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Research Article

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GIS_ Based Digital Soil Map of Abuja

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Abstract The world over time had faced serious challenges of food shortage and non availability of good quality water. This had led to premature death due to malnutrition and cholera outbreak. Also improper choice of soil type has led to collapsed of built structures resulting from foundation failure. Soil is also regarded as the 'skin of the earth" an interface with its lithosphere, hydrosphere and biosphere. It consists of solid phase (minerals and matter) and porous phase that contain gasses and water. Soil is the end products caused by the influence of climate, relief, organisms and parent materials interacting for a period of time. The methodology was carefully shown with a detailed flowchart that is explicit. The results from the studies show that remote sensing and GIS can be used to develop a digital soil map for the study area. The used of Landsat 7 ETM+ and SRTM of 2013, existing soil map and the existing survey data were used to perform remote sensing and GIS operation. ENVIS 4.7 was used for data processing while ArcGIS 10.1 was used for database creation and spatial analysis. The derived results from the remote sensing and GIS methods shows that the techniques is suitable for developing a database that will generate results for soil information within the different soil mapping units in the six area council of Abuja. It is recommended that in the future further studies should ensure that soil survey is carryout at a larger scale and precise mapping units.

Keywords Database, Digital, GIS, Soil

Introduction

The world over time had faced serious challenges of food shortage and non availability of good quality water. This had led to premature death due to malnutrition and cholera outbreak. Also improper choice of soil type has led to collapsed of built structures resulting to foundation failure. The problem is due to the various soil types, compositions and properties. Hence the need to have an accurate soil test for a particular location is necessary to know the soil type, texture and properties. This will help to determine the choice for dam sites, farm sites, crop suitability and soil test for structural foundation analysis. If this information is store in a GIS database, it is known as digital soil map. Soil is the top surface of the earth crust. It is form from the debris of rock and weathering materials. It is the upper layer of the earth in which plants grows. It is the mixture of minerals, organic matter, gasses, liquids, and the countless organisms that promote life on the earth. According Rebecca, L.K., (2014), Soil may be defined as a thin layer of the earth's crust which serves as a natural medium for the growth of plants. The functions and benefits of soil to mankind can be explained as follows: it is a medium for plant growth; it serves as mean of water storage, supply and purification; it is a modifier and the atmosphere of the earth; it is a habitat. These functions help to modify and develop the soil. Soil is also regarded as the 'skin of the earth" an interface with its lithosphere, hydrosphere and biosphere. It consists of solid phase (minerals and matter) and porous phase that contain gasses and water. Soil is the end products caused by the influence of climate, relief, organisms and parent materials interacting for a period of time. It developed continuously due to some physical, chemical and biological processes cause by weathering coupled with erosion as explained by:

Cheshorth, W., (2008). The various discussion on the important of soil to man require the knowledge of the different kind of soil that exist in nature, their properties, texture and composition.

Aim

The aim of the study is to develop a digital soil map for Abuja and to build a database that will describe the various soil types, characteristics and composition. This will enhance choice of soil suitable for good crops production.

Objectives

The aim will be achieved through the following objectives:

i. To produce a digital soil map of the study area that will contains the soil type, structures and properties
ii. To produce the slope and aspect map of the study area that will described the various landform within the study area which will enhance choice of irrigation site
iii. To create a database for the study area that will specify the type of crops suitable for the various soil types.

The Study Area

The study area is Abuja the Federal Capital Territory. It was carved out from the old Nasarawa, Kogi and Niger state in 1796 as the Federal Capital City of Nigeria. It is bounded by latitude 8^0 25'N and latitude 9^0 25' N and longitude 6^0 45'E and longitude 7^0 39'E. It has boundary with Kogi state in the south, Kaduna in the north, Nasarawa in the east and Niger state by the west. The major language spoken among the people are mainly Gbagyi, Nupe, Koro, Gwandara, and Gade. Its total area is about 724,473.9 hectares. The major food is mainly corn, yams, millet, beans, garri, and cassava floor, garden eggs, soya beans, mellon, okra, groundnuts and vegetables. The major occupation among the people within the study area is farming. The gbagyi's are peaceful people and homely.

