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Use of geographic information system (GIS) in production of soil series map of Oyo State, Southwestern Nigeria

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Abstract

Soil is a natural resource that can be grouped into various soil types with different characteristics/properties that provide growing benefits and limitations. Soil plays an important role back to human existence and the knowledge of soil is the basis to its usefulness and management. Production of soil map give understanding about the soil series available in an environment. This study focused on mapping of soils series in Oyo State, Nigeria and it distribution across the thirty three (33) local government area of the state using geographic information system (GIS) application. The method used in this study was the use of Oyo State soil map which was extracted from Nigeria soil map (shape file) and subdivided into demarcated potion per local government areas. Nine soil series were classified and determined within the study area and they were differentiated with different color composite. The results showed that only one soil series exists in Akinyele, Lagelu, Egbeda, Ogbomosho North and Ogbomosho South, Ibadan North, North East, Northwest, Southeast and Southwest local government, and mixed soil series in other areas. Individual soil series present per local government area were determined. The results of the soil map produced in this study will help in improving soil data available within each local government area and Oyo State at large. It will also help in having the understanding of soil series types, its supplies and usefulness for different use in human daily activities in the study area.

Keywords: Usefulness and management, soil series, GIS application, demarcation, color composite.

Introduction

The representation of map is not achievable, rather a structured identity of knowledge about the spread of soil across a geographic region are represented. Variation in soils is horizontally and vertically above the geographic region and the unfavorable impact of these variations on land use cannot be overlooked. The duty performed by the soil surveyor is primarily determination of soils series types, demarcates each of the series types and represents the category of the soil on a map. Soil map serve as a database of soil resources of a given area and allows the soil users in making intense use of the field information in production of plans and choice-making[1]. Determination of soil series by soil surveyors explained and makes available enough information based on categories, properties as well as behaviour of such series in a particular area[2,3].

Concept of three-dimensional representation of soil variant in thoughts is what the surveyor expert map was based, and this is based constant use of aerial photography through photogrammetric means and gathered the field data relatively with land forms, vegetation, land use and geology[2,4,5]. The degree in standard of map unit purity for a clearly defined ratio in size of soil series maps of a location requires adequate changes in present soil survey[6,5]. The standard of a soil representation in map form is largely dependent on relevance, representativeness and reliability of information presented there in. Reliability based on map information is enhanced through the purity and homogeneity of soil map[7-10]. The mapping units of soil purity are a foundation upon which the basis of soil management and land use depends[11].

GIS was used to determine the accuracy of unrefined-ratio of sized in land standard maps in scale 1:200,000 and 1:1 000,000, which was used to assess viable upgrades in making use of separate up-scaling methods of first-rate-soil scale facts in 1:5,000 in North region Germany. It was observed that the classification of the up-scaling process criterion was not relevant in achieving the standard of land maps in scale of 1:1,000,000[12].

Differences in units of map must be highly correlated and useful in land-use and land management[13]. However this is not appropriate due to the fact that the range of one soil to another is dissimilar and the range of their inconsistence became regularly irregular[7, 14-16]. Complete soil spatial and attribute data by means of two detailed studies is defined in the next component needed which will be used in modeling the environmental[17-20]. Variety in units of soil map and soil characteristics at numerous ratio using two detailed researches were examines, and detected that the surface inconsistent of soil was a dependant of the map ratio,

surface region, and clearly defined soil homes[5]. 590 million hectares of alluvial soils are within the earth and this is not enough but however they all used for agricultural purposes[21].

The representation through the knowledge of soil surveyors is as a result of soil diagrammatic representation, soil categorization and their unit's[22], which are from the observation obtained from the field, which were combined as the most important soil-made determinant, and information obtained directly from the field. Soil mapping using computerized means is an undertaking great demand in relation to achieving the major use of soils in several locations. In defining the soil map units the information on soil maps is enclosed in, which together contain the legend of the map in the spatial process of the map units[22]. Soil mapping unit is the key concept in soil prediction. The property of soil based on proportion of the region covered by a unit of map unit was determined by the Soil Resource Information System in Australian. Determination of unreliable is executed on the basis of the portion of the area covered and its adopted distribution[23].

Many studies have proven soil map production as a viable means of having continuous and reliable soil record/data. In spite of this, they tend to ensure constant up to date soil record and abolish hindrances in their use[24,25]. Available data offer will assists in solving many geographical and environmental problems[26,27] across local, regional and national levels. Further analysis from the field data resulted into new data during the processing[28,29], and the result of the new data tend to assist overcome the restrictions positioned over conventional soil maps. With those benefits related to such soil mapping generation, its effects was unsuccessful in several locations with lots of environmental difficulties are nevertheless not resolved. Computerized soil model was combined with Geographical Information System and Remote sensing technology which was proposed to overcome obstacles imposed with the aid of conventional soil maps in some of Asian countries[28,29]. The use of computer technology in soil mapping in minnesota[24,27], Europe geographic soil database[26] and New Zealand soil map[30], were proposed. Despite transformation increase in soil mapping, some countries including Nigeria are still using the old method of producing soil series maps, and no significant efforts have been made at returning to a computerized soil representation mapping. Furthermore, Remote sensing and Geographic Information System application for knowledge and enhancing soil records in those locations stay speculative. Therefore, this study proposed a computerized soil series map of Oyo State and its distribution across the thirty three local government area present using remote sensing and geographic information system techniques.

