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Full Length Research

Extra predictive value of a manuscript soil map of Imo State, Nigeria

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ABSTRACT: Predictive accuracy of a soil map is the scientific requirement for its use. To determine the extra information contained in a manuscript soil map (1:250,000) of Imo State, in the coastal plains sand zone of the state, its predictive accuracy was compared with that of the published (1:1,000,000) version. The study was done with 106 soil samples randomly taken in the location of study with the auger at two depths, 0-20cm and 20-40cm, which were analysed using standard laboratory procedures to determine physic-chemical properties – sand, silt, clay, silt/clay, pH, Exch. Ca, Mg, K, Na, Al, H, Al+H, ECEC, BS, ESP, OC, TN.. Data were statistically analysed using Coefficient of Variation (CV%), Analysis of Variance (ANOVA) with means separated at a 5% level of significance, and the technique based on relative variance (I-RV). Both maps had better predictive accuracy for alluvial soils than well-drained units delineated based on minor relief differences. Despite high within unit variation of properties, map units generally differed significantly at 5% in terms of sand, silt, silt/clay, Al, H, Al+H, ECEC, BS, ESP, OC, K. Predictive accuracies (1-RV) for the parameters ranged from 0.01 for pH to 0.62 for BS. Sand and silt had relatively good predictions at both depths and scales, with values ranging from 0.42 to 0.57. The parameters silt/clay, K, Al, H, ECEC, and Al+H, had better prediction at subsoil with values ranging from 0.26 to 0.58. The manuscript map had improved prediction at the topsoil for Al, H, Al+H, BS, ESP, OC, and TN with values improving from a range of 0.04 – 0.25 to one of 0.15 – 0.62. At the subsoil, the same map had improved prediction for silt/clay ratio with values changing from 0.17 to 0.32. Despite being at a small scale too, the manuscript soil map brought out the soil's potential better, which fact makes it a better base map for more detailed mapping of the soils than the published one. The study thus recommends making reference to the manuscript map for further studies.

Keywords: Accuracy, coastal plains sand, Imo State, manuscript soil map, Nigeria.

INTRODUCTION

Soil is a major component of land influencing its use. Its distribution is determined by a survey that culminates in its representation on a map. The map, known as the soil map, consists of map units that convey information on the basis of which the use of the land in question is planned (Amin *et al.*, 2019; Shobayo *et al*., 2019; Soil Science Division Staff, 2017). This function of a soil map as a scientific tool for land use planning is better served by a detailed soil map. Unfortunately, such detailed soil maps are lacking in the developing parts of the world due to the high cost of their production (Young, 1998; Gonzalez *et al*., 2018).

The Federal Department of Agricultural Land Resources (FDALR) produced a small-scale soil map covering the entire country of Nigeria, which according to Ojuola *et al*. (2019), has remained the reference point at the national level. However, the map has been noted to be limited in utility (Olaniyan and Ogunkunle, 2007a,b).

Observing manuscript soil maps (ie. Field Map) to be 2 to 2.5 times that of published soil maps in scale, Dent and Young (1981) recorded that for many years the British Soil Surveys employed a system of published maps at 1:63,360, but manuscript maps at 1:10,560 – 1:25,000, with the latter being available for inspection in the field. So, the information contained in the manuscript map was used to augment that of the published map. With the accuracy of soil maps being influenced by map scale, spatial location, etc. (Lin *et al*., 2005), the extra information contained in the manuscript map will vary with location. In the absence of detailed soil maps the extra information in the manuscript map becomes handy. But it is often neglected.

At publication, the soil map of Nigeria was reduced from 178 mapping units all over the country for the manuscript to 58 (Anande–Kur, 1990; Esu, 2005). So, the manuscript map has the potential for extra significant information. However, both maps lacked information about their predictive accuracies (Sonneveld, 2005; Olaniyan and Ogunkunle, 2007b). Determination of maps' predictive accuracies quantifies data quality which informs land use and soil management (Adewuyi *et al*., 2018; Raynukaazhakarsamy and Sathiaseelan, 2018; Stehman and Czaplewski, 1998).

A comparison of the accuracies of the manuscript and published soil maps in the densely populated Owerri agricultural zone of Imo State, Nigeria, brings out the differences in information contents of both maps. Specifically, the objectives of the study were to:

- Determine the predictive accuracy of the manuscript soil map of the location of study;
- Determine the predictive accuracy of the published soil map of the location of study;
- Compare the two maps to bring out the extra information contained in the manuscript map.

The study shows properties that are well predicted and thus provide information that boosts the value of the reconnaissance map as a base map for further studies, thereby enhancing its use.

