Journal of Agricultural Science and Practice
Volume 11(2), pages 48-59, June 2026
Article Number: E6AFDA8E2
ISSN: 2536-7072
https://doi.org/10.31248/JASP2026.569
https://integrityresjournals.org/journal/JASP

Full Length Research

Taxonomic classification update and re-evaluation of soils of Old Imo State using legacy data

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Received Date: 20 February 2026 | Accepted Date: 04 May 2026 | Published Date: 30 June 2026

ABSTRACT: The ever-mounting population pressure on the land of old Imo State of Nigeria necessitated a re-evaluation of the soils using data from the reconnaissance soil survey of the location produced in 1985, and which has remained the major source of soil information for the location. The exercise involved updating the soils' classifications using later editions of USDA Soil Taxonomy and FAO World Reference Base (WRB), as well as determining the soils' Fertility Capability Classifications (FCC) and suitability ratings. The soils' parent materials were classified into sandstone (st), sand and sandstone (sst), shale and sandstone (shs), shale (sh), coastal plain sands (cps), and Alluvium (Al). However, updating the soils' classifications taxonomically, more classes of soils were recognised than was originally the case. The major classes by USDA Soil Taxonomy were Typic Paleudult, Kandic Plinthaquult, and Typic Paleudalf; while for the WRB, they were Acrisol, Nitisol, Lixisol and Cambisol. By the FCC, loam dominated all soils at the Type level. At the Substrata type level, clay dominated the shale derived soils, while loam was still dominant for the other soils. Physical barriers – d(dryness), g(gley), r^+ (gravel) – were mainly with shale, while the chemical constraints – a (Aluminium toxicity), k(low nutrient capital reserve), e(low cation exchange capacity) – were more with the sandy parent materials. Using soil texture, the fertility indices of the soils rated moderately suitable (S_2) for the shale derived soils but marginally suitable (s_3) for soils of the other parent materials thus: Sh (75%, S2), > ShS (65.3%, S2), > AL (40.3%, S3) > CPS (32.9%, S3), > St (31.9%, S3) > SSt (29.9%, S3). There is a relationship between parent material and soil fertility. When only legacy data is available, geological formations in the location should guide the grouping of the soils for effective management. There is a need to sample the soils again.

Keywords: Fertility, legacy soil data, soil parent material, update of taxonomic classification.

INTRODUCTION

Old Imo State is a location in Southeast Nigeria noted to have high population density that puts great pressure on the land. According to FAO (2021), most of the people depend on land for their livelihood. The resultant constant cultivation of the land leads to soil degradation in the location (Dike *et al*., 2018; Ogbonna, 2012; Udokporo *et al*., 2015). With a population growth rate of 2.6% in Nigeria (Yahaya *et al*., 2020), the pressure is not abating. Knowledge of the intrinsic qualities of soils constitutes the basis for the suitability assessment of such soils for different uses. The necessary information for such evaluation is usually obtained from soil maps at different scales (AbdelRahman and Afifi, 2024). But in the developing parts of the world, only small-scale soil maps are available most of the time (Young, 1998), and such are often in legacy form. With less priority on systematic soil mapping, Young (1998) notes the current attitude to be to make use of whatever information is already available.

Hence, Naspendra *et al*. (2023) opined that legacy soil data are particularly useful in land suitability analysis.

Legacy soil maps provide data sets from which agriculturally useful information can be derived. The process of achieving this, according to Raynukaazhakarsamy and Sathiaseelan (2018), involves extracting and analysing hidden predictive information and then transforming it into a relevant form. But when only soil map information is available, such information can be extracted by updating or refining, extrapolating and disaggregating (Ma *et al*., 2019).

The Reconnaissance Soil Survey of Imo State, Nigeria (1:250,000) Soils Report [Federal Department of Agricultural Land Resources (FDALR), 1985] has remained the major source of soil data in the location of study. It provides a huge dataset covering a number of soil parent materials/geological formations. Yet only a qualitative suitability assessment of the soil for arable crop production, based on relief, was reported. Fertility, which is critical to the soil's productivity (Enwezor *et al*., 1981), was neglected. Considering also the improvements made with soil classification since the production of the map (Brevik *et al*., 2016), the earlier classifications of the soils were obviously outdated and therefore limited scientific communication.

So, the main objective of the study was to re-evaluate the soils of the location using legacy soil data. But specifically, the objectives were to:

1. Update the soils' taxonomic classifications.
2. Determine the soils' fertility capability classifications.
3. Rate soil parameters to get a quantity for the Soil Fertility Index.
4. Relate soils' parent materials to their fertility potentials.