Study area: Oyo State is one among of the 36 States of the Federal Republic of Nigeria with Ibadan as its capital city. The state has a total population of 7,041,198 as at 2006 population census counting[31]. The state has thirty three (33) local Government areas with a Perimeter boundary of 8574km and a total landmass area of 26939km^2. From Google earth satellite imagery 2015, it is situated at geographic latitude 8° 00'N of the equator and longitude 4° 00'E of Greenwich meridian. It consists of five geographical distributions which are; Ibadan, Oyo, Ogbomoso, Ibarapa, and Oke-Ogun. Figure-1 below describes the study area. Table-2 below described the thirty three (33) Local Government areas of Oyo State with their landmass in (Km^2).

Materials and methods

Material: i. Nigeria soil data shape file, ii. Laptop Computer (Dell version) for graphic design and material typing, iii. 32 Gigabyte Hard drive (data and document storage), iv. Hp laserjet 2014 (for document printing), v. ArcGIS10.2.1.

Methods: The data for the study were from existing softcopy soil maps (shape file) of Nigeria, which were collected from Federal Department of Agricultural Land Resources (FDALR), Abuja. ArcGIS 10.2.1 was used to carrying out GIS analysis. The soil map of Nigeria was imported into ArcGIS environment so as to clip out the portion of studied area. The clipped layer was projected into the geographical coordinates, GCS_WGS 1984, zone number 32. All soil boundaries containing in each of the local government area of Oyo State were demarcated using ArcGIS 10.2.1 with different color composite. Non-spatial database based on soil series, for example; topography (landform)/relief, geology, mapping unit (Acode) was created and linked with the vector map. Thematic map based on soil series were produced. The Oyo State soil map was demarcated by local government area (Figure-3). In order to determine the soil series contained in each of the local government area, each of the local government area was digitized by portion of soil contained which was used to calculate the perimeter and area covered by each of the soil series contained (Table-2 and 3) (Figure-4).

Description of the soil series according to their classification in Oyo State, Nigeria and its distribution across the thirty three (33) local government of the state as stated from the attribute table generated from the shape file: i. Dark and intense to terribly dark and intense and extremely of little depth to dark and intense average in amount extremely dried soils; sand, sand to sandy containing humus at the uppermost layer above sandy to sandy clay loam and widely containing gravel sub-soils (Yellow color). ii. Dark and intense to terribly dark and intense extremely dried soils; containing humus to sandy humus, sandy clay humus at the uppermost layer above containing gravel sandy clay, humus clay sandy sub-soils.(Blue color). iii. Dark and intense extremely dried soils; sandy loam, loamy sand, widely gravelly uppermost layer above containing gravel sandy clay loam, sandy clay or clay containing humus, widely patterned sub-soils (Red color). iv. Widely dark and intense extremely dried with few poorly dried soils; loamy sand uppermost layer above sandy to sandy clay containing humus and widely containing gravel of sub-soils (Light blue color). v. Shallow and moderate averagely dark and intense in amount to

dark and intense extremely dried and some-what poorly to poorly dried soils; loamy sand to sand loamy and widely containing gravel uppermost layer above sandy clay containing humus to sandy clay and past. (Olive green color). vi. Terribly dark and intense well drained and extremely dark and intense poorly dried soils; sandy loam, sandy loam, sandy clay loam or loamy sandy uppermost layer above containing gravel sandy containing clay humus, clay containing humus or humus sand sub-soils. (Violent color). vii. Terribly dark and intense extremely dried soils; sandy containing humus at the uppermost layer widely containing gravel above sandy clay containing humus to sandy clay and widely containing sub-soils (Lighter red color). viii. Terribly dark and intense extremely dried few shallow dark red and containing gravel soils; sand to sandy containing humus at the uppermost layer above sandy to sandy clay containing humus and sandy clay sub-soils (Purple color). ix. Terribly shallow to shallow, dark and intense extremely dried soils; sand to sandy containing humus at the uppermost layer, widely containing gravel and above basis, over sandy clay loam sub-soils, widely contain gravel (Dark red color).