MATERIALS AND METHODS

Location

The location of the study is the Owerri Agricultural Zone of Imo State, Nigeria, which lies within Lat. 5°15'N to 5°45'N, and Long. 7°30'E to 6°45'E. It is within the lowland humid tropics, having rainforest vegetation dominated by oil palm (Elaeis guineensis) and pennisetum grass species. Total annual rainfall in the location is 2,250 – 2,500 mm, which is bi-modal, having 3 dry months. Temperatures are high all through the year with mean annual maximum range of 30-33°C. Dominant geology of the area is coastal plains sand. Arable cropping is the main land use with dominant crops being cassava, yam, maize and melon. The location has a total land area of 3,401.29Km^2 (340,129 ha) and a population density of 1,206 persons per square kilometre, on average. Figure 1 shows the location of the study.

Field study

The base data for the study were soil maps of Imo State by the Federal Department of Agricultural Land Resources (FDALR), Abuja. The parts of the maps covering the location of the study were thus extracted. Specifically, the reconnaissance soil survey of Imo State, Nigeria (1:250,000), soils report maps (FDALR, 1985) being the manuscript map; and the reconnaissance soil survey of Nigeria (1:1,000,000) soils report (FDALR, 1990) being the published map, were used.

Map units for map 1:250,000 are:
441 - nearly level floodplains (recent alluvium);
432 - nearly level to gently undulating plains, developed from coastal plains sand;
431 - nearly level plains developed from coastal plains sand;
434 - gently undulating plains and mangrove swamps developed from sub recent alluvium;
438 - nearly level sombreirowarri deltaic plain developed from subrecent alluvium.

Map units for map 1:1,000,000 are:
IRF - Imo River Floodplain;
CPS - Coastal Plains Sand;
DPS - Deltaic Plains Soils

Soil sampling

Within an area of 308 Km^2 from each of the map units, transects were placed where physiographic variations were close. Sampling points were staggered to cover the length and breadth of the transect and placed at points typical of soil units to capture the greatest variability (Hengl *et al*., 2003; Yang *et al*., 2016). Samples were taken with the auger at two depths (0 – 20 cm, 20 – 40 cm), from fields that were fallow so as to reduce the effect of management. The sampling model adopted was an attempt to limit the number of samples to what can be managed without necessarily undermining the result of the study.

The number of sample points against the map units for map (1:250,000) were: 441(8), 432(7), 431(10), and 438(7). Mangrove swamps were not sampled due to difficulty in accessing them. Total number of samples for this map were (32 x 2) = 64.

For map (1:1,000,000), the number of sample points against units were: IRF(6), CPS(8), and DPS(7). Total number of samples was thus (21 x 2) = 42. The overall total number of samples was therefore (64+42) = 106.

Laboratory analysis

Soil samples collected from the field were analysed in the laboratory following standard procedures as earlier