The paper thus presents updated taxonomic classifications and re-evaluation of soils, relating the soils' parent materials to their fertility potentials, thereby improving the interpretation and usage of data recorded in the survey report.

MATERIALS AND METHODS

Location of study

The location is in Southeast Nigeria. With the creation of states, what was Imo State at the time of the soil survey of the location was split into the whole of present Imo State and parts of Abia and Ebonyi States. Figure 1 shows the three states as presently constituted, vis-à-vis other states of Nigeria. The location lies between Lat. 4°40′ and 8°15′N; and between Longitude 6°40′ and 8°05′E. The climate is tropical, comprising two major seasons: rainy and dry seasons. The range of mean annual rainfall is 2000 – 2,500 mm, while that of temperature is 26°C – 28°C (78°F – 82°F). The vegetation is tropical rainforest, with dominant plant species including Oil palm (*Elaeis guineensis*), African Oil bean (*Pentaclethra macrophylla*), as well as pennisetum grass species. The location is made up of the following geological formations: Coastal plains sand; Bende-Ameke group; Upper coal measures; False Bedded sandstone; Lower coal measures; Imo clay shales; Nkporo Shale group; Eze-Aku shales; Asu River group; Recent Alluvium. These are shown in Figure 2. Cultivation of arable crops is the major land use, with the major crops being cassava, yams, maize, cocoyams, etc. Location covers a land area of 13,032 Km^2.

Field study and sampling

The survey report of the location showed that eighteen (18) mapping units were delineated based on topography and geomorphology. With the auger, forty-six (46) profiles were located within the units. Samples were taken from the horizons of the profiles for the laboratory after the descriptions of the profiles.

Laboratory analyses

Procedures adopted in analysing the samples as recorded in the document were: Hydrometer method for particle size analysis; Glass electrode method for pH in 1:1 soil to water and IN KCL; Walkley-Black oxidation method for OC; Kjeldhal digestion method for Total nitrogen; Bray and Kurtz extraction method for available-P; IN NH_4OAC (pH 7) extraction method for exch. Cations, followed by Atomic absorption spectrometry for Ca & Mg as well as flame photometry for K & Na; same NH, OAC (pH 7) extraction method for CEC; Base saturation was calculated.

Data acquisition

The Reconnaissance Soil Survey of Imo State, Nigeria (1:250,000) Soils Report (FDALR, 1985) is the main source of data used. These were profile descriptions, including the physical and chemical data of 46 pedons. The record showed that soil samples were analysed in different laboratories, while the soil classification systems adopted were those of USDA Soil Taxonomy (Soil Survey Staff, 1975) and FAO/Unesco Soil Map of the World Legend (FAO/Unesco, 1974). Due to missing data, profile AN428 was not captured in the exercise. So, the data of 45 pedons were evaluated.

Evaluation procedure

Taxonomic classification: Standards of the 12th edition

Figure 1. Map of States of Nigeria showing Imo, Abia and Ebonyi States highlighted.

of USDA Soil Taxonomy (Soil Survey Staff, 2014) and those of FAO World Reference Base (WRB, 2015) were used to update the soil classifications.

Fertility Capability Classification (FCC): Fertility Capability Classification systems, as modified by Sanchez *et al*. (1982, 2003), were adopted. Specific soil properties used as criteria were soil texture, colour, presence of mottles ≤ 2 chroma, saturation of soils with water, soil pH, exchange K and CEC values.

Suitability rating of parameters: In order to quantify soil fertility, soil parameters were rated. The index was obtained by expressing the actual rating as a percentage of the optimal rating. The ratings adopted were those recorded in the survey report, most of which had international origin. Optimal values adopted in this study were: pH (6.5), O.M. (3%), K(0.6me/100g), CEC (25me/100g), BS (normal), Total N (0.25%), and av.P (20ppm). The optimal value of silt was 50%, while 30% was for clay. The average of the two separates represents the soil texture rating. The methodology of the suitability rating is recorded in detail by Ukaegbu *et al*. (2015). The average of parameter ratings for a pedon represented the Fertility Index. Relating this value to the rating scale of Dent and Young (1981) as earlier reported (Ukaegbu *et al*., 2015) gave the suitability class for the pedon. In principle, this method of rating was based on the ascribed sufficiency level of parameters.

Statistics analysis

The Pearson correlation model was used to determine relationships among parameter ratings at $p<0.001$. The essence being to determine the influence of management on the soil's fertility potentials.