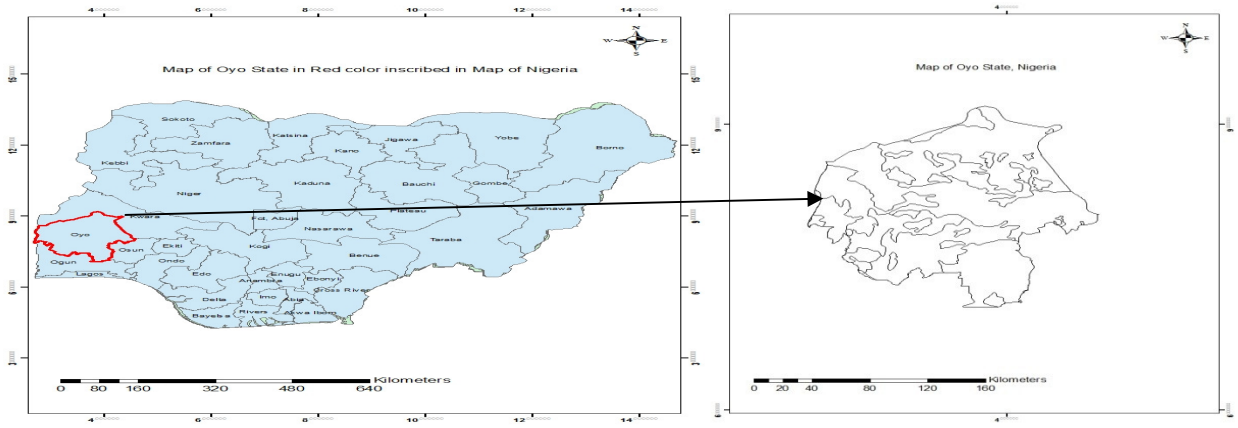


Figure-1: Map of Oyo State generated from map of Nigeria.

Table-1: Characteristics based on Topography/Relief, Geology and Mapping Unit

S/No by Soil Series	Topographic (Landform)/relief	Geology	Mapping units
1	Undulating dissected plains (Yellow color)	Undifferentiated Basement Complex	21c
2	Undulating plains (Blue color)	Undifferentiated Basement Complex	10a
3	Undulating plains with separated Inselbergs (Red color)	Undifferentiated Basement Complex	11a
4	Gently undulating plains with separated rock outcrops and inselbergs (Light blue color)	Undifferentiated Basement Complex	18d
5	Undulating plains with separated rock outcrops and hills (Olive green color)	Undifferentiated Basement Complex	22c
6	Gently undulating plains (Violent color)	Undifferentiated Basement Complex	7c
7	Nearly level to gently undulating plains (Lighter red color)	Undifferentiated Basement Complex	15g
8	Undulating plains (Purple color)	Sandstone Abeokuta Formation	17b
9	Hills and Ridges (Dark red color)	Undifferentiated Basement Complex	24b

Results and discussion

The results below described the soil series based on their classification within the study area. Figure-2 showed the soil map area of Oyo state inscribed in Nigeria soil map. Figure-3 described the soil series classifications with different color composite (yellow, blue, red, light blue, olive green, violent, lighter red, purple and dark red). Figure- 4 describes selection of individual soil contained per local Government. Figure-5 and 6 describes the categories of soil series type and the trend across categories. Figure-7 describes the percentages (%) by landmass for each local government area of the state.

Table- 2: Oyo State Local Government Area with their landmass area in (Km^2).

Local Government Area	(Perimeter Boundary in km)	(Landmass Area in km^2)	Percentage (%) area by Landmass
Afijio	282	795	2.95
Akinyele	109	540	2.00
Atiba	585	1790	6.64
Atisbo	1299	2023	7.51
Egbeda	73	261	0.97
Ibadan North	30	39	0.14
Ibadan North East	16	15	0.06
Ibadan North West	22	29	0.11
Ibadan South East	19	21	0.08
Ibadan South West	25	39	0.14
Ibarapa Central	169	462	1.71
Ibarapa East	177	827	3.07
Ibarapa North	437	1087	4.04
Ido	282	972	3.61
Irepo	260	937	3.48
Iseyin	528	1419	5.27
Itesiwaju	442	1205	4.47
Iwajowa	672	1937	7.19
Kajola	234	487	1.81
Lagelu	79	370	1.37
Ogo Oluwa	94	357	1.33
Ogbomoso North	67	235	0.87
Ogbomoso South	39	87	0.32
Olorunsogo	337	1146	4.25
Oluyole	178	561	2.08
Oorelope	228	951	3.53
Ona Ara	116	358	1.33
Orire	638	2115	7.85
Oyo East	89	155	0.58
Oyo West	211	518	1.92
Saki East	575	2094	7.77
Saki West	475	2055	7.63
Surulere	230	961	3.57