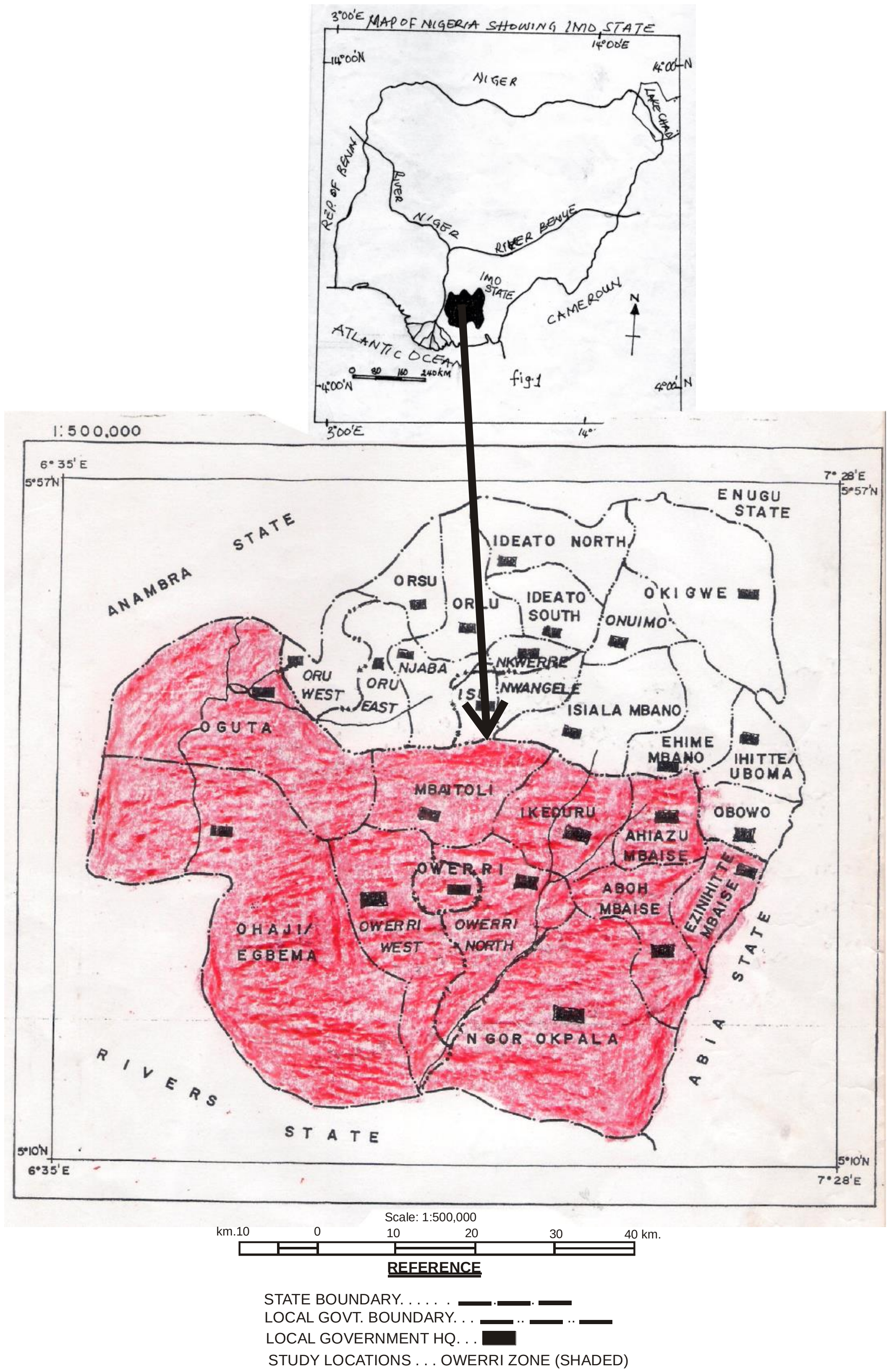

Figure 1. Map of Imo State showing Local Government Areas with the shaded representing location of study.

reported (Ukaegbu *et al*., 2022). Samples were analysed for particle sizes – sand, silt, clay; pH, Exch. Bases-Ca, Mg, K, Na; Exch. Acidity – Al, H, Al+H; Effective Cation Exchange Capacity (ECEC), Base Saturation (BS), Exchangeable Sodium Percentage (ESP), Organic Carbon (OC), Total nitrogen (TN) and available Phosphorus (av.P).

Statistical analyses

The variability of parameters within map units and over the whole area of study was expressed as coefficients of variation (CV%) obtained by expressing the standard deviation of the parameter as a percentage of the mean of the same parameter.

Further, analysis of variance (ANOVA) statistic was used to determine the effectiveness of mapping. The means of parameters for the various map units were separated at a 5% significance level.

The ability of soil map to predict soil parameters was also determined using the formula 1 - RV (Dent and Young 1981).

Where: $\text{RV (Relative Variance)} = \frac{\text{Variance within map units}}{\text{Total Variance over whole area}}$

RESULTS AND DISCUSSION

The extent soil properties vary within and between map units is a measure of accuracy and of course usefulness of the mapping exercise. According to Dent and Young (1981), a soil map is valuable only when the units differ significantly, in statistical terms, among themselves, with such differences having a significant effect on land use and soil management. At publication, the soil