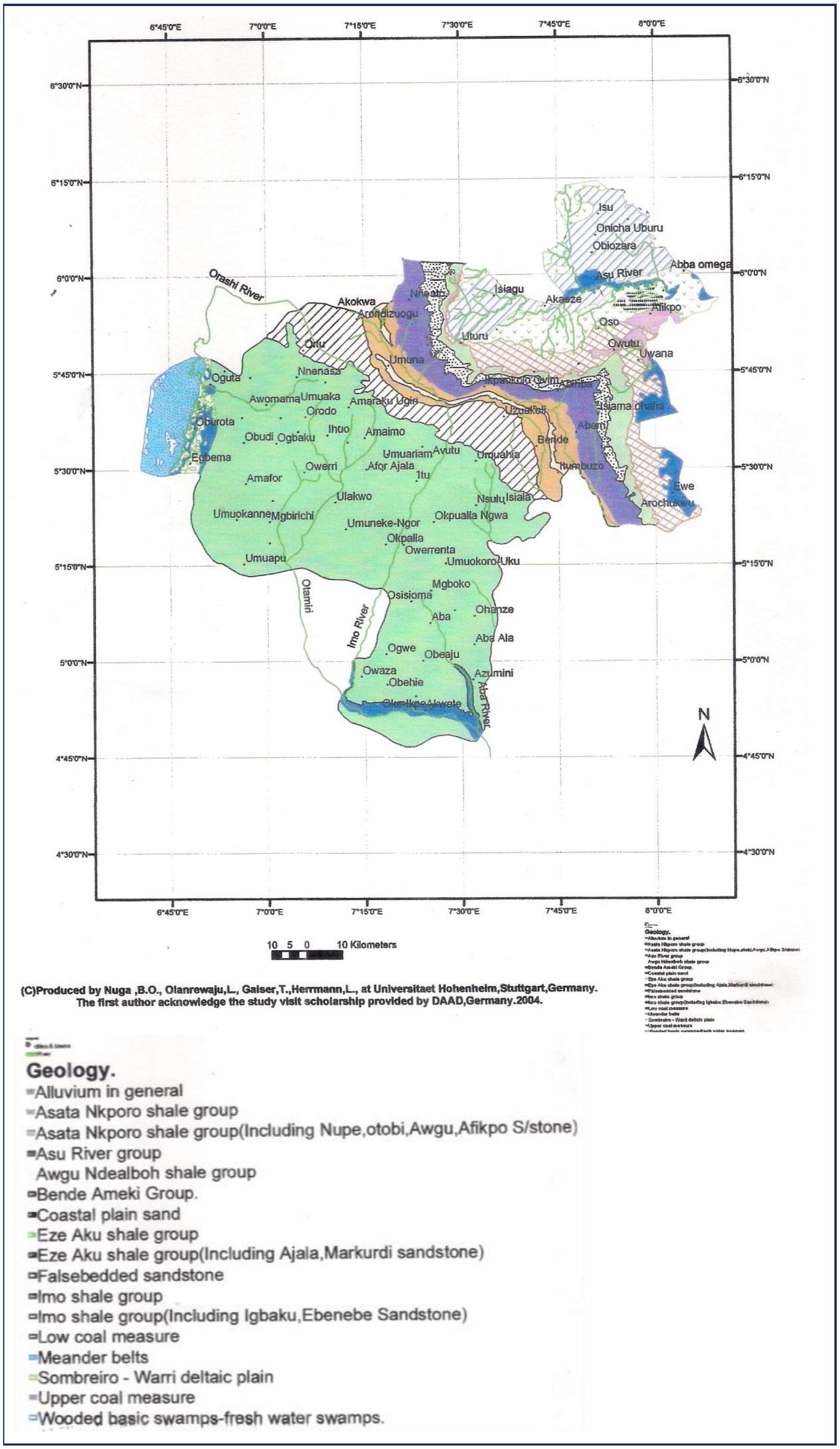

Figure 2. Digitized Geology Map of Old Imo State (Source: Ukaegbu *et al*., 2023).

