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Original Research

Comparative Assessment of Qualitative Land Capability Classification and a Parametric Capability Index Along a Toposequence in Southwestern Nigeria

Fakorede Bolaji Martins* & Fasina Abayomi Sunday

Department of Soil Science and Land Resources Management, Federal University Oye-Ekiti, Nigeria

***Corresponding Author Details:**
Email: bolajiofgod@gmail.com

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Abstract

Land capability assessment provides a broad framework for identifying the degree and nature of land limitations that govern sustainable agricultural use. This study compared a qualitative USDA-type capability classification with a parametric capability index for six pedons distributed across upper-, middle-, and lower-slope positions along a toposequence in Erinmope-Ekiti, southwestern Nigeria. Two profile pits were examined at each slope position, described morphologically, and sampled by genetic horizon for routine physical and chemical analyses. The soils were predominantly sandy loam to clay, with clay commonly increasing with depth. Pedon-level mean pH ranged from 5.36 to 6.38, electrical conductivity from 0.46 to 2.60 dS m^{-1}, organic carbon from 8.57 – 22.80 g kg^{-1}, effective cation exchange capacity from 1.52 to 2.94 cmol kg^{-1}, and base saturation from 59.24 to 94.47%. Under the qualitative system, low ECEC was the principal class-determining soil limitation, and the pedons were classified as Class V; erosion, drainage, salinity and effective soil depth contributed secondary limitations at specific positions. The parametric procedure was implemented using the square-root aggregation equation and the supplied land-quality ratings, produced the capability indices of 13.08, 12.74, 11.32, 12.96, 10.26 and 12.31% for US1, US2, MS1, MS2, LS1 and LS2, respectively. The indices fall within Class VII. The difference between the two outputs arises principally from the aggregation rule: the qualitative approach is controlled by the most severe limitation, while the parametric index compounds the lowest ratings of the major land-quality groups. The results demonstrate that method selection can materially affect the apparent severity of land limitations and that capability interpretation should retain the individual limitation profile rather than rely on the overall class alone. Management should emphasize erosion control, organic-matter maintenance, balanced nutrient management, protection of lower-slope drainage conditions, and monitoring of sites with relatively high electrical conductivity.

1. Introduction

Land capability assessment provides a broad framework for determining the degree of use and management that land can sustain without unacceptable deterioration (AbdelRahman, 2023). It differs from crop-specific land suitability evaluation: capability concerns the general capacity of land for broad classes of use and conservation management, whereas suitability asks how well a defined land unit meets the requirements of a specified use. The FAO framework emphasizes the systematic identification of land qualities, limitations and land-use requirements, while the USDA capability system groups soils according to the severity and persistence of limitations affecting sustained agricultural use (FAO, 1976; Soil Survey Staff, 2017). This distinction is essential as both concepts utilize similar soil and landscape data while addressing fundamentally different interpretive questions. Topography is a particularly important control on capability because slope position modifies runoff, erosion risk, drainage, soil-water movement, redistribution of fine particles, and the lateral movement and accumulation of organic and mineral constituents. In southwestern Nigeria, studies of toposequences have repeatedly shown systematic but site-specific changes in profile depth, texture, drainage, organic matter, exchange properties and nutrient status with landscape position (Ojedokun *et al*., 2021; Osinuga *et al*., 2020; Fawole *et al*., 2023). Such variability means that capability cannot reliably be inferred from a single representative profile when a landscape contains contrasting upper-, middle-, and lower-slope environments.

Two broad approaches are relevant to the present comparison. Qualitative capability classification assigns land characteristics to limitation classes and uses the most severe class-

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determining limitation to determine the overall capability class. This structure is characteristic of the USDA land-capability concept, in which erosion, wetness, soil and climatic limitations are expressed through classes and subclasses (Alabi, 2021). A parametric approach, by contrast, converts individual land characteristics into numerical ratings and combines them mathematically. The square-root formulation associated with the Sys-Ogunkunle land evaluation tradition has been widely applied in land-evaluation studies, including work demonstrating that low fertility, texture, drainage and other constraints can substantially reduce composite indices (Osinuga *et al*., 2020).

A qualitative classification is deliberately conservative with respect to the most severe limitation: one factor can control the overall class even when the remaining properties are favourable. A parametric index instead allows several moderate limitations to reduce a continuous score simultaneously. Consequently, two methods can describe the same soil accurately while assigning different classes as they answer the aggregation problem differently. Recent studies have emphasized this broader issue. Ukaegbu *et al*. (2023), for example, found that different land evaluation systems did not always produce equivalent interpretations for soils of the southeastern Nigerian coastal plain, underscoring the need to understand what each system actually aggregates rather than treating outputs as directly interchangeable. Madueke *et al*. (2021) and Adekiya *et al*. (2022) stated that most studies have commonly focused on soil characterization, crop-specific suitability evaluation, or the application of a single capability or land-evaluation system. A paired comparison of qualitative and parametric capability aggregation using the same landscape can therefore help distinguish differences arising from the aggregation rules from those arising from differences in soil properties.