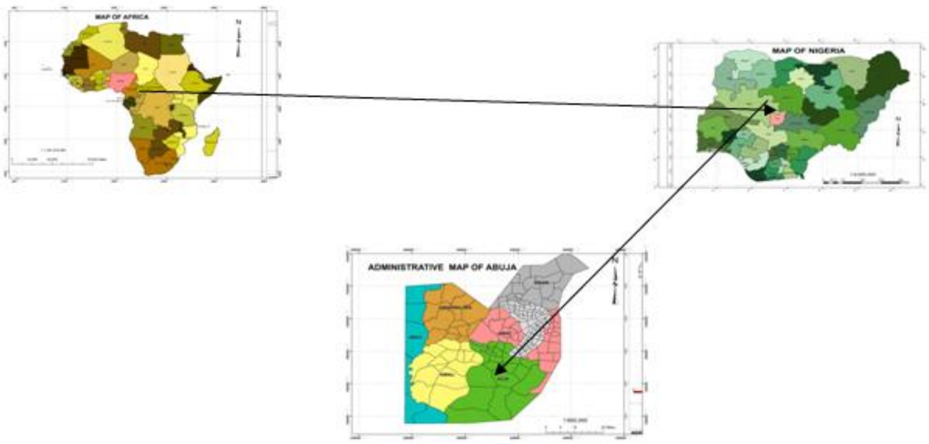

Figure 1: Map of the Study Area

Methodology

The method adopted in this study was data acquisition, data processing, database design, analysis and discussion of results. The flowchart below depicts the methods adopted.

Data Acquisition, Presentation and Analysis

The Landsat 7 ETM+ downloaded imageries of 2013, SRTM imageries, and soil maps were acquired to carry out the studies. The soil map of Abuja, the administrative map indicating the six area council was scanned and saved in a jpeg format. The scanned maps were digitized in ISRI ArcGIS to delineate the six area council in Abuja. ENVIS was use for image combination and processing and to generate lineament map for the study area. The result of soil test from the six area council was used to develop a database for the study.

