment, 52(6), 275–281.

Eneyo, V. B. (2026a). *Tourism development systems and planning models*. In *Sustainable tourism and environmental systems* (pp. 213–227).

Eneyo, V. (2026b). *Environmental management and impact assessment in tourism*. In *Sustainable tourism and environmental systems* (pp. 228–248).

Eni, D. D., Iwara, A. I., & Offiong, R. A. (2011). Analysis of soil-vegetation interrelationships in a south-southern secondary forest of Nigeria. International Journal of Forestry Research, 3(2), 128–147. https://doi.org/10.1155/2012/469326

Essoka, A., & Jaiyeoba, A. (2008). A study of soils formed along a toposequence granitic-gneiss material in a rainforest region of Cross River State-southeastern Nigeria. University of Calabar.

Fasona, M. J., & Omojola, A. S. (2005). Climate change, human security, and communal clashes in Nigeria. Human Security and Climate Change, An International Workshop, Asker, Norway (Unpublished conference paper).

Idoga, S., & Azagaku, D. E. (2005). Characterization and classification of soils of Janta area, Plateau State of Nigeria. Nigeria Journal of Soil Science, 15, 116–122.

Jamieson, T., Gordon, R., Cochrane, L., & Patterson, G. (2004). Fundamental aspects of soil-water-plant relationships (Technical Report). Resource Stewardship Division, Nova Scotia Department of Agriculture and Fisheries, Truro, Nova Scotia.

Jenny, H. (1941). Factors of soil formation: A system of quantitative pedology. McGraw Hill.

Khormali, F., Ayoubi, S., Foomani, F. K., Fatemi, A., & Hemmati, K. A. (2007). Tea yield and soil properties as affected by slope position and aspect in Lahijan area, Iran. International Journal of Plant Production, 1, 245–259.

Moorman, T. B., Cambardella, C. A., James, D. E., Karlen, D. L., & Kramer, L. A. (2004). Quantification of tillage and landscape effects on soil carbon in small Iowa watersheds. Soil and Tillage Research, 78, 225–236.

Pickering, C. M., & Green, K. (2009). Vascular plant distribution in relation to topography, soils, and micro-climate at five Gloria sites in the Snowy Mountains, Australia. Australian Journal of Botany, 57(3), 189–199.

Rodrigues, R. S., Jhonathan-de, O. S., Walnir, G. F., Rubens, M. S., & Andreza, V. N. (2018). The influence of soil on vegetation structure and plant diversity in different tropical savanna and forest habitats in Brazil. Journal of Plant Ecology, 2(3), 115–137.

Rodriguez-Iturbe, I. (2000). Ecohydrology: A hydrologic perspective of climate-soil vegetation dynamics. Water Resources Research, 36(1), 3–9.

Runhong, L., Yuanfang, P., Han, B., Shichu, L., Yong, J., Hongrun, J. N., & Wanqing, H. (2020). Variations in soil physicochemical properties along slope position gradient in secondary vegetation of the hilly region, Guilin, southwest China. Environmental Earth Sciences, 79, 1–12.

Tsui, C. C., Chen, Z. S., & Hsieh, C. F. (2004). Relationships between soil properties and slope position in a lowland rain forest of southern Taiwan. Geoderma, 123, 131–142.

Tunçay, T., Dengiz, O., Bayramin, I., Kilic, S., & Baskan, O. (2019). Assessing topographic wetness index as a tool for digital soil mapping. Eurasian Journal of Soil Science, 8(1), 40–49.

Van der Maarel, E. (2004). Vegetation ecology. Blackwell.

Zhang, X. Y., Liu, M. Z., Zhao, X., Li, Y. Q., Zhao, W., Li, A., Chen, S., Chen, S. P., Han, X. G., & Huang, J. H. (2018). Topography and grazing effects on storage of soil organic carbon and nitrogen in the northern China grasslands. Ecological Indicators, 93, 45–53.