Erinmope-Ekiti provides a useful setting for this comparison because its gently undulating, schist-derived landscape contains distinct upper-, middle-, and lower-slope environments with differences in profile depth, clay accumulation and wetness expression. This study therefore aimed to (i) characterize the morphological and physicochemical variation of soils along the toposequence; (ii) classify the pedons using a qualitative land-capability procedure; (iii) calculate a parametric capability index using the stated square-root formulation; and (iv) compare the two outputs to determine how aggregation method influences the interpretation of land-use limitations and management requirements. The central hypothesis was that the two approaches would identify broadly similar limiting processes but could assign different overall capability classes because their aggregation rules differ.

2. Materials and Methods

2.1 Study area

The study was conducted in Erinmope-Ekiti, Ekiti State, southwestern Nigeria, within the southern Guinea savanna zone (Figure 1). The investigated landscape is a gently undulating toposequence developed over Precambrian Basement Complex materials, with schist-derived parent material. The study area lies between 8°02′ to 8°03′ N and 5°08′ to 5°09′ E, at elevations of about 540–560 m above sea level. The climate has distinct wet and dry seasons, with annual rainfall of approximately 1,250–1,600 mm, mean annual temperature of about 26–28 °C, and mean annual relative humidity of approximately 81.7% during wet cropping cycle (Fakorede *et al*., 2025). These conditions, together with the gently undulating relief and basement-complex geology, provide a suitable environment for examining the interaction of topography, soil development and land limitations.

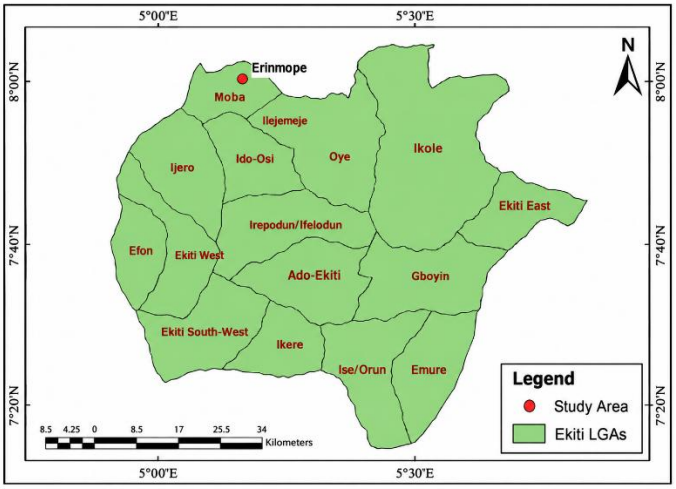


Figure 1. Map showing the location of the study area

2.2 Field survey, profile description and sampling

A reconnaissance survey was undertaken to identify relatively homogeneous landscape units and establish a representative toposequence crossing upper-, middle- and lower-slope positions. Two profile pits were excavated at each position, giving six pedons (US1, US2, MS1, MS2, LS1 and LS2). Profile locations were geo-referenced using a GPS receiver (Table 1). Morphological descriptions followed standard soil-survey terminology and included horizon depth, colour, mottling, texture, structure, consistence, roots, inclusions and boundary characteristics (Soil Science Staff, 2017). Soil samples were collected by genetic horizon, air-dried, gently disaggregated and passed through a 2-mm sieve before laboratory analysis.

Table 1. Geographic coordinates, elevation, and landscape position of the studied pedons

Slope position	Pedon	Latitude (°N)	Longitude (°E)	Elevation (m)
Upper Slope	US1	8.0644	5.14148	557
Upper Slope	US2	8.065	5.139	554
Middle Slope	MS1	8.0597	5.14152	552
Middle Slope	MS2	8.0575	5.13833	551
Lower Slope	LS1	8.06106	5.14193	545
Lower Slope	LS2	8.06229	5.14013	543

2.3 Laboratory analyses

Particle-size distribution was determined by the hydrometer method (Bouyoucos, 1962). Soil bulk density was determined by the core method. Soil pH was determined potentiometrically in water and 1 M KCl using a glass-electrode pH meter. Electrical conductivity (EC) was measured in a 1:2.5 soil-to-water extract. Organic carbon was determined by dichromate wet oxidation (Nelson and Sommers, 1982), and total nitrogen by the micro-Kjeldahl procedure (Bremner and Mulvaney, 1982). Available phosphorus was determined following the IITA procedure (IITA, 1979). Exchangeable Ca, Mg, K and Na were extracted with neutral ammonium acetate and quantified using flame photometry and atomic absorption spectrophotometry, as appropriate. Exchangeable acidity was determined by 1 N KCl extraction followed by titration with 0.05 N NaOH (McLean, 1965). Total exchangeable bases (TEB) were calculated as Ca + Mg + K + Na; ECEC was calculated as TEB + exchangeable Al + exchangeable H; and base saturation (BS) was calculated as 100 × TEB/ECEC.