Table-3: Soil series present in each of the 33 Local Government Local Area

Local Government Area	Soil Series Color	Area (km2)	Percentage Area (%) in State	Perimeter (km)
Afijio	Yellow	52	0.66	45
	Light blue	272	7.13	127
	Deep Blue	471	15.18	110
	Olive green	0	0	0
Akinyele	Deep Blue	540	17.41	109
Atiba	Yellow	1071	13.68	250
	Light Blue	61	1.60	51
	Lighter Red	285	3.55	121
	Olive Green	373	9.64	163
Atisbo	Yellow	890	11.37	890
	Light Blue	274	7.18	120
	Lighter Red	900	11.21	248
	Olive Green	49	1.27	41
Egbeda	Deep Blue	261	8.41	73
Ibadan North	Deep Blue	39	1.26	30
Ibadan Northeast	Deep Blue	15	0.48	16
Ibadan Northwest	Deep Blue	29	0.93	22
Ibadan Southeast	Deep Blue	21	0.68	19
Ibadan Southwest	Deep Blue	39	1.26	25
Ibarapa Central	Light Blue	393	10.30	90
	Olive Green	43	1.11	43
	Purple	26	89.66	36
Ibarapa East	Yellow	37	0.47	24
	Light Blue	790	20.70	153
Ibarapa North	Lighter red	4	0.05	13
	Yellow	288	3.68	88
	Olive Green	584	15.10	210
	Light Blue	211	5.53	126
Ido	Yellow	12	0.15	17
	Light Blue	413	10.82	124
	Deep Blue	547	17.63	141
Irepo	Yellow	301	3.85	83
	Lighter Red	636	7.93	177
Iseyin	Olive Green	492	12.72	194
	Yellow	216	2.76	141
	Light Blue	711	18.63	193
Itesiwaju	Yellow	875	11.18	280
	Lighter Red	274	3.41	117
	Olive Green	56	1.45	45
Iwajowa	Lighter Red	690	8.60	234
	Olive Green	1095	28.31	327
	Light Blue	38	1.00	50
	Yellow	104	1.33	61
Kajola	Light Blue	2	0.05	6
	Lighter Red	108	1.35	84
	Yellow	98	1.25	66
	Olive Green	279	7.21	78
Lagelu	Deep Blue	370	11.93	79
Ogbomosho North	Yellow	235	3.00	67
Ogbomosho South	Yellow	87	1.11	39
Ogooluwa	Light Blue	2	0.05	9
	Yellow	264	3.37	78
	Dark Red	2	1.60	7
Olorunsogo	Yellow	85	1.09	61
	Lighter Red	1023	12.75	235
	Light Blue	21	0.55	22
	Olive Green	17	0.44	19
Oluyole	Red	140	95.89	48
	Deep Blue	421	13.57	130
Ona-Ara	Deep Blue	349	11.25	94
	Red	6	4.11	12
	Purple	3	10.34	10
Orelope	Lighter Red	887	11.05	144
	Yellow	56	0.72	71
	Olive Green	8	0.21	13
Orire	Light Blue	155	4.06	82
	Olive Green	352	9.10	157
	Lighter Red	1048	13.06	256
	Yellow	660	8.43	143
Oyo East	Light Blue	116	3.03	52
	Yellow	39	0.50	37
Oyo West	Yellow	I67	2.13	66
	Olive Green	61	1.58	48
	Light Blue	290	7.60	97
Saki East	Yellow	194	2.48	96
	Olive Green	459	11.87	131
	Dark Red	82	65.60	51
	Light Blue	26	0.68	37
	Lighter Red	1333	16.61	260
Saki West	Yellow	1176	15.02	202
	Light Blue	42	1.10	36
	Lighter Red	837	10.43	237
Surulere	Yellow	920	11.75	175
	Dark Red	41	32.80	55

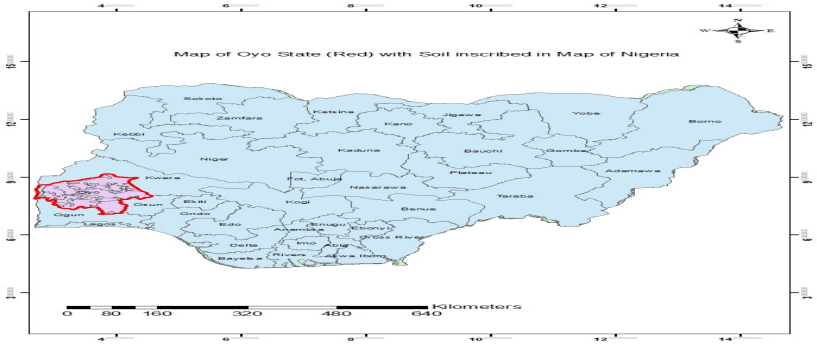


Figure-2: Map of Oyo State (Boundary red color) with soil inserted in map of Nigeria.