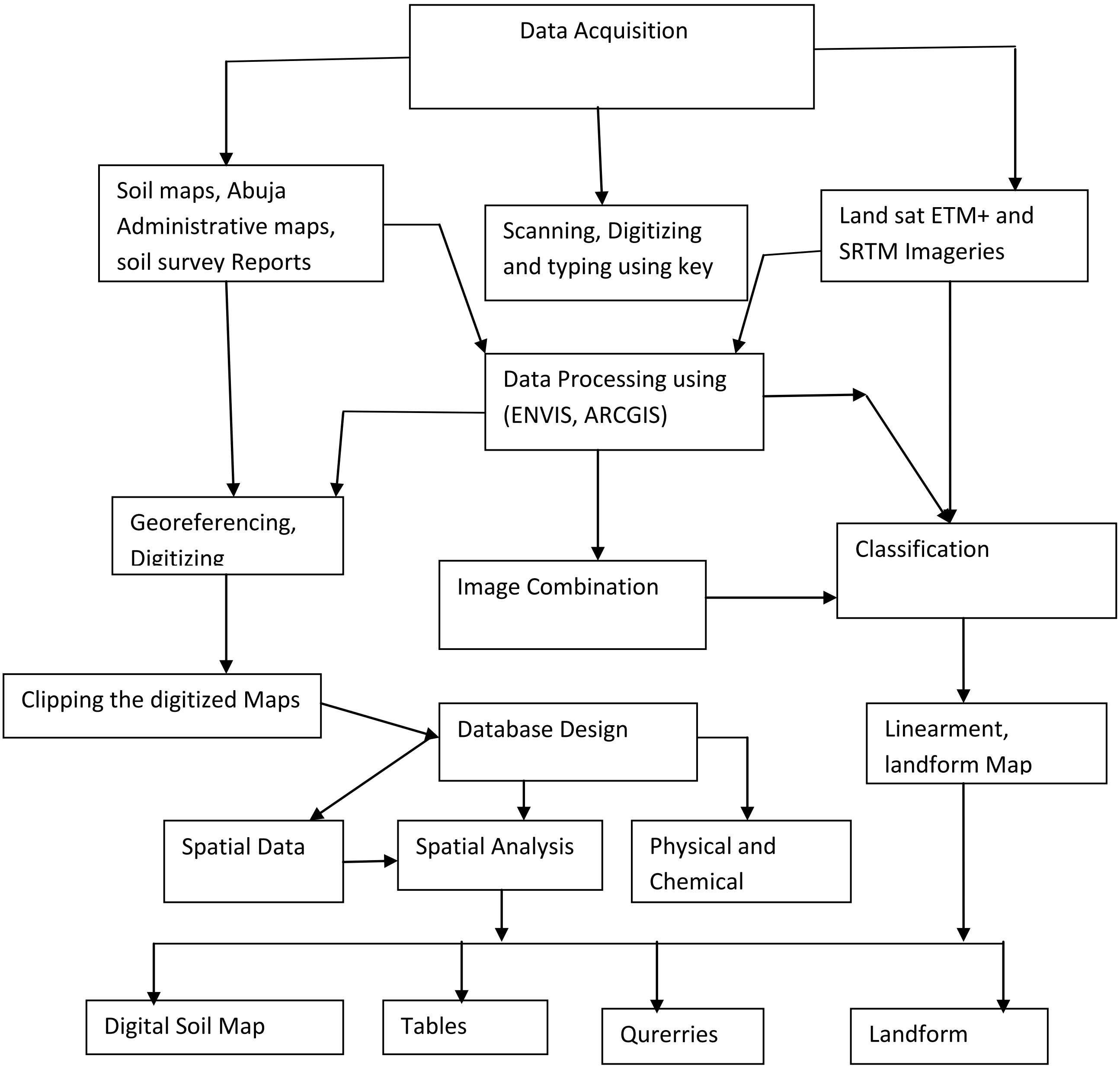

Figure 2: Methodology Flow Chat of the Study Area

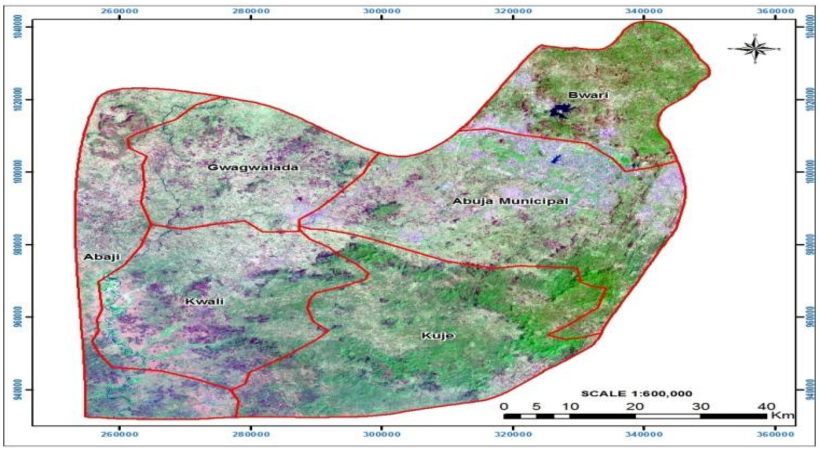

Figure 3: Clipped Image and Area Council map

The results of the LandSat processed image and SRTM data generated from the database are the landform map generated from combined LandSat Image and SRTM data describing the study area geology, relief, slope and aspect. The database contained the soil information of the study area, it can be use to perform query at will to retrieve require soil information from the database and update can be added when necessary.