2.4 Qualitative land-capability classification

The qualitative procedure was based on the qualitative USDA land-capability concept of Klingebiel and Montgomery (1961), as operationalized by the critical limits used in the study. The assessment considered erosion hazard, slope, drainage, flooding, salinity, rock fragments, effective soil depth, ECEC, surface texture, effective precipitation and climate. Each characteristic was assigned to a capability class (Table 2). The overall capability class was determined by the most severe class-determining limitation, while subclasses were used to identify the type of limitation. This approach follows the central logic of the USDA capability system, in which the class expresses the aggregate degree of limitation but the subclass identifies the dominant kind of restriction.

2.5 Parametric capability index

The parametric procedure followed the numerical land-evaluation tradition associated with Sys *et al*. (1993) and its application by Ogunkunle (1993). Individual land characteristics were represented by percentage ratings on a 0–100 scale. For each major land-quality group; erosion, excess water, soil limitation and climate—the lowest rating was selected. The study's square-root aggregation equation was then applied as:

$$IC = A \times \sqrt{(B \times C \times D) / 1000} \quad (1)$$

where IC is the capability index; A is the lowest rating among the four major land-quality groups; and B, C and D are the lowest ratings from the remaining three groups. The class boundaries used were Class I (70–100%), II (50–69%), III (30–49%), IV (25–29%), V (20–24%), VI (15–19%), VII (10–14%) and VIII (0–9%).

Table 2. Study-applied critical limits used for qualitative land-capability classification

Property	I	II	III	IV	V	VI	VII	VIII
Erosion hazard – erosion	None/slight	Moderate	Severe	Very severe	None/slight*	Not class-determining	Not class-determining	Not class-determining
Slope angle (%)	≤1	≤3	≤5	≤10	≤18	≤35	≥35	≥35
Drainage class	Well/mod. well	Mod. well/somewhat poorly	Somewhat poorly/poorly	Poor	Not class-determining	Not class-determining	Not class-determining	Not class-determining
Flooding	None	Rare	Occasionally moderate	Frequent/severe	Frequent—prevents normal production	Frequent—prevents normal production	Frequent—prevents normal production	Frequent—prevents normal production
Salinity, EC (dS m−1)	<1	1–2	≤3	>3	4–8	8–16	>16	>16
Rock outcrop, stones & boulders	<0.1	≥0.1 to <3	≥3 to <15	≥15 to <50	≥15 to <50	≥15 to <50	≥50 to <90	≥90
Effective soil depth (cm)	>90	45–90	22.5–45	7.5–22.5	<7.5	0	0	0
ECEC (cmol kg^{-1})	25–40	12–25	6–12	>5	≤5	2	1	0
Surface texture	SL, SCL, CL; LS if <20 in thick	LS, S or SC; C if <60% clay	C (≥60% clay)	Coarse/very heavy texture	Very coarse sand	Not class-determining	Not class-determining	Not class-determining
Effective precipitation (mm)	≥1117.6	787.4–<1117.6	635–<787.4	482.6–<635	Not class-determining	284–482.6	<284	Not class-determining
Nature of climate	Humid; rainfall evenly distributed	Humid; occasional dry spells	Subhumid; drought frequently reduces yield	Semi-arid; drought frequently reduces yield	Semi-arid	Arid	Arid	Arid

SL = sandy loam; SCL = sandy clay loam; CL = clay loam; LS = loamy sand; S = sand; SC = sandy clay; C = clay.

2.6 Data analysis

Data generated across the horizons in the pedons were subjected to descriptive statistics using IBM SPSS Statistics (Version 26.0). Mean values, standard deviations (± SD), and coefficient of variation (CV) were computed to characterize the variability of the measured soil properties. The LCC calculations were independently checked by tracing each assigned capability class to the corresponding individual factor ratings and the minimum rating within each capability group. A comparative dual-axis land capability visualization chart was plotted using Python's Matplotlib library.

3. Results and Discussion

3.1 Morphological characteristics

The soil depth ranged from 81 cm in US2 to 146 cm in MS1, with the middle-slope pedons having the deepest profiles (Table 3). Surface horizons were mainly loam or sandy loam, whereas subsurface horizons commonly became sandy clay loam, sandy clay, clay loam or clay, indicating pronounced textural differentiation with depth. This pattern, together with strong subangular to angular blocky structure and very sticky to very plastic consistence in several subsoil horizons, indicates substantial subsoil development (Regassa *et al*., 2023). Clay translocation was particularly evident in MS1 and MS2, where clay coatings (cutans) occurred within the Btg horizons. The progressive increase in clay content and development of clay-enriched subsoil horizons is consistent with eluviation and illuviation processes (Pal, 2021). These features indicate that pedogenesis has substantially modified the original parent material and produced strongly differentiated profiles along the slope. Evidence of periodic saturation was strongest in the lower-slope soils. LS1 and LS2 contained numerous prominent mottles within successive Btg horizons, beginning at relatively shallow depths. Recent studies by Bello *et al*. (2026) affirmed that the abundance and persistence of these mottles indicate fluctuating soil-water conditions and restricted internal drainage, consistent with their aquic morphological expression. Although mottling also occurred in some upper- and middle-slope horizons, its expression was generally less continuous than in the lower-slope pedons. Parent-material influence was also evident, particularly in US1, where partly weathered schist, saprolitic material, stones and hard-pan materials occurred within the profile. These features may constrain effective rooting depth and influence internal water movement. The pedons showed clear vertical and lateral morphological differentiation along the toposequence, reflecting differences in slope position, drainage, parent material and pedogenic development. Similar relationships between landscape position and soil morphological variability have been reported in comparable tropical landscapes (Alabi, 2021; Fawole *et al*., 2023). The observed morphological differentiation is consistent with the soil classifications, particularly the Alfisol-related designations associated with clay-enriched subsoils and the Aquic subgroup classification of LS1 and LS2, which is supported by their prominent and persistent mottling and evidence of periodic saturation.