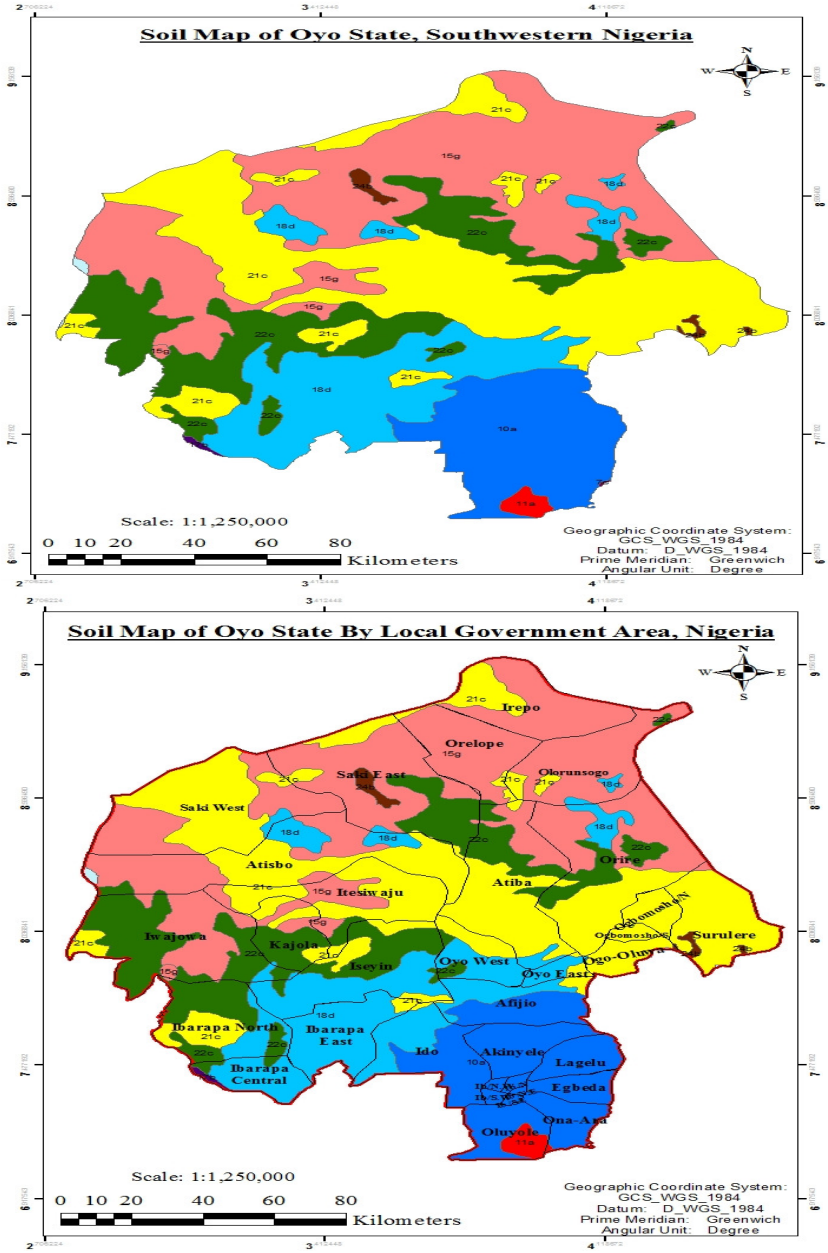
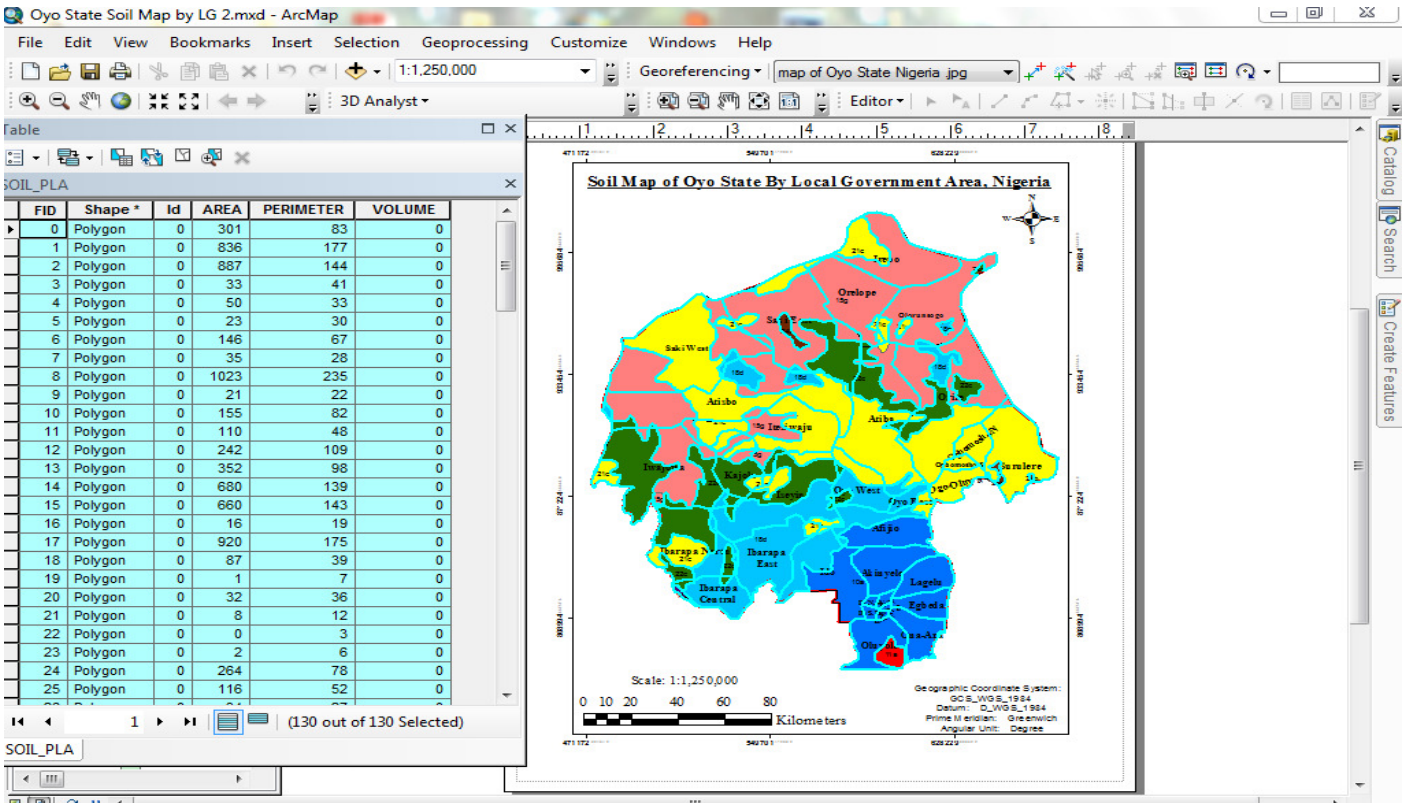


Figure-3: Composite soil map series of Oyo State and its Distribution across the Local Government Areas.