RESULTS AND DISCUSSION

Records of the soils of the location of study showed the soil parent materials to be differentiated into sandstone (st), sand and sandstone (sst), shale and sandstone (shs), shale (sh), coastal plains sand (cps), and alluvium (Al). However, updating the soils' classifications by the standard of the 12th edition of USDA Soil Taxonomy (Soil Survey Staff, 2014), classes of soils recorded are as given in Table 1. On the other hand, the equivalent classes of the same soils using the FAO World reference base (IUSS Working Group, 2015) are as given in Table 2. Generally, the major diagnostic criteria that informed the soils' classifications were silt/clay ratio, argillic horizon, concretions, pH, cec, bs, oc, mottling and chroma ≤ 2, texture, etc., indicating gleization, plinthization and argillation as the main pedogenetic processes in the location (Ojanuga *et al*., 1981; Ukaegbu and Ugwa, 2020). Specifically, soils' pH values and accompanying bs, indicating the extent of leaching, differentiated the Alfisols from the Ultisols, as well as the Dystrudepts from the Eutrudepts. Where data of cec and bs were incomplete or missing, as in IM431 - 03, IM431 - 06, IM432 - 05, IM434 - 01, IM434 - 02, IM435 - 01, IM436 - 01, the values of the concerned parameters were estimated from the pH records (Spaargaren, 2005). Profile distribution of OC was diagnostic of the inceptisols in the valleys or the kandic horizons on the plains. Soil moisture regimes - ustic and udic - were estimated from long-term weather records. Correlation between the USDA and WRB systems helped in deciding the reference soil groups of the location (Bouwman, 1990; Esu, 2010). These updates somewhat contrast with the former classifications presented in Tables 3 and 4.

The present classification (Table 1) shows 27 classes recognised, with the dominant being Typic Paleudult, Kandic Plinthaquult and Typic Paleudalf. Table 2 shows 7 classes recognised at the first level of WRB. The most dominant in this case were Acrisol, Nitisol, Lixisol and Cambisol, in decreasing order of dominance. Many qualifiers were used in describing the soils at the second tier of WRB classification. More classes of soils have been recognised with the later editions of the classification systems, some of which vary from the former.

The increase in the number of recognised classes is attributed to the improvement in the classification of tropical soils (Esu, 2010; SSS, 2014; WRB, 2015). In addition, some of the classes were misplaced abinitio. However, since the recommended procedures for soil analyses were not strictly followed in the laboratories in producing the data, as well as some incomplete data encountered in some cases, the process of classification involved approximations. And since soil properties change over time (Brevik *et al*., 2016; Busch and Presley, 2014), this present effort does not substitute the need for sampling the soils again.

Table 1. Classification of soils by USDA soil taxonomy

Site	Soil class
IM404-01	Rhodic Kandiudalf
AN404-01	Typic Rhodudalf
AN404-02	Oxic Dystrudept
AN404-03	Aeric Endoaquept
AN404-04	Rhodic Paleudult
AN404-05	Rhodic Kandiudalf
AN404-06	Typic Endoaqualf
IM408-01	Typic Plinthudult
IM408-02	Kandic Plinthaquult
IM408-03	Typic Plinthaquult
AN410-01	Rhodic Kandiustalf
AN411-01	Typic Plinthustalf
IM415-01	Haplic Plinthustult
IM415-02	Typic Plinthaquult
IM415-03	Kandic Plinthaquult
IM415-04	Haplic Plinthustullt
AN424-01	Typic Kandiustult
AN424-02	Aquic Dystrustept
AN424-03	Kandic Plinthaquult
AN428-01	Typic Hapludalf
IM431-01	Typic Paleudult
IM431-02	Typic Paleudult
IM431-03	Typic Paleudult
IM431-04	Arenic Kandiudalf
IM431-05	Typic Paleudult
IM431-06	Typic Paleudult
IM432-01	Typic Paleudult
IM432-02	Arenic Paleudult
IM432-03	Typic Kandiudult
IM432-04	Typic Paleudult
IM432-05	Typic Paleudult
IM434-01	Typic Paleudult
IM434-02	Typic Paleudult
IM435-01	Oxyaquic Dystrudept
IM436-01	Plinthic Petraquept
IM437-01	Arenic Paleudalf
IM437-02	Arenic Kandiudalf
IM437-03	Typic Paleudalf
IM437-04	Typic Paleudalf
IM437-05	Plinthic Paleudalf
IM437-06	Typic Dystrudept
IM437-07	Humic Psammentic Dystrudept
IM437-08	Typic Paleudalf
IM437-09	Typic Plinthaquult
IM437-10	Kandic Plinthaquult
IM437-11	Plinthic Petraquept

Table 2. Soil classification by WRB.