3.2 Physicochemical properties

The pedon-level physicochemical data (Table 4) demonstrate substantial heterogeneity across the toposequence. Clay ranged from 244.80 to 324.80 g kg^{-1}, sand from 495.20 to 695.20 g kg^{-1}, and silt from 40.00 to 180.00 g kg^{-1}. The relatively coarse surface textures and finer subsurface horizons are consistent with the morphological observations. Silt showed a higher CV (34.34%) than clay (10.71%), indicating greater relative spatial variability in the silt fraction. Such variability may reflect differences in erosion, deposition, particle sorting, parent-material expression and pedogenic redistribution. Soil pH ranged from 5.36 to 6.38, indicating moderately to slightly acidic conditions (Babalola *et al*., 2024). The highest pH occurred in MS2, while the lowest occurred in US1. A tendency toward higher pH at some lower positions is consistent with possible downslope leaching of base cations, but this should be regarded as an interpretation rather than a demonstrated transport mechanism. Electrical conductivity (EC) ranged from 0.46 to 2.60 *d*S m^{-1} and had a high CV (58.96%). The absolute EC values indicate that soluble salts were not a landscape-wide severe constraint under the criteria used, although the higher values at MS2 and LS1 justify monitoring where drainage and evaporation could favour salt accumulation. Organic carbon varied from 8.57 to 22.80 g kg^{-1} among the six pedons and showed a CV of 39.38%, while organic matter ranged from 14.77 to 39.30 g kg^{-1} and had a nearly identical CV of 39.37%. The relatively high variability was largely associated with the markedly higher OC and OM values recorded in LS2 (22.80 and 39.30 g kg^{-1}, respectively), compared with the other pedons. Total nitrogen ranged from 1.16 to 1.68 g kg^{-1} and available P from 8.28 to 11.88 mg kg^{-1}. Exchangeable Ca and Mg dominated the exchange complex, while ECEC ranged from 1.52–2.94 cmol kg^{-1}, indicating a low value (Yang *et al*., 2022). Base saturation (BS) was comparatively high (59.24–94.47%), demonstrating that a high proportion of the small exchange complex was occupied by basic cations. According to Da Silva *et al*. (2022), the nature of the parent materials influences BS of the soil. The combination of low ECEC, variable organic carbon, changing clay content and lower-slope wetness is particularly important for land capability.

3.3 Qualitative land-capability classification

The qualitative classification identified low ECEC as the dominant soil limitation across the toposequence (Table 5). With all the pedons exhibiting ECEC values ≤5 cmol kg^{-1}, the ECEC criterion was consistently placed in Class V (Osinuga *et al*., 2026). The qualitative capability class is therefore Class V for all the pedons. Although the overall class is uniform, the subclass structure reveals important spatial differences. Erosion limitations were stronger at the middle-slope positions, drainage limitations were more pronounced at the lower slope, salinity ratings were relatively more restrictive at