From the results of Figure-3, it showed that soil with yellow color has a total perimeter of 2537 km and area of 7827km^2. Deep blue soil with a total perimeter of 848km and area of 3102km^2. Red soil with a total perimeter of 60km and area of 146km^2. Light blue color has a total perimeter of 1375km and total area of 3817km^2. Olive green soil with a total perimeter of 1469km and area of 3868km^2. Lighter red soil with a total perimeter of 2126km, and area of 8025km^2. Purple soil color with a total perimeter of 46km and area of 29km^2. Dark red soil with a total perimeter of 113km and area of 125km^2.

The result from Figure-4 showed demarcation of portion of soil series type present per local government area. Table-3 has described the analysis of the results.



FID	Shape *	Id	AREA	PERIMETER	VOLUME
0	Polygon	0	301	83	0
1	Polygon	0	836	177	0
2	Polygon	0	887	144	0
3	Polygon	0	33	41	0
4	Polygon	0	50	33	0
5	Polygon	0	23	30	0
6	Polygon	0	146	67	0
7	Polygon	0	35	28	0
8	Polygon	0	1023	235	0
9	Polygon	0	21	22	0
10	Polygon	0	155	82	0
11	Polygon	0	110	48	0
12	Polygon	0	242	109	0
13	Polygon	0	352	98	0
14	Polygon	0	680	139	0
15	Polygon	0	660	143	0
16	Polygon	0	16	19	0
17	Polygon	0	920	175	0
18	Polygon	0	87	39	0
19	Polygon	0	1	7	0
20	Polygon	0	32	36	0
21	Polygon	0	8	12	0
22	Polygon	0	0	3	0
23	Polygon	0	2	6	0
24	Polygon	0	264	78	0
25	Polygon	0	116	52	0

Figure-4: showing selection of individual soil contained per local Government.

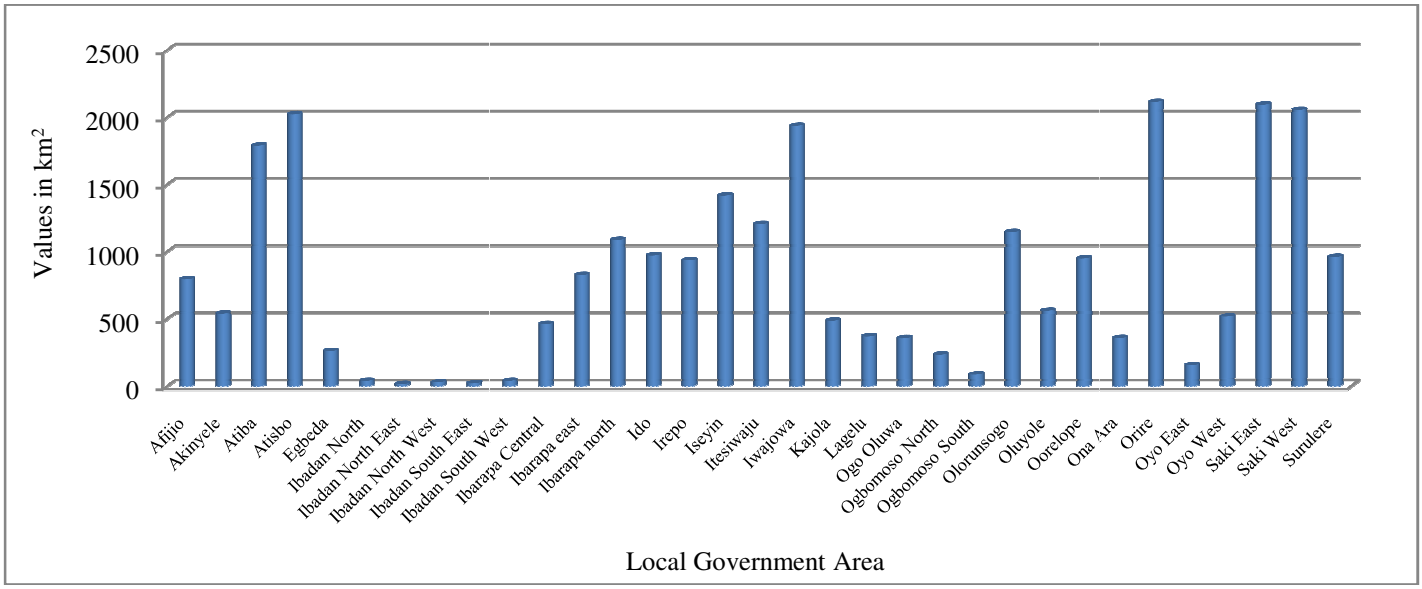


Figure-5: Landmass across category for the 33 Local Government Areas.