mapping units as concerning the location of the study were purely morphological, namely – Imo river flood plain (IRF), coastal plains sand (CPS), and Deltaic plain (DPS). But at manuscript scale, with minor relief differences recognized, the coastal plains sand was split into nearly level plains (431), and gently undulating plains (432), while the Deltaic plain was split into gently undulating plains including mangrove swamps (434), and nearly level sombreirowarri deltaic plain (438). Imo river flood plain (441) remained the same as at publication.

Table 1 shows the variability of soil properties at topsoil for the manuscript soil map (1:250,000). The table shows the range of coefficients of variation (CVs, %) to vary from 7.5% for sand in mapping unit 431 to 119% for total nitrogen (TN) in unit 432. Sand and pH had the least variations. Generally, properties varied most in unit 441 but least in unit 438. At a 5% level of significance, mapping units generally differed significantly among themselves at the topsoil in terms of sand, silt, clay, silt/clay, Al, H, ECEC, BS, Al+H, ESP, and OC. Mapping unit 441 was differentiated most from others in terms of most of the parameters and was followed by unit 438.

At subsoil (Table 2) range of CVs of properties for the manuscript map varied from 8.7% for sand in unit 431 to 113% for TN in unit 432. The analysis of variance result at a 5% level of significance shows the mapping units to generally differ in terms of sand, silt, clay, silt/clay, K, Al, ECEC, and Al+H. Unit 441 was also differentiated most, followed by unit 438.