Site	Soil Class
IM404-01	Rhodic Lixisol (Arenic)
AN404-01	Rhodic Acrisol (Loamic)
AN404-02	Ferralic Cambisol (Loamic)
AN404-03	Gleyic Cambisol (Colluvic)
AN404-04	Rhodic Nitisol (Aric)
AN404-05	Rhodic Lixisol (Aric)
AN404-06	Gleyic Lixisol (Loamic)
IM408-01	Stagnic Plinthosol (Acric)
IM408-02	Plinthic Acrisol (Humic)
IM408-03	Gleyic Acrisol (Humic)
AN410-01	Rhodic Lixisol (Loamic)
AN411-01	Stagnic Luvisol (Humic)
IM415-01	Plinthic Acrisol (Densic)
IM415-02	Plinthic Acrisol (Epieutric)
IM415-03	Plinthic Acrisol (Epieutric)
IM415-04	Plinthic Acrisol (Arenic)
AN424-01	Acric Nitisol (Endostagnic)
AN424-02	Plinthic Cambisol (Loamic)
AN424-03	Plinthic Acrisol (Clayic)
AN428-01	Stagnic Luvisol (Loamic)
IM431-01	Rhodic Acrisol (Humic)
IM431-02	Acric Nitisol (Humic)
IM431-03	Rhodic Nitisol (Humic)
IM431-04	Abruptic Lixisol (Arenic)
IM431-05	Rhodic Nitisol (Humic)
IM431-06	Acric Nitisol (Humic)
IM432-01	Xanthic Lixisol (Epidystric)
IM432-02	Xanthic Acrisol (Arenic)
IM432-03	Acric Nitisol (Humic)
IM432-04	Xanthic Acrisol (Loamic)
IM432-05	Xanthic Acrisol (Loamic)
IM434-01	Chromic Acrisol (Humic)
IM434-02	Chromic Acrisol (Epieutric)
IM435-01	Gleyic Cambisol (Clayic)
IM436-01	Reductic Gleysol (Clayic)
IM437-01	Rhodic Nitisol (Humic)
IM437-02	Lixic Nitisol (Humic)
IM437-03	Chromic Lixisol (Epidystric)
IM437-04	Acric Nitisol (Humic)
IM437-05	Ferritic Nitisol (Ochric)
IM437-06	Chromic Cambisol (Arenic)
IM437-07	Rhodic Cambisol (Arenic)
IM437-08	Chromic Lixisol (Epidystric)
IM437-09	Plinthic Acrisol (Humic)
IM437-10	Pinthic Acrisol (Humic)
IM437-11	Reductive Gleysol (Alic)

Table 3. Former classification of soils using USDA soil taxonomy standards.

Soil Class
Typic Paleudult (11)
Rhodic Paleudult (1)
Oxic Dystropept (8)
Typic Paleudalf (1)
Aquic Hapludult (1)
Aeric Hapludult (1)
Typic Paleustult (4)
Typic Ustorthent (1)
Typic Paleustalf (2)
Plinthic Haplustult (1)
Aeric Paleaquult (1)
Typic Haplustalf (1)
Typic Hapludalf (1)
Arenic Paleudult (2)
Typic Tropudults (4)
Typic Tropaquept (5)
Aeric Tropaquept (2)
Typic Dystropept (1)
Aquic Dystropept (1)

Figures in brackets represent numbers of Pedons so classified.

Table 4. Former classification of soils by FAO/UNESCO standards

Soil Class
Dystric Nitosol (15)
Dystric Cambisol (9)
Orthic Luvisol (5)
Orthic Acrisol (4)
Dystric Regosol (1)
Plinthic Acrisol (1)
Gleyic Nitosol (1)
Eutric Cambisol (1)
Dystric Acrisol (4)
Gleyic Cambisol (9)

Figures in brackets represent number of Pedons so classified.

Table 5 shows the Fertility Capability Classifications of the soils. Type and Substrata type data show the soils to be dominated by loamy topsoils and subsoils. While the sandy topsoils were mainly found with the parent material described as ‘sand and sandstone’, the clayey subsoils were mainly with the shale derived soils. The dominant textures thus make for good water holding capacity. Soils with sharp textural contrasts (eg, LC), which potentially

Table 5. Fertility Capability Classification (FCC) of soils.