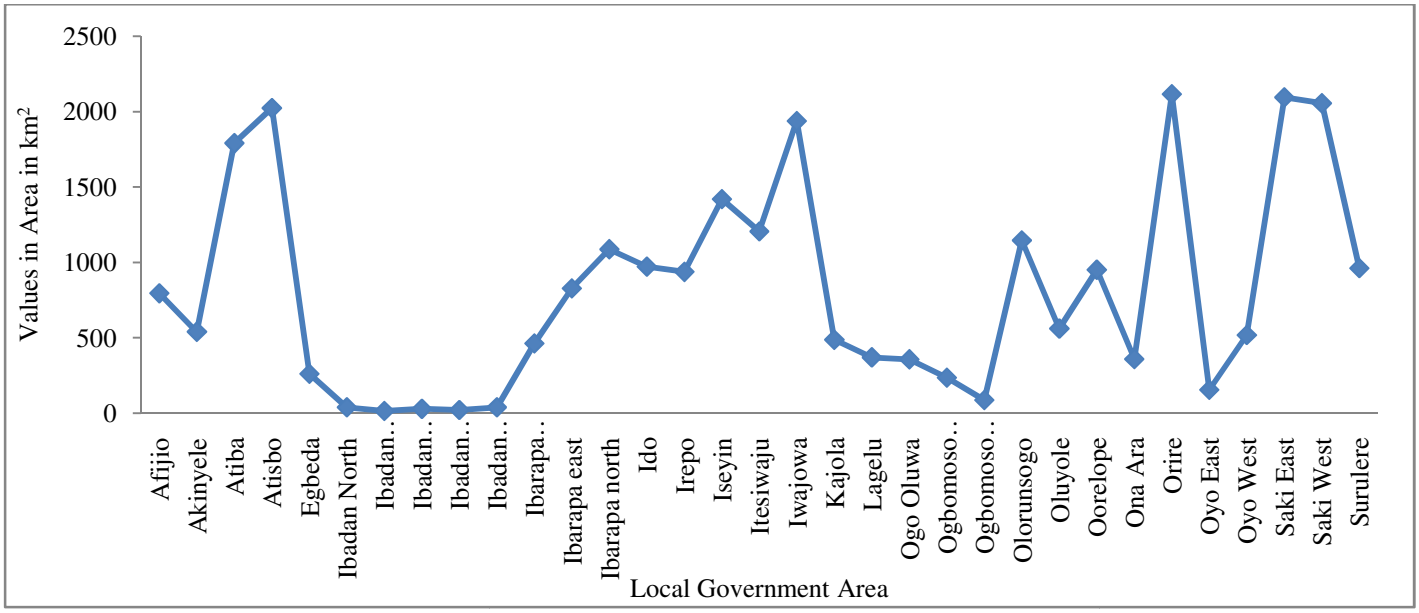


Figure-6: Trend per Landmass across for the 33 Local Government Areas.