Table 3. Morphological characteristics of the soils

Horizon	Depth	Colour	Mottles	Texture	Structure	Consistence	Inclusion
US1 Typic Paleustalf							
A1	0–20	7.5YR 3/2, dark brown	None	Gravelly sandy loam	Weak, fine crumb	Slightly sticky–slightly plastic	Many roots and stones
A2	20–33	5YR 3/3, dark brown/reddish	None	Gravelly sandy loam	Weak, coarse crumb	Slightly sticky–slightly plastic	Many roots and stones
Btg1	33–52	2.5YR 4/6, red	Few, medium, distinct	Gravelly sandy clay	Strong, coarse crumb	Very sticky–very plastic	Many roots/stones; partly weathered schist
Btg2	52–117	2.5YR 4/4, reddish brown	Many/common, prominent	Sandy clay loam	Moderate, medium angular blocky	Slightly sticky–slightly plastic	Few roots; partly weathered schist
Btg3	117–143	2.5YR 4/8, red	Many/medium/distinct	Sandy clay	Strong, medium angular blocky	Very sticky–very plastic	Saprolite, weathered rock, hard pan
US2 Typic Haplustalf							
A1	0–18	7.5YR 2.5/3, very dark brown	None	Sandy loam	Strong, fine crumb	Slightly sticky–slightly plastic	Many roots
Btg1	18–29	5YR 5/3, reddish brown	None	Gravelly sandy loam	Strong, coarse crumb	Very sticky–very plastic	Many roots and stones
Btg2	29–65	2.5YR 4/6, red	Few, medium, faint	Sandy clay loam	Strong, coarse angular blocky	Very sticky–very plastic	Few roots and stones
Btg3	65–81	5YR 4/6, yellowish red	Common, fine, faint	Sandy clay loam	Strong, medium angular blocky	Very sticky–very plastic	Few roots and stones
MS1 Typic Haplustalf							
A1	0–13	7.5YR 2.5/3, very dark brown	None	Loam	Moderate, medium crumb	Slightly sticky–slightly plastic	Many roots
A2	13–25	7.5YR 3/2, very dark greyish brown	None	Sandy clay loam	Moderate, coarse crumb	Slightly sticky–slightly plastic	Many roots
Btg1	25–44	2.5YR 4/4, reddish brown	Few/common, faint	Sandy clay loam	Strong, medium subangular blocky	Very sticky–very plastic	Few roots; cutans
Btg2	44–88	5YR 4/6, yellowish red	Many	Sandy clay	Strong, medium subangular blocky	Slightly sticky–slightly plastic	—
Btg3	88–107	5YR 4/6, yellowish red	Common, medium, prominent	Clay	Strong, medium subangular blocky	Very sticky–very plastic	—
Btg4	107–146	2.5YR 4/6, dark red	Many, medium, prominent	Sandy clay	Strong, medium angular blocky	Very sticky–very plastic	—
MS2 Typic Paleustalf							
A1	0–22	7.5YR 3/3, dark brown	None	Loam	Moderate, medium subangular blocky	Slightly sticky–slightly plastic	Many roots
Btg1	22–36	7.5YR 3/4, dark brown	Few, medium, faint	Sandy clay loam	Strong, medium subangular blocky	Very sticky–very plastic	Many roots
Btg2	36–75	5YR 4/6, yellowish red	Many, medium, prominent	Clay	Moderate, medium subangular blocky	Very sticky–very plastic	Cutans

Table 3 Cont'd. Morphological characteristics of the soils

Horizon	Depth	Colour	Mottles	Texture	Structure	Consistence	Inclusion
Btg3	75–140	2.5YR 4/6, red	Many, medium, prominent	Clay	Strong, medium subangular blocky	Very sticky–very plastic	Few roots; cutans
LS1 Aquic Haplustalf							
A1	0–6	7.5YR 3/1, very dark grey	None	Loam	Moderate, medium crumb	Slightly sticky–slightly plastic	Many roots
A2	6–21	7.5YR 4/2, brown	None	Sandy loam	Moderate, fine crumb	Slightly sticky–slightly plastic	Many roots
Btg1	21–39	7.5YR 4/4, brown	Many, medium, prominent	Clay loam	Strong, medium subangular blocky	Very sticky–very plastic	–
Btg2	39–60	10YR 5/8, dark yellowish brown	Many, medium, prominent	Clay	Strong, medium subangular blocky	Very sticky–very plastic	Few roots
Btg3	60–110	10YR 5/6, yellowish brown	Many, medium, prominent	Clay	Strong, medium subangular blocky	Very sticky–very plastic	–
LS2 Aquic Haplustalf							
A1	0–10	7.5YR 2.5/2, very dark brown	None	Loam	Moderate, medium subangular blocky	Slightly sticky–slightly plastic	Many roots
A2	10–36	7.5YR 3/3, dark brown	None	Clay loam	Moderate, fine crumb	Slightly sticky–slightly plastic	Many roots and few stones
Btg1	36–52	5YR 4/4, reddish brown	Common, medium, distinct	Silty clay loam	Strong, medium subangular blocky	Very sticky–very plastic	Few roots
Btg2	52–92	2.5YR 4/8, red	Many, medium, prominent	Clay	Strong, medium subangular blocky	Very sticky–very plastic	Few roots
Btg3	92–120	2.5YR 4/6, red	Many, medium, prominent	Clay	Strong, medium subangular blocky	Very sticky–very plastic	–

Note. US = upper slope; MS = middle slope; LS = lower slope. Horizon designations and observations are retained from the field dataset.