Parent material/site	Type	Substrata type	Modifiers						FCC Unit
			g	d	r+	a	k	e	
Sandstone									
IM404-01	S						x	x	Ske
AN404-01	L					x	x	x	Lake
AN404-02	L					x	x	x	Lake
AN404-03	L					x	x	x	Lake
AN404-04	L	C				x	x		Lcak
AN404-05	L						x	x	Lke
IM437-06	S					x	x	x	Sake
Sand and sandstone									
AN410-01	L			x		x	x	x	Ldake
IM437-01	S							x	Se
IM437-02	S							x	Se
IM437-03	S	L						x	SLe
IM437-04	L				x			x	Lr^{+}e
IM437-05	L	C						x	LCe
IM437-07	S						x	x	Ske
IM437-08	L	S				x	x	x	LSake
Shale and sandstone									
IM408-01	L	C				x	x		LCak
IM408-02	L		x			x			Lga
IM408-03	L		x		x	x			Lgr^{+}a
AN411-01	L	C			x				LCr^{+}
IM415-01	L				x	x		x	Lr^{+}ae
IM436-01	C		x		x				Cgr^{+}
IM437-09	L		x		x	x		x	Lgr^{+}ae
IM437-10	L					x		x	Lae
IM437-11	C		x		x	x			Cgr^{+}a
Shale									
IM415-02	L	C	x		x	x			LCgr^{+}a
IM415-03	L			x				x	Lde
IM415-04	S	C		x	x				SCdr^{+}
AN424-01	L	C		x		x	x	x	LCdake
AN424-02	L	C	x	x					LCgd
AN424-03	C		x		x				Cgr^{+}
IM435-01	C					x	x		Cak
Coastal plain sands									
IM431-01	L					x		x	Lae
IM431-02	L	C				x			LCa
IM431-03	L	C				x			LCa
IM431-04	S	L				x			SLa
IM431-05	L	C				x			LCa
IM431-06	L					x	x		Lak
IM432-01	L					x	x	x	Lake
IM432-03	S	L				x			SLa
IM432-04	L							x	Le
IM432-05	L	C				x		x	LCae

Table 5. Fertility Capability Classification (FCC) of soils.

Alluvium							
AN404-06	C		x	x			Cga
IM432-02	S					x	Se
IM434-01	L			x	x	x	Lake
IM434-02	S	L			x	x	SLke

would be highly erodible, were mostly on plains. Physical constraints – g(aquic soil moisture regime), d (ustic soil moisture regime) and r^+ indicating the presence of gravel, were found mostly with the shale-derived soils. These conditions obviously affect the management of the soils. Waterlogging and accompanying anaerobic conditions mean that not all crops (except rice) are suited to the location. Shale is in the northern part of the location of study, with less annual rainfall than the southern part. The relative dryness of the zone is, however, cushioned by the ability of the soils to retain moisture. Presence of gravels (r^+) was not so concentrated as to hamper cultivation. Chemical constraints found were a-aluminium toxicity, k-low nutrient capital reserve, and e-low cation exchange capacity. These chemical limitations were more with the sandy parent materials than with shale. Due to insufficient data, the ‘i' modifier couldn’t be ascertained. However, the pedons with C type, most of which were the shale-derived soils, have the potential for ‘i'. Similar studies (Ukaegbu *et al*., 2023; Udoh *et al*., 2013) within the same ecological zone have comparable results. However, FCC units have varied with the parent materials. No two parent materials have the same FCC units, thus showing the influence of the former on the latter. Udoh *et al*. (2013) found soils from different parent materials of the Acid sands of Akwa Ibom State, Nigeria to belong to different FCC units and then concluded that the FCC system was efficient in grouping the soils for management. Some other studies have also shown parent material to influence the suitability ratings of soils of the location and similar soils for the cultivation of arable crops - cassava, cocoyam, maize, groundnut (Ahukaemere *et al*., 2022; Asadu and Enete, 1997; Nsor and Akamigbo, 2015), this being due to the influence of parent material on the soils’ fertility potentials. Most of the constraints encountered are taken care of by routine soil management via chemical amelioration.

The taxonomic classifications captured the physical features with terms such as plinthic, ferric, aquic, gleyic, etc. The relative fertility of the shale-derived soils is only slightly captured taxonomically by WRB at the 2nd level with supplementary qualifiers such as Epieutric, Humic, Loamic, clayic. The WRB, more than USDA Soil Taxonomy, seems to tally with the FCC as noted by Rasaei and Mohajer (2019). However, the USDA classification stopped at subgroup level.

To quantify soil fertility, the physical and chemical properties of the soils were rated. The result of the rating is given in Table 6. Values ranged from 0.7% for av.P at site IM434-01 to 330.0% for av.P. at site AN411-01. Some excessive values got for OM, av.P and exch. K are attributable to the effect of management. Table 7 shows the parameters having the strongest correlations with profile averages to be TN (r = 0.774), Exch. K (r = 0.700) and av.P (r = 0.699). These are followed by CEC (r = 0.551) and SOC (r = 0.567). These values are attributed to the use of NPK fertilisers, the residual effect of which can last for years. Use of fertilisers also boosts both SOC and CEC in the soil (Ellerbrock and Gerke, 2016). The moderate correlations between Exch. K and TN (r=0.599) as well as between SOC and TN (r = 0.580) further buttress the effect of fertiliser application. However, the excessive ratings may also be highlighting the need to investigate the scale further for the local soils. The high values further show that such naturally infertile soils are amendable (Bouwman, 1990; IUSS Working Group, 2015). These parameters have, nonetheless, been noted to be influenced by management in the area of study (Akamigbo, 1999; Nnaji *et al*., 2002). Assessing soil fertility in sandy soils along a Toposequence Transect in Sandai, West Kalimantan, Pulunggono *et al*. (2024) also recorded excessive values. However, profile averages range from 29.4% to 154.9%. In terms of suitability class, this is from Marginally suitable (S_3) to Highly suitable (S_1). This result has not quite agreed in some cases with that reported in the original document, which was based on relief and soil morphology. For example, Unit 411 on a steep escarpment was considered unsuitable in the former evaluation but highly suitable in the present. The present study is a fertility evaluation which should be situated within the framework of the former.