Table 3 shows the variability of properties at topsoil for the published scale (1:1,000,000). Coefficients of variation of properties have ranged from 8.4% for sand in unit CPS to 110% for TN in unit DPS. Analysis of variance results showed mapping units to generally differ at 5% in terms of sand, silt, clay, silt/clay, K, ECEC, Al+H, and ESP. Unit IRF differed from others in most of the properties. At the subsoil for the published map. Table 4 shows pH to have the least CV of 10% in unit CPS while TN had the biggest CV of 117% in the same unit. In terms of analysis of variance, the units differed based on sand, silt, clay, K, Al, H, ECEC, BS, Al+H, and OC. Unit IRF differed mostly from the others in terms of most of the properties.

Soil-forming factors, including management, have been noted to influence soil property spatial variability in any field (Beckett and Webster, 1971; Igbal *et al*., 2005). The mapping units differed mainly due to the influence of parent material and topography. Despite sampling from fallow fields, management might have contributed too to the high within the unit variation of properties. In a small area of 2,400 m^2 on a plain within the coastal plains sand unit, Ukaegbu and Nnawuihe (2020) recorded high variability of av.P, exch. Ca, Mg, acidity, and moderate variation of OM, ECEC, and BS, due to the influence of management. But sand and pH had low variation, this being attributed to the acid sandy nature of the soil's parent material as well as the humid climate of the environment. While the high variability of properties within the floodplain is in tandem with the nature of the unit, longer fallows, due to the lower population density of the deltaic plain (Ukaegbu, *et al*., 2022), might have contributed to the lower variability of properties within the unit. Natural fallows have been reported to decrease soil variability (Ghartey *et al*., 2012). Similarly, there is an increment in soil homogenization with time (Saldana *et al*., 1998). So, the subrecent alluvium should be more homogenous than the recent alluvium based on this fact too.

Generally, there was a high within unit variation of properties. Olaniyan and Ogunkunle (2007a,b) found comparable results evaluating the accuracy of the soil map of Nigeria in Kwara State. This they attributed mainly to the broad definition of mapping units and small scale of maps. Explaining further, they noted a loose definition of map units in terms of geomorphology, with the result that most of the units had three or more taxonomic units. The same is true for the location of the present study. This fact

Table 1. Range, mean, standard deviation and coefficient of variation of physico-chemical properties of soils for units of map of scale (1:250,000). Topsoil parameters.

M.U.		Sand	Silt	Clay	Silt/Cay	pH	Ca	Mg	K	Na	Al	H	ECEC	BS	Al+H	ESP	OC	TN	av.P
	Min.	20	13	13	0.6	4	0.8	0.4	0.09	0.02	0.36	1.0	7.2	19	1.4	0.23	0.84	0.06	14.6
	Max.	72	51	37	2.1	5.6	4.8	3.4	0.28	0.19	3.0	5.68	15.0	82	7.5	2.64	2.8	0.50	90.0
411	Mean	50^{a}	28^{a}	22^{a}	1.3^{a}	4.7^{a}	2.9^{a}	1.7^{a}	0.15^{a}	0.12^{a}	1.3^{a}	2.9^{a}	9.1^{a}	54.5^{a}	4.2^{a}	1.4^{a}	1.31^{ac}	0.19^{a}	33.6^{a}
	SD	23.2	15.8	9.3	0.54	0.61	1.8	1.2	0.07	0.06	0.98	1.9	3.0	22.2	2.4	0.79	0.72	0.16	28.4
	CV (%)	46.4	56.4	42.3	42	13	62.1	71	47	50	75.4	66	33	41	57	56	55	84	85
	Min.	64	2	4	0.2	4.0	0.8	0.4	0.08	0.06	0.16	0.40	2.3	24	0.56	0.85	0.84	0.01	14
	Max.	94	19	25	1.2	5.8	4.0	3.2	0.20	0.20	2.0	4.24	8.5	77	5.8	3.85	2.6	0.70	68
432	Mean	78.8^{b}	7.4^{b}	14^{b}	0.56^{b}	4.7^{a}	2.1^{a}	1.5^{a}	0.12^{a}	0.11^{a}	0.84^{ab}	1.8^{b}	6.4^{b}	59.3^{ac}	2.7^{b}	1.8^{a}	1.3^{a}	0.16^{a}	27.6^{a}
	SD	7.7	4.2	5.4	0.30	0.57	0.91	0.8	0.04	0.04	0.49	0.99	1.6	15.8	1.3	0.79	0.51	0.19	18.6
	CV (%)	9.8	57	39	54	12	43	53.3	33.3	36.4	58	55	25	27	48.2	44	39.2	119	67.4
	Min.	71	3	4	0.21	4.1	1.2	0.4	0.05	0.06	0	0.16	3.1	36	0.16	0.85	0.40	0.01	4.0
	Max.	92	17	24	2.43	5.7	4.8	4.8	0.32	0.29	1.12	3.2	11.5	98	4.1	4.26	2.8	0.21	110
431	Mean	80.5^{b}	6.5^{b}	13^{b}	0.59^{b}	4.8^{a}	2.5^{a}	1.9^{a}	0.13^{a}	0.16^{a}	0.59^{b}	1.3^{b}	6.6^{b}	70.9^{bc}	1.9^{c}	2.4^{b}	0.95^{bc}	0.06^{a}	34.6^{a}
	SD	6.0	3.1	4.9	0.44	0.48	1.1	1.16	0.07	0.07	0.37	0.75	1.8	15.0	0.96	0.97	0.47	0.04	30.3
	CV (%)	7.5	47.7	38	75	10	44	61.1	54	44	63	58	27.3	21.2	51	40.4	50	67	88
	Min.	50	1	5	0.05	4.1	1.2	0.4	0.05	0.07	0.12	0.60	3.7	50	0.88	1.21	0.52	0.01	5.0
	Max.	91	35	21	2.33	5.9	5.6	2.4	0.13	0.20	1.12	1.84	9.4	87	1.96	4.4	1.3	0.33	69
438	Mean	77.6^{b}	11.2^{b}	11.2^{b}	1.02^{a}	4.8^{a}	2.7a	1.3^{a}	0.08^{a}	0.15^{a}	0.45^{b}	1.06^{b}	5.7^{b}	71.2^{c}	1.4^{c}	2.9^{b}	0.79^{b}	0.10^{a}	22.3^{a}
	SD	14.8	11.4	5.5	0.80	0.65	1.3	0.82	0.03	0.04	0.26	0.36	1.7	13.0	0.35	1.1	0.23	0.11	18.8
	CV (%)	19.1	102	49	78	14	48.2	63	38	27	58	34	30	18.3	25	38	29	110	84.3