Table 4. Pedon-level mean physicochemical properties

Pedon	Clay	Sand	Silt	BD	pH	EC	OC	OM	N	AvP	K	Na	Ca	Mg	Ex.Al^{3+}	Ex.H^{+}	ECEC	BS
	g kg^{-1}				H_2O	dS m^{-1}	g kg^{-1}			mg kg^{-1}	cmol kg^{-1}							%
US1	244.80	595.20	160.00	1.39	5.36	0.46	9.57	16.50	1.46	8.44	0.12	0.17	0.70	0.30	0.08	0.16	1.52	84.22
US2	324.80	595.20	80.00	1.35	5.76	1.27	12.23	21.09	1.16	9.53	0.09	0.11	1.00	0.40	0.08	0.24	1.92	83.34
MS1	304.80	635.20	60.00	1.33	5.84	0.56	14.41	24.84	1.68	11.56	0.17	0.17	0.80	0.60	0.08	1.12	2.94	59.24
MS2	264.80	695.20	40.00	1.37	6.38	2.32	11.13	19.19	1.37	11.88	0.54	0.30	1.40	0.50	0.04	0.12	2.89	94.47
LS1	324.80	495.20	180.00	1.30	6.12	2.60	8.57	14.77	1.65	8.28	0.24	0.36	1.30	0.80	0.08	0.16	2.93	91.82
LS2	304.80	595.20	100.00	1.23	5.58	0.69	22.80	39.30	1.34	9.69	0.37	0.13	0.70	0.50	0.16	0.32	2.18	77.98
SD	69.51	39.54	78.39	0.06	0.41	0.79	5.17	8.90	0.20	7.07	0.16	0.07	0.39	0.21	0.09	0.34	0.72	12.03
CV (%)	10.71	32.21	34.34	4.32	6.80	58.96	39.38	39.37	13.83	55.30	62.33	35.28	36.36	39.34	70.17	71.98	27.10	15.48

Note. AvP = available phosphorus; EC = electrical conductivity; OC = organic carbon; OM = organic matter; Ex.Al^{+3} = exchangeable aluminium; Ex.H^{+} = exchangeable hydrogen; ECEC = effective cation exchange capacity; BS = base saturation. SD = standard deviation; CV = coefficient of variation.

Table 5. Qualitative land-capability ratings and classes

Properties	Upper slope 1	Upper slope 2	Middle slope 1	Middle slope 2	Lower slope1	Lower slope 2
Erosion hazard (e)						
[1]Erosion	II	II	III	III	II	II
[2]Slope angle (%)	II	II	II	II	I	I
Excess water (w)						
[1]Drainage class	II	II	II	II	III	III
[2]Flooding	I	I	I	I	I	I
Soil limitation (s)						
[1]Salinity (EC- ds/m)	II	II	III	III	II	III
[2]Rock outcrop, stone and boulders	I	I	I	I	I	I
[3]Effective soil depth (cm)	I	II	I	III	I	I
[4]ECEC (cmol kg-1)	V	V	V	V	V	V
[5]Surface textural class	I	I	I	I	I	I
Climate (c)						
[1]Effective precipitation (mm)	I	I	I	I	I	I
[2]Nature of climate	I	I	I	I	I	I
Overall Capability Class	$Ve^{1,2}w^{1}s^{1,4}$	$Ve^{1,2}w^{1}s^{1,3,4}$	$Ve^{12}w^{1}s^{1,4}$	$Ve^{1,2}w^{1}s^{1,3,4}$	$Ve^{1}w^{1}s^{1,4}$	$Ve^{1}w^{1}s^{1,4}$

Note. The overall class is controlled by the most severe class-determining limitation. ECEC is the class-determining limitation in all the pedons. The subgroup notation e, w, s, and c denote erosion, excess water, soil, and climate, respectively.

MS1, MS2 and LS2, and effective depth imposed a limitation at US2 and especially MS2. These differences demonstrate why a single capability class should not be interpreted as evidence that the pedons are functionally identical. The class summarizes the overall severity of limitation; the subclass and underlying property data explain the management problem. Similar studies by Hun and Sarun (2026) declared that the dominance of ECEC is consistent with the broader interpretation of these soils as having limited nutrient-retention capacity despite relatively high base saturation. Low exchange capacity is particularly consequential where continuous cultivation and high rainfall can promote nutrient depletion. Land-evaluation studies likewise identify fertility and exchange properties among important constraints to agricultural use, although the relative importance of individual constraints varies with parent material, topography and land-use context (Ogunkunle, 1993; Ukaegbu *et al*., 2023).

3.4 Parametric capability index

The parametric ratings show a different pattern because the index incorporates the lowest rating from each major land-quality group (Table 6). The most restrictive ratings generally occurred in the soil-limitation group, particularly the ECEC-related rating (20–26), while erosion, drainage, and salinity also reduced the group minima. In contrast, the climate group remained comparatively favourable, with effective precipitation and climate ratings of 90 and 95, respectively. The contrast between the favourable climate group and the restrictive soil group indicates that climate was not a major constraint on the capability index in this landscape. The parametric capability indices are 13.08, 12.74, 11.32, 12.96, 10.26, and 12.31% for US1, US2, MS1, MS2, LS1, and LS2, respectively. The values of the pedons fall within the 10–14% interval corresponding to Class VII. The low indices reflect the combined effects of erosion, excess water, and soil limitations, despite the comparatively favourable climate ratings. Thus, the parametric approach integrates the effects of multiple limitations into a continuous capability index, resulting in a more restrictive classification than may be indicated by a single class-determining limitation under a qualitative system. (Ajayi *et al*., 2025). The findings highlight the need for conservation-oriented management, including erosion control, maintenance or improvement of soil organic matter and nutrient-retention capacity, and careful management of drainage and soluble salts.