Determining the soil fertility index averages of the parent materials resulted in a sequence of their relationships, thus: shale and Sandstone (82.1%, S_1) > Alluvium (67%, S_2) > Coastal plain sand (59.1%, S_2) > Sand and sandstone (53.8%, S_2) = Shale (53.4%, S_2) > Sandstone (36.1%, S_3). This finding contradicted the result of the FCC evaluation, which showed shale to have the least of the soils’ chemical constraints. This is explained by differences in approach as well as in definitions of criteria, and the fact that more parameters were rated in the suitability rating method, as earlier noted by Ukaegbu *et al*. (2023). In addition, the suitability rating in relation to the parent materials was affected by management. A scrutiny of Table 6 showed excess values of av.P boosted the

Table 6. Suitability ratings of parameters given as percentages of their optimal rates.

Site	Texture	exch.K	pH	BS	CEC	OM	TN	av.P	Profile average
IM404-01	12.7	18.3	92.3	57	3.6	26.7	28	21.5	32.5
AN404-01	32.7	26.7	76.9	18	24.2	30	8	19.0	29.4
AN404-02	42.7	10	73.8	44	12.6	36.7	20	75.3	39.4
AN404-03	46.7	16.7	80	33	15.8	13.3	20	21	30.8
AN404-04	42.4	25	83.1	33	33.8	30	36	80.5	45.5
AN404-05	30	23.3	89.2	76	8.7	20	16	8.8	34.0
AN404-06	96.7	61.7	70.8	30	188	30	28	95	75.0
IM408-01	76	21.7	76.9	-	-	96.7	44	-	63.1
IM408-02	63.4	81.7	72.3	37	37.2	83.3	60	25.5	57.6
IM408-03	55.7	191.7	70.8	51	39.2	193.3	124	38.5	95.5
AN410-01	30.7	36.7	83.1	37	10.2	26.7	04	35.0	32.9
AN411-01	74.7	153.3	76.9	48	96	90	84	330.0	119.1
IM415-01	41.7	85	73.8	48	13.9	80	68	31	55.2
IM415-02	89	68.3	80	57	22.8	60	60	15.5	56.6
IM415-03	29	68.3	89.2	91	9.2	30	20	27.5	45.5
IM415-04	20.7	101.7	93.8	96	60	96.7	80	40	73.6
AN424-01	95	13.3	80	50	16.68	27	12	6.15	37.5
AN424-02	81.7	83.3	70.8	24	86	6.7	80	12	55.6
AN424-03	106.7	35.8	76.9	56.5	57.3	25	18	4.4	47.6
IM431-01	32.4	20	72.3	9.0	26.4	167.3	36	62	53.2
IM431-02	40.4	45	81.5	30	18.4	156.7	84	9	58.1
IM431-03	32.0	111.7	76.9	11	78	176.7	88	7	72.7
IM431-04	25.4	35	78.5	-	-	116.7	48	-	60.7
IM431-05	53	68.3	76.9	30	19.6	136.7	32	-	59.5
IM431-06	33.4	50	75.4	-	-	163.3	64	66	75.4
IM432-01	33	38.3	75.4	27	33.6	86.7	60	155	63.6
IM432-02	21.4	35	95.4	71	22	76.7	92	230	80.4
IM432-03	24	58.3	83.1	40	28	126.7	56	-	59.4
IM432-04	35	38.3	89.2	39	17.2	73.3	28	-	45.7
IM432-05	20	111.7	83.1	36	22.8	18.7	04	-	42.3
IM434-01	27	10	67.7	10	21.2	145.3	24	0.7	38.2
IM434-02	16	25	96.9	83	20.8	263.3	84	5.2	74.3
IM435-01	103	30	78.5	25	23.2	130	04	66	57.5
IM436-01	89	133.3	101.5	-	-	193.3	160	252	154.9
IM437-01	27	68.3	89.2	60	10	86.7	56	46	55.4
IM437-02	16	43.3	84.6	60	10	80	56	46	49.5
IM437-03	16.7	76.7	80	47	11.6	146.7	164	67.5	76.3
IM437-04	33.4	136.7	76.9	48	180	76.7	80	35.5	83.4
IM437-05	67	76.7	81.5	38	10	73.3	56	29	53.9
IM437-06	16.4	25	84.6	40	8	73.3	52	31.5	41.4
IM437-07	13.7	28.3	86.2	43	7.2	56.7	64	28	40.9
IM437-08	34.7	31.7	81.5	31	9.2	56.7	40	18.5	37.9
IM437-09	50.4	76.7	87.7	54	20.8	76.7	56	39	57.7
IM437-10	38.4	76.7	76.9	47	15.2	73.3	60	45	54.1
IM437-11	98	110	78.5	85	60.8	90	84	45	81.4