Figure 3 shows the information on the different area council within the study area. Agricultural land is more in Kuje, Kwali, Gwagwalada and Bwari Area Council.
Also the processed image with the STRM produces the landform, slope and aspect maps.

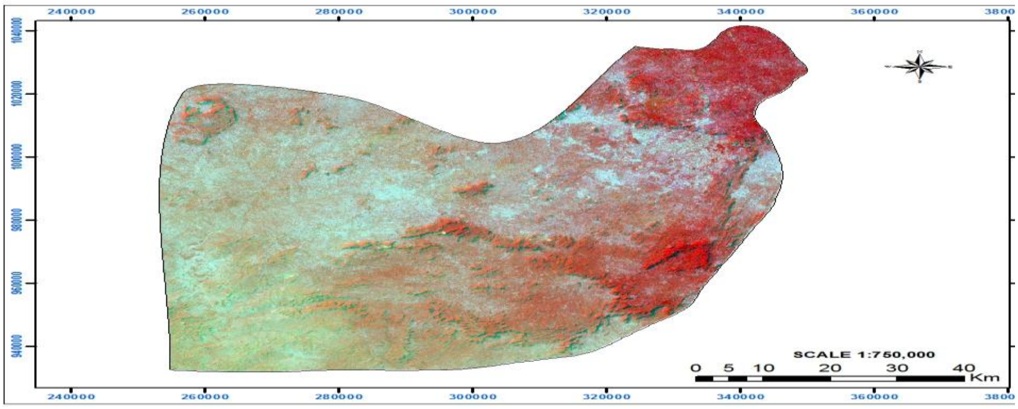

Figure 4: Showing Land Form Map of the Study Area

This is characterized with hill and mountain which is a determining factor of the soil parent material. It also serves as prove to verify the various soil textures located within the soil map