3.5 Comparative assessment of the LCC Approach

The comparison shows a methodological divergence rather than a contradiction in the underlying soil observations. The qualitative procedure places all the pedons in Class V as the same severe ECEC limitation controls the class rating. In contrast, the parametric index combines the most restrictive rating from each of the four major land-quality groups. Thus, a pedon can receive the same qualitative class as another pedon while obtaining a lower or higher parametric index due to erosion, drainage or salinity differ (Ramamurthy *et al*., 2020). The middle slope illustrates this particularly well. MS1 has a relatively low ECEC-related rating of 22 and an erosion rating of 46, producing an index of 11.32% (Figure 2). MS2 has a slightly higher soil rating of 26 but a similarly low erosion and drainage combination, giving 12.96%. The qualitative system does not translate these differences into different classes because ECEC remains the controlling Class V limitation. The parametric index preserves some of the numerical contrast, but both pedons remain in the same broad Class VII interval. The lower slope illustrates a different mechanism. LS1 has the

Table 6. Parametric capability ratings and indices

Properties	Upper slope 1	Upper slope 2	Middle slope 1	Middle slope 2	Lower slope 1	Lower slope 2
Erosion hazard (e)						
[1]Erosion	65	65	46	46	65	65
[2]Slope angle (%)	55	55	63	63	90	90
Excess water (w)						
[1]Drainage class	60	62	64	60	45	45
[2]Flooding	95	95	95	95	95	95
Soil limitation (s)						
[1]Salinity (EC- *d*s/m)	65	65	45	45	65	45
[2]Rock outcrop, stone and boulders	97	97	97	97	97	97
[3]Effective soil depth (cm)	100	80	100	35	95	90
[4]ECEC (cmol kg^{-1})	24	23	22	26	20	24
[5]Surface textural class	90	85	85	90	85	90
Climate (c)						
[1]Effective precipitation (mm)	90	90	90	90	90	90
[2]Nature of climate	95	95	95	95	95	95
Parametric capability index (%)	13.08	12.74	11.32	12.96	10.26	12.31
Parametric capability class	VII	VII	VII	VII	VII	VII

Note. Ratings are on the 0–100 scale supplied for the parametric procedure. The index is calculated from the minimum rating within each major land-quality group.

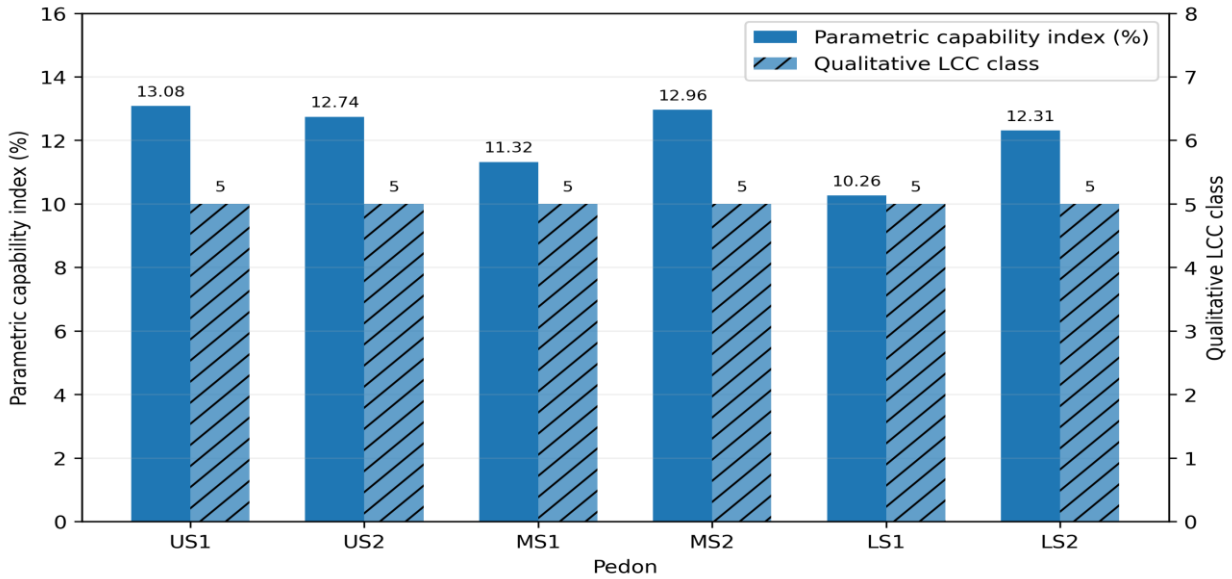


Figure 2. Comparison of parametric capability indices and qualitative capability classes. The left axis reports the parametric capability index (%) and the right axis reports the qualitative capability class (I–VIII). The pedons are Class V under the qualitative assessment and Class VII under the parametric index.

lowest parametric index (10.26%) because the drainage and soil group minima are 45 and 20, respectively. LS2 has a soil minimum of 24 and therefore a higher index.