NB: Means with different letters in a column are significantly different at the 0.05 level.

notwithstanding, the unit of alluvial soils of recent origin was most accurately mapped judging by the large number of properties on the basis of which it significantly differed from others. This was followed by deltaic alluvium of subrecent origin. Using topography as basis for mapping, Basayigit and Senol (2008) also recorded good predictive accuracies by reconnaissance soil map (1:200,000) of soils of some plains and basins in Turkey. The units of the coastal plains sand delineated based on minor differences in relief have not varied much. Such minor differences in relief (i.e. location is generally of low relief) did not influence soil properties much at the depths sampled.

The scale of the map has also been noted to influence the variability of soil properties (Lin *et al.*, 2005; Basayigit and Senol, 2008). The influence of

Table 2. Range, mean, standard deviation and coefficient of variation of physico-chemical properties of soils of map units of map scale (1:250,000). Subsoil parameters.

M.U.		Sand	Silt	Clay	Silt/Cay	pH	Ca	Mg	K	Na	Al	H	ECEC	BS	Al+H	ESP	OC	TN	av.P
	Min.	12	20	15	0.67	4.1	2.0	0.4	0.10	0.06	0.48	2.4	8.1	36.0	3.04	0.60	0.6	0.02	14
	Max.	64	52	40	2	5.8	5.6	3.2	0.17	0.24	4.2	6.4	16.8	69.0	10.6	2.96	1.1	0.16	110
411	Mean	41.7^{a}	30.5^{a}	27.8^{ab}	1.1^{a}	4.8^{a}	3.0^{a}	1.4^{a}	0.14^{a}	0.15^{a}	2.2^{a}	4.2^{a}	11.1^{a}	43.0^{a}	6.4^{a}	1.5^{a}	0.86^{a}	0.10^{a}	46.7^{a}
	SD	20.3	15.2	8.4	0.51	0.67	1.4	1.0	0.03	0.06	1.3	1.5	3.3	12.8	2.6	0.85	0.20	0.05	37.1
	CV (%)	48.7	50	30	46.4	14	47	71.4	21.4	40	59.1	36	30	30	41	57	23.3	50	79.4
	Min.	50	2	4	0.07	4.1	1.0	0.10	0.05	0.03	0	0.08	4.1	35.0	0.16	0.44	0.04	0.01	6.5
	Max.	94	19	45	0.76	6.0	4.8	3.2	0.17	0.27	1.52	3.12	9.4	97.0	4.0	5.1	1.54	0.30	57
432	Mean	72.1^{b}	6.1^{b}	21.9^{ab}	0.32^{b}	4.9^{a}	2.7^{a}	1.4^{a}	0.09^{b}	0.14^{a}	0.69^{b}	1.4^{b}	6.4^{b}	66.8^{b}	2.1^{b}	2.3^{a}	0.57^{a}	0.08^{a}	27.3^{a}
	SD	11.5	5.1	9.7	0.23	0.51	1.1	0.88	0.04	0.09	0.48	0.90	1.3	17.5	1.1	1.44	0.42	0.09	16
	CV (%)	16	84	44.3	72	10.4	41	63	44.4	64.3	70	64.3	20.3	26.2	52.4	63	74	113	59
	Min.	65	2	7	0.08	4.2	0.80	0.40	0.04	0.04	0.08	0.48	3.5	37.0	0.80	0.67	0.08	0.01	1.2
	Max.	86	11	29	2.2	5.9	5.6	3.6	0.13	0.29	1.28	3.3	12.0	85.0	4.1	4.5	1.38	0.21	128
431	Mean	75.8^{b}	5.2^{b}	18.9^{bc}	0.39^{b}	4.9^{a}	2.2^{a}	1.6^{a}	0.08^{b}	0.14^{a}	0.58^{b}	1.3^{b}	5.9^{b}	67.4^{b}	1.9^{b}	2.4^{a}	0.58^{a}	0.05^{a}	32^{a}
	SD	6.6	2.2	6.1	0.41	0.48	1.0	0.85	0.03	0.08	0.33	0.72	1.6	13.3	0.85	1.1	0.33	0.05	32
	CV (%)	8.7	42.3	32.3	105	9.8	45.5	53	38	57	57	55.4	27	20	45	46	57	100	100
	Min.	42	3	6	0.18	4.0	1.2	0.80	0.05	0.09	0.12	0.64	4.3	38.0	0.96	1.4	0.11	0.01	7.0
	Max.	86	33	29	1.9	5.5	4.6	4.0	0.11	0.24	2.68	2.64	8.6	95.0	3.7	4.0	0.90	0.30	28.0
438	Mean	71.5^{b}	12.8^{c}	15.7^{c}	0.84^{a}	4.7^{a}	2.8^{a}	1.6^{a}	0.08^{b}	0.16^{a}	0.72^{b}	1.2^{b}	6.5^{b}	71.0^{b}	1.9^{b}	2.5^{a}	0.40^{a}	0.10^{a}	17^{a}
	SD	16	10.3	7.1	0.57	0.45	0.96	0.93	0.02	0.04	0.76	0.55	1.3	16.7	0.93	0.77	0.25	0.11	7
	CV (%)	22.4	80.5	45	68	9.6	34.3	58	25	25	106	46	20	24	4.9	31	63	110	41.2

NB: Means with different letters in a column are significantly different at the 0.05 level.

the map scale has been better captured using the formula (1-RV) given in Table 5. This gives predictive accuracy of a soil map that is based on the purity of a map unit relative to that of the whole area. Table 5 shows the predictive accuracies of the two maps for the various properties to range from 0.01 for pH and Na to 0.62 for BS, this being equivalent to 1 to 62% accuracies. Dent and Young (1981) recorded the critical values of Predictive Accuracy (PA) given by 1-RV to be 0.5 for physical properties and 0.3 for chemical properties general purpose soil maps. As a rule of thumb, Gonzalez *et al*. (2018) opined that a Soil Survey should aim at the map units being composed of at least 50% of the right soil. Based on these, the two maps

Table 3. Range, mean, standard deviation and coefficient of variation of physico-chemical properties of soils for map units of map (1:1,000,000). Topsoil parameters.