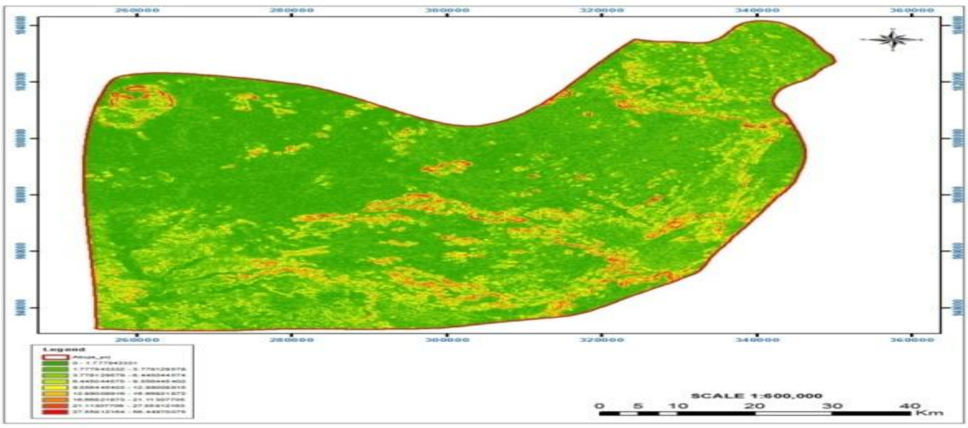

Figure 5: Slope Map

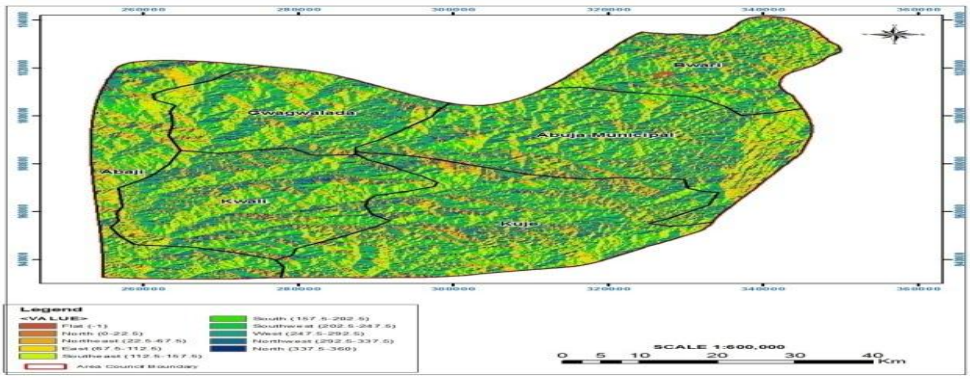

Figure 6: Aspect Map

The slope map in figure 5, shows the angle of inclination of the land form within the study area while aspect map in figure 6 shows the direction of slope. These indicate the area liable to water erosion and to decide possible mapping unit that is well drain and the one not well drain to make choice for dam and farm site.

Abuja Soil Map

The scanned and digitized Abuja map and the clipped area council maps in ArcGIS was used to produced the digital soil map of the study area and database created for the digital soil map that can generate query for demanding question about the study. Figure 7 show the Digital soil map of Abuja depicting the mapping unit, type of soil and soil properties in the six Area councils.