3.6 Land-management implications

The combined evidence identifies four management priorities: erosion control on sloping land, maintenance of organic matter and nutrient-retention capacity, protection of lower-slope drainage conditions, and monitoring of soluble salts where EC is relatively elevated. As a result of low ECEC throughout the toposequence, nutrient management should favour balanced and appropriately split fertilizer applications and practices that maintain or increase soil organic matter. Organic inputs can improve aggregate stability and contribute to nutrient retention, but application rates should be based on crop demand and local soil-test information rather than on the capability class alone. Erosion control is particularly relevant

to the upper and middle slopes. Maintenance of protective surface cover, retention of crop residues, reduced soil disturbance and contour-oriented cultivation where feasible can reduce runoff and soil loss. These measures are consistent with the general conservation orientation of capability classification, which seeks to match land use with the degree of limitation and the management required to prevent degradation (Klingebiel and Montgomery, 1961; FAO, 1976).

The lower-slope pedons require a different emphasis. Prominent mottling, Btg horizons and poorer drainage ratings indicate periodic saturation. Rather than treating the lower slope as simply a poorer version of the upper slope, management should account for its distinct hydrological behaviour. Where agriculture is maintained, crop choice and timing should be compatible with wetness, and drainage interventions should be designed cautiously so that they do not accelerate erosion or cause downstream impacts. The relatively high EC values in MS2 and LS1 should be monitored, but the measured values should not be described as severe salinity under the adopted criteria. Similarly, the Class VII parametric result should not be interpreted as evidence that all agricultural activity is impossible. Capability classification describes the degree of limitation and management risk; it does not by itself establish economic profitability or the suitability of a specific crop. This distinction is important as land suitability is use-specific and can change with management, crop requirements and improvement measures (FAO, 1976). Overall, the study supports a site-specific management interpretation: the overall class is useful for broad planning, while the individual limitation profile is necessary for deciding what to do on the ground. This is particularly important for toposequences, where applying a single management package across the slope can overlook the contrasting erosion and wetness processes identified in the present profiles.

3.7 Methodological implications and limitations

A qualitative class is not simply a rounded version of a parametric score, and a parametric score should not be presented as if it were a direct numerical translation of the USDA capability class. The qualitative system is limitation-driven and categorical; the parametric procedure is rating-driven and mathematical. The two outputs are therefore complementary descriptions of constraint severity rather than interchangeable measurements. The study has several limitations. First, the sample comprises six pedons along a toposequence, so the results should not be extrapolated automatically to all soils of Ekiti State or the wider southwestern Nigerian region. Second, the analysis is based on soil and site characteristics rather than crop yields, erosion measurements, hydrological observations, farm economics or measured long-term degradation. Third, the parametric index inherits the assumptions of its rating scales and aggregation equation. Finally, the qualitative critical limits used here are a study-applied operationalization of the USDA capability concept; they should not be interpreted as a universal replacement for local capability criteria. These limitations do not invalidate the comparison, but they define the scale at which the conclusions are defensible.

4. Conclusion

The pedons along the toposequence in Erinmope-Ekiti exhibit clear morphological and physicochemical differentiation associated with landscape position. Subsurface clay accumulation, mottling, changes in profile depth, variable organic carbon, low ECEC and contrasting drainage conditions collectively define the principal land limitations. The qualitative capability procedure classified the pedons as Class V because low ECEC was the controlling limitation. Although the type and severity of secondary limitations varied among slope positions. The parametric indices were 13.08, 12.74, 11.32, 12.96, 10.26 and 12.31% for US1, US2, MS1, MS2, LS1 and LS2, respectively, placing the pedons in Class VII. The difference between the qualitative Class V outcome and the parametric Class VII outcome is attributable primarily to the aggregation rule: the qualitative system is controlled by the most severe limitation, whereas the parametric index compounds the lowest ratings of the major land-quality groups. The principal management requirements are therefore erosion control on upper and middle slopes, maintenance of soil organic matter and nutrient-retention capacity, careful management of lower-slope wetness, and monitoring of sites with relatively elevated EC. The study demonstrates that capability assessment is most informative when the overall rating is interpreted together with its limiting factors and the aggregation logic used to obtain it. For land-use planning in topographically heterogeneous landscapes, combining a categorical capability class with a transparent parametric index can reveal both the dominant constraint and the degree of within-class variation.

5. Recommendations

- Use the individual limitation profile, rather than the final capability class alone, to guide field-level management decisions.
- Prioritize erosion-control measures on upper and middle slopes, including protective surface cover, residue retention, reduced disturbance and contour-oriented cultivation where feasible.
- Maintain or increase soil organic matter through appropriate organic inputs, residue management and diversified cropping systems to support nutrient retention in the low-ECEC soils.
- Use soil-test-guided, balanced and appropriately timed fertilizer applications rather than relying on high fertilizer rates to compensate for low nutrient-retention capacity.
- Manage lower-slope areas according to their wetness regime; avoid indiscriminate drainage that could increase

downstream erosion or alter the hydrological function of the landscape.

- Monitor EC in MS2 and LS1 and other sites where soluble salts may accumulate, while avoiding classification of these soils as severely saline unless the adopted diagnostic criteria are met.
- Where future work is undertaken, expand sampling to additional toposequences and combine soil capability assessment with crop performance, erosion measurements, hydrological observations and economic information to test the practical consequences of the two evaluation approaches.

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