M.U.		Sand	Silt	Clay	Silt/Clay	pH	Ca	Mg	K	Na	Al	H	ECEC	BS	Al+H	ESP	OC	TN	av.P
	Min.	20	13	13	0.60	4	0.8	0.4	0.09	0.02	0.36	1.0	7.2	19	1.4	0.23	0.84	0.05	14.6
	Max.	72	51	37	2.1	5.6	4.8	3.4	0.28	0.19	3.0	5.7	15	82	7.5	2.64	2.8	0.19	90.0
IRF	Mean	50.0^{a}	28^{a}	22^{a}	1.3^{a}	4.7^{a}	2.9^{a}	1.7^{a}	0.15^{a}	0.12^{a}	1.3^{a}	2.9^{a}	9.1^{a}	54.5^{a}	4.2^{a}	1.4^{a}	1.3^{a}	0.11^{a}	33.6^{a}
	SD	23.2	16	9.3	0.53	0.61	1.8	1.2	0.07	0.06	0.98	1.9	3.0	22.2	2.4	0.79	0.72	0.05	28.4
	CV (%)	46.4	57	42.3	41	13	62.1	70.6	47	50	75.4	66	33	41	57.1	56.4	55.4	46	85
	Min.	64	2	4	0.20	4	0.8	0.4	0.05	0.06	0	0.16	2.3	24	0.16	0.85	0.40	0.01	4.0
	Max.	94	19	25	2.4	5.8	4.8	4.8	0.32	0.29	2.0	4.24	11.5	98	5.8	4.26	2.8	0.28	110
CPS	Mean	80^{b}	7.0^{b}	13.4^{b}	0.58^{b}	4.8^{a}	2.3^{a}	1.7^{a}	0.13^{a}	0.14^{a}	0.68^{a}	1.5^{a}	6.5^{b}	66.5^{a}	2.2^{b}	2.2^{a}	1.1^{a}	0.07^{a}	32^{a}
	SD	6.7	3.5	5.1	0.38	0.51	1.0	1.1	0.06	0.06	0.43	0.88	1.7	16.2	1.13	0.94	0.50	0.06	26.4
	CV (%)	8.4	50	38.1	66	10.6	43.5	65	46.2	43	63.2	59	26.2	24.4	51.4	43	46	86	83
	Min.	50	1	5	0.05	4.1	1.2	0.4	0.05	0.07	0.12	0.60	3.7	50	0.88	1.21	0.52	0.01	5.0
	Max.	91	35	21	2.3	5.9	5.6	2.4	0.13	0.20	1.12	1.84	9.4	87	3.0	4.4	1.3	0.33	69.0
DPS	Mean	78^{b}	11.2^{b}	11.2^{b}	1.02^{a}	4.8^{a}	2.7^{a}	1.3^{a}	0.08^{b}	0.15^{a}	0.45^{a}	1.1^{a}	5.7^{b}	71.3^{a}	1.5^{b}	2.9^{b}	0.79^{a}	0.10^{a}	22.3^{a}
	SD	15	11.4	5.5	0.80	0.65	1.3	0.82	0.03	0.04	0.26	0.36	1.7	13.0	0.59	1.1	0.23	0.11	18.8
	CV (%)	19.2	101.8	49	78.4	13.5	48.1	63.1	38	27	58	33	30	18.2	39.3	38	29.1	110	84.3

NB: Means with different letters in a column are significantly different at the 0.05 level.

Table 4. Range, mean, standard deviation and coefficient of variation of physico-chemical properties of soils for map units of map (1:1,000,000). Subsoil parameters.

M.U.		Sand	Silt	Clay	Silt/Clay	pH	Ca	Mg	K	Na	Al	H	ECEC	BS	Al+H	ESP	OC	TN	av.P
	Min.	12	20	15	0.67	4.1	2	0.4	0.10	0.06	0.48	2.4	8.1	36	3.0	0.60	0.60	0.02	14
	Max.	64	52	40	69	5.8	5.6	3.2	0.17	0.24	4.2	6.4	16.8	69	10.6	3.0	1.1	0.16	110
IRF	Mean	41.7^{a}	30.5^{a}	28^{a}	12.5^{a}	4.7^{a}	3.0^{a}	1.4^{a}	0.14^{a}	0.15^{a}	2.2^{a}	4.2^{a}	11.1^{a}	43^{a}	6.4^{a}	1.5^{a}	0.86^{a}	0.10^{a}	46.7^{a}
	SD	20.3	15.2	8.4	27.7	0.65	1.4	1.0	0.03	0.06	1.3	1.5	3.3	12.8	2.6	0.85	0.20	0.05	37.1
	CV (%)	49.3	49.8	30	222	13.8	46.7	71.4	21.4	40	59	36	30	30	41	56.6	23.3	50	79.4
	Min.	50	2	4	0.07	4.1	0.8	0.1	0.04	0.03	0	0.08	3.5	35	0.16	0.44	0.04	0.01	1.2
	Max.	94	19	45	2.2	6.0	5.6	3.6	0.17	0.29	1.52	3.3	12.0	97	4.1	5.1	1.54	0.30	128
CPS	Mean	74^{b}	5.6^{b}	20.1^{b}	0.38^{a}	4.9^{a}	2.4^{a}	1.5^{a}	0.08^{b}	0.14^{a}	0.62^{b}	1.3^{b}	6.1^{b}	67^{b}	2.0^{b}	2.4^{a}	0.58^{ab}	0.06^{a}	29.9^{a}
	SD	9	3.6	7.7	0.36	0.49	1.1	0.85	0.03	0.07	0.39	0.79	1.5	14.8	0.93	1.2	0.36	0.07	26.7
	CV (%)	12.2	64.3	38.3	94.7	10	45.8	57	38	50	63	61	25	22.1	46.5	50	62.1	117	89.3

Table 4. Contd.