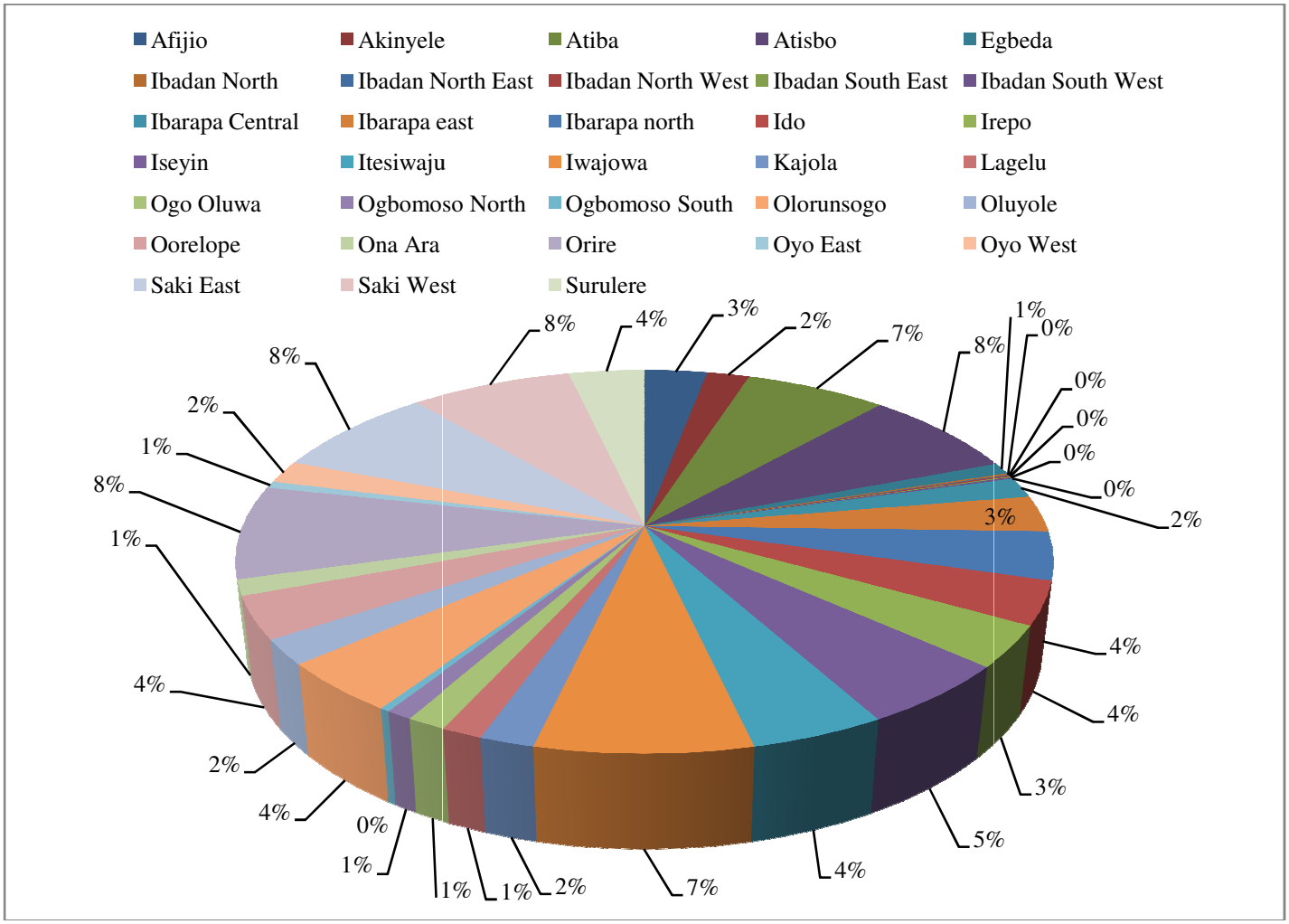


Figure-7: Percentage by landmass area per local Government.

From the Figure-3 of soil map by local government area, it showed that Akinyele with (17.41%), Lagelu (11.93%), Egbeda (8.41%), Ibadan North (1.26%), Ibadan Northeast (0.48%), Ibadan Northwest (0.93%), Ibadan Southeast (0.68%) and Ibadan Southwest (1.26%) only contained soil with (Deep Blue colour) legend (figure 3) of the entire state. It also showed that Ogbomosho North with (3.00%) and Ogbomosho South with (1.11%) of the total of the state contain (yellow colour). Ido and Afijio contain (yellow colour) with (0.15%, 0.66%), (Light blue colour) with (10.82%, 7.13%) and (Deep Blue colour) with (17.63%, 15.18%) see figure 3. *Oyo East and Ibarapa East* contain (Yellow colour) with (0.50% and 0.47%) and (Light blue colour with (3.03%, 20.70%). *Ibarapa Central* contain (Light blue colour) with (10.30%), (Olive green colour) with (1.11%) and (Purple colour) with (89.66%). *Oyo West* and Iseyin contain (Olive green colour) with (1.58%, 12.72%), (Yellow colour) with (2.13%, 2.76%) and (Light blue colour) with (7.60%, 18.63%). *Oluyole* contain (Deep Blue colour) with (13.57%) and (Red colour) with (95.89%).

Ogo-Oluwa contain (Yellow colour) with (3.37%), (Light blue colour) with (0.05%) and (Dark red colour) with (1.60%). Oyo East contain (Yellow colour) with (0.05%) and (Light blue colour) with (3.03%). *Surulere* contain (Yellow colour) with (11.75%) and (Dark red colour) with (32.80%). Atiba, *Atisbo, Orire, Olorunsogo, Iwajowa, Kajola and Ibarapa North* contain (Lighter red colour) with (3.55%, 11.21%, 13.06%, 12.75%, 8.60%, 1.35%, 0.05%), (Olive green colour) with (9.64, 1.27%, 9.10%, 0.44%, 28.31%, 7.21, 15.10%), (Yellow colour) with (13.68%, 11.37%, 8.43%, 1.09%, 1.35%, 1.25%, 3.68%) and (Light Blue colour) with (1.60%, 7.18%, 4.06%, 0.55%, 1.00%, 0.05%, 5.53%) see figure 3. Saki West contain (Yellow colour) with (15.02%), (Lighter red colour) with (10.43%), and (Light blue colour) with (1.10%). Saki East (Yellow color) with (2.48%), (Lighter red colour) with (16.61%), (Olive green colour) with (11.87%), (Dark red colour) with (65.60%) and (Light blue color) with (0.68%). Orelope contain (Yellow colour) with (0.72%), (Lighter red colour) with (11.05%), (Olive green colour) with (0.21%). Irepo contain (Yellow colour) with (3.85%), (Lighter red colour) with (7.93%). The results from the discussion above showed that some portion of soil contained larger extent area such as soil series with lighter red colour, light blue colour, yellow colour, and olive green while some take smaller portion area like red colour, dark red colour, and purple.

Conclusion

The study uses geographic information system (GIS) application technology to map soil series in Oyo State, Nigeria and its distribution within the local government areas. The result from the finding will go a long way in assisting in knowing the soil series present in each local government area and in Oyo State in general. It will also help in knowing the amount shared out of the percentage of soil series types and its usefulness for all kind of activities by human. Moreover, the results will help the soil users towards knowing the available soil series and the location area to get the useful ones when the needs for such soil series types required. Therefore, further study is recommended based on slope, texture, drainage, properties, soil pH values and how part of the soils study act effectively with one another so as to benefit our environment and economy of the state as a whole large.

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