values for the three best rated parent materials. The unequal number of samples for the parent materials should also be noted. However, the relationship of the parent materials changed when rated based only on texture, thus: Shale (75%, S_2) > Shale and Sandstone (65.3%, S_2) > Alluvium (40.3%, S_3) > Coastal plain sand (32.9%, S_3) > Sandstone (31.9%, S_3) > Sand and sandstone (29.9%, S_3). This rating, based on texture,

Table 7. Pearson Correlation Matrix (r) indicating r elationships among parameter ratings.

	Texture	Exch.K	pH	BS	CEC	SOC	TN	Av.P	Profile ave.
Texture	1.000								
Exch.K	0.206	1.000							
pH	-0.307	-0.066	1.000						
BS	-0.073	0.174	0.649	1.000					
CEC	0.374	0.467	-0.363	-0.085	1.000				
SOS	-0.117	0.258	0.067	-0.052	-0.039	1.000			
TN	-0.023	0.599	0.182	0.214	0.178	0.580	1.000		
Av.P	0.155	0.326	0.201	0.040	0.234	0.142	0.384	1.000	
Profile ave.	0.302	0.700	0.160	0.223	0.551	0.567	0.774	0.699	1.000

$P<0.001$. Interpretation: 'r' ≥ 0.70 = strong; 0.50 to 0.69 = moderate; 0.30 to 0.49 = weak to moderate; < 0.30 = weak.

seems more reliable due to the age of the data. For a legacy soil data of West Sumatra that was 30 years old, Naspendra *et al*. (2023) observed only physiographic information, physical properties and soil morphology to be eligible. Among the parameters rated Texture, pH, exch. K and CEC were included in FCC criteria. The rest of FCC criteria were morphological and not rated. And for the rated, Texture had positive correlation only with CEC and exch. K, both of which correlated well with profile average. So, the rating based on texture is comparable to that of FCC while eliminating most of the parameters influenced by management. The rating based on texture is further supported by an earlier work by Akamigbo and Asadu (1983), who found soil parent materials in Southeastern Nigeria to significantly influence soil textures. They observed that soils derived from false-bedded sandstones, coastal plain sands and sandy alluvium were generally coarse. Describing the lithologies of geologic formations of the location of study, Ogbonna (2012) showed them to have varying degrees of shale inclusion. The greater the shale content, the less coarse the soil texture. The cation exchange capacity of soils of southeastern Nigeria had also been found to significantly relate to the soil's clay content (Asadu and Akamigbo, 1990). This thus makes texture a significant factor influencing the soil's fertility. This fact has been highlighted in a recent study by Awwal and Fatihu (2024).

So, in the absence of a better map, the map of geologic formations of the location should be a good guide for soil management. This is especially needful as farmers in this part of the world use non-scientific approaches to estimate soil fertility (Akinbode *et al*., 2024). In this era of precision agriculture, it is recommended that management should be tailored to suit soils so as to enhance their productivity (Ajayi *et al*., 2025). But this is hardly the case in the area of study, as noted by Asadu *et al*. (2002).

Conclusion

With legacy data, the study updated the classifications of soils of old Imo State and got more classes of soils than was the case ab initio, due to the improvement in the classification of tropical soils. Evaluating legacy data further showed geological formations as a good guide to determining soil fertility index (SFI) in the location and should therefore be factored into the SFI model. Based on texture, which was still considered eligible among the legacy data, the soil fertility indices for the shale-derived soils rated moderately suitable (S_2) while the other parent materials rated marginally suitable (S_3). There is a relationship between soils' parent materials and their fertility potentials.

Recommendation

While resampling the soils is necessary, the lithologies of geological formations in South East Nigeria should be analysed in detail to improve the soil fertility predictive potential of geology in the area.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The Federal Department of Agricultural Land Resources and the Soil Survey Team that produced the soil map of the location of study are well appreciated.

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