	Min.	42	3	6	0.18	4.0	1.2	0.80	0.05	0.09	0.12	1.64	4.3	38	0.96	1.4	0.11	0.01	7.0
	Max.	86	33	29	1.9	5.5	4.6	4.0	0.11	0.24	2.7	2.6	8.6	95	3.7	4.0	0.90	0.30	28
DPS	Mean	71.5^{ab}	12.8^{ab}	1^{6b}	0.83^{a}	4.7^{a}	2.8^{a}	1.6^{a}	0.08^{b}	0.16^{a}	0.72^{b}	1.2^{b}	6.5^{b}	71.2^{b}	1.9^{b}	2.5^{a}	0.40^{b}	0.10^{a}	16.7^{a}
	SD	16	10.3	7.1	0.61	0.45	0.96	0.93	0.02	0.04	0.76	0.55	1.3	16.7	0.93	0.78	0.25	0.11	6.8
	CV (%)	22.4	80.5	44.4	73.5	9.6	34.3	58	25	25	106	46	20	23.5	49	31.2	63	110	41

NB: Means with different letters in a column are significantly different at the 0.05 level.

Table 5. Predictive accuracies of soil maps given by the formula 1-RV.

Parameters	Topsoil		Subsoil	
	1:250,000	1:1,000,000	1:250,000	1:1,000,000
Sand	0.42	0.42	0.44	0.43
Silt	0.45	0.45	0.57	0.57
Clay	0.22	0.21	0.17	0.15
Silt/Clay	0.21	0.21	0.32	0.17
pH	0.02	0.01	0.01	0.03
Ca	0.06	0.03	0.08	0.04
Mg	0.06	0.03	0.01	0.08
K	0.11	0.11	0.30	0.26
Na	0.11	0.02	0.01	0.01
Al	0.21	0.17	0.39	0.38
H	0.25	0.21	0.54	0.53
ECEC	0.19	0.19	0.46	0.45
BS	0.62	0.07	0.22	0.22
Al+H	0.32	0.25	0.58	0.58
ESP	0.21	0.14	0.06	0.06
OC	0.15	0.08	0.11	0.11
TN	0.15	0.04	0.07	0.05
av.P	0.04	0.02	0.09	0.22

considered have good predictions for sand and silt, at both depths; Al, H, ECEC, Al+H at subsoil for both scales; and BS at topsoil for the manuscript map. However, the manuscript map has improved prediction at the topsoil for Al, H, Al+H, BS, ESP, OC, TN; while silt/clay at the subsoil, as against the published map. Improvement in prediction means a reduction in variance within map units relative to the variance over the whole area. For example, Table 1 shows units of the manuscript map to differ significantly in terms of BS at the topsoil. Unit 441 compared with 432 while differing with the others;

unit 438 differed with 441 while comparing with the others in terms of BS. In contrast, Table 3 shows units of the published map not to differ statistically at the top soil based on the parameter (BS). At the subsoil (Table 2) units of the manuscript map differed statistically in terms of silt/clay ratio. Units 441 and 438 compare but differ with each of 432 and 431 both of which compare. However, for the published map (Table 4), the units did not differ in terms of silt/clay at the subsoil. The greater number of mapping units for the manuscript map resulting from the improved scale is the reason for the improvement in prediction. Such improvement can also take place in spite of high within unit variation (Rossiter *et al*., 2017; Ukaegbu and Akamigbo, 2021).

The parameters, Al, H, Al+H, ESP, OC, and TN, with improved prediction, are considered important to management while silt/clay has been noted for its pedogenetic significance. According to Oberthür *et al*. (1996) classical soil survey techniques require partition of variance for stable soil properties such as texture, CEC and organic matter. Based on this fact, the manuscript soil map has significant extra information, despite being also at a small scale. It thus reveals the soil's potential for agricultural development better than the published map. However, it needs to be seen what the result will be at greater intensity of sampling.

Conclusion

Despite being at a small scale too, the manuscript soil map expressed the potentials of soils of location of study better than the published map, with improved predictions of Al, H, Al+H, BS, ESP, OC, TN, Silt/Clay. The map had better predictive accuracy for alluvial soils than for units delineated based on minor relief differences. There was high within unit variation of properties all the same, thus highlighting the need for detailed mapping of the soils. The manuscript map is a better base map than the published for improving the scale of soil map. Study further shows the effect of reduction in map scale at publication.

Recommendation

There is a tendency to overlook the manuscript map. It is not enough to look at the published soil map of the location of the study. The manuscript soil map should also be considered as it boosts the information contained by the reconnaissance soil map of the area studied.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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