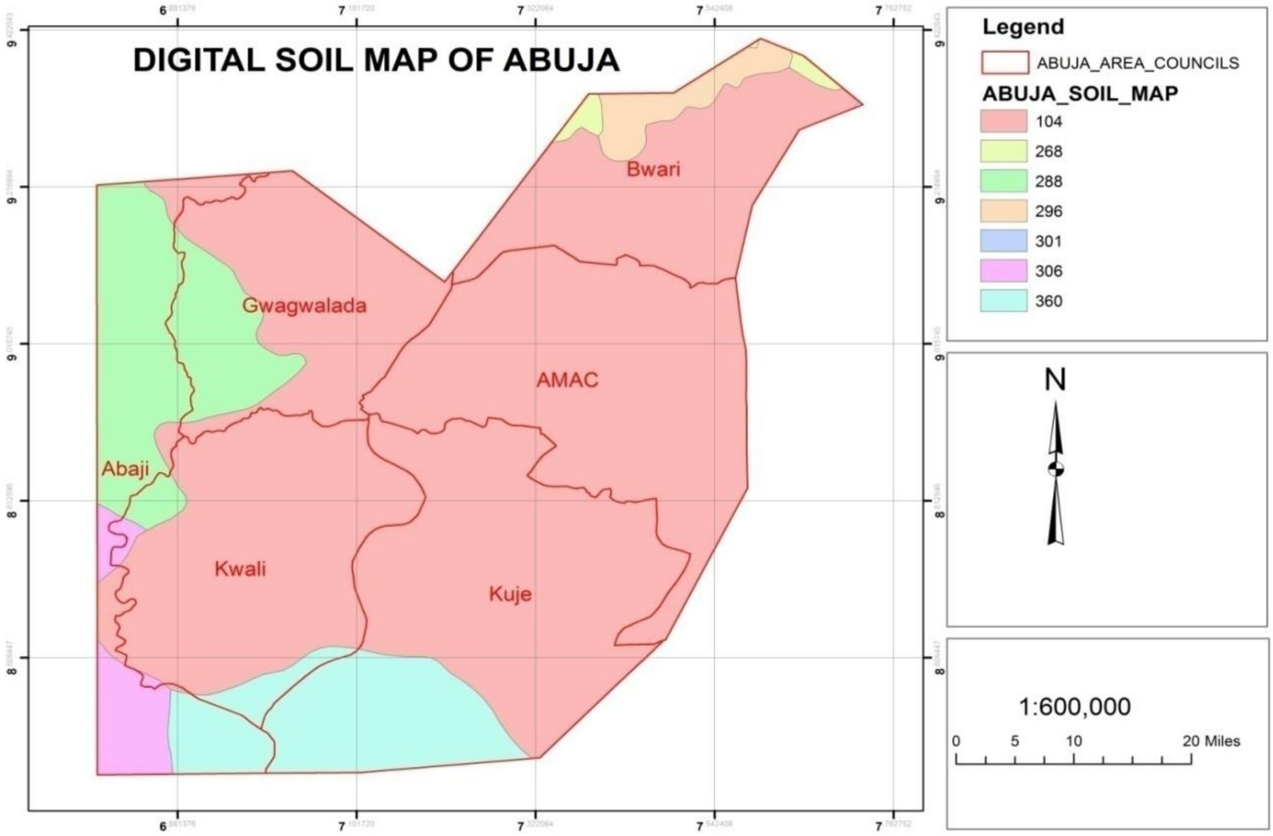

Figure 7: Digital Soil Map of Abuja

Table 1: Chemical and Physical Properties of Soil

Mapping	**Unit**		**18D**		**Texture**	**pH, H_2O**	**OC/KCl%**	**Total N**
Horizon	Dept(cm)	Particle Sizes						
		Sand	Silt	Clay				
AP	0-18	83	7	10	LS	5.6	0.4	0.06
AB	18-40	81	6	13	LS	5.4	0.55	0.11
BA	40-56	84	8	8	LS	5.6	0.52	0.04
IIB	56-90	60	10	30	SCL	5.8	0.16	0.03
11BC	90-176	57	12	31	SCL	5.7	0.16	0.02
Available P Exchangeable Cations				mg/100g Soil				
PMM	CA	MG	K		NA	BS%		
190	1.5	1	0.3		3.4	82		
270	2.5	1.4	0.3		5.9	71		

250	3	1.6	0.3		6.3	77		
260	2.5	1.7	0.3		5.6	82		
300	2.8	1.8	0.3		6.0	81		

Mapping	**Unit**		**22C**		**Texture**	**pH, H_2O**	**OC/KCl%**	**Total N**
Horizon	Dept (cm)	Particle Sizes						
		Sand	Silt	Clay				
A1	0-24	85.3	7.4	7.3	LS	5.4	0.68	0.08
B21T	24-40	78.3	7.4	14.3	SL	4,9	0.44	0.06
B22T	40-58	63.3	4.9	31.8	SCL	4.8	0.44	0.05
B23T	58-93	80.4	9.9	9.8	LS	5.2	0.24	0.3
BC1	93-132	62.3	7.9	29.8	SCL	5.4	0.16	0.002
BC2	132-180	68.8	9.4	22.3	SCL	5.5	0.12	0.02
Available P Exchangeable Cations			mg/100g soil		Cec			
PMM	CA	MG	K	NA		BS%		
1.4	2.4	2.2	0.09	0.02	4.25	51.6		
0.7	2.7	3.5	0.15	0.02	4.34	57.3		
0.7	4.1	2.1	0.18	0.05	8.7	50		
0.7	4.7	3.7	0.15	0.05	8.75	60.5		
0.7	4.0	1.6	0.15	0.007	7.5	53.6		
0.4	6.0	1.8	0.13	0.07	0.25	60.6		

Chemical and Physical Properties of Soil

Mapping	**Unit**		**21C**		**Texture**	**Ph, H_2O**	**OC/KCl%**	**Total N**
Horizon	Dept(cm)	Particle sizes						
		Sand	Silt	Clay				
A	0-7	69	25	6	SL	6.6	5.6	1.36
BT1	7-38	57	24	19	SCL	5.9	4.7	0.78
BT2	38-62	56	39	37	CL	6.0	5.2	0.06
BT3	62-93	35	40	35	CL	6.4	5.7	0.07
BT4	93-140	47	25	28	SCL	6.5	5.4	
			Exchangeable Cation					
			mg/100g Soil					
		CA+mg	K	NA	CEC	BS(%)		
		1	0.18	0.4	6	26		
		0.8	0.1	0.3	5.75	20		
		2	0.25	0.25	8	31		
		2.2	0.2	0.2	7.5	35		
		3	0.2	0.2	8	45		
Mapping	Unit		15E		Texture	pH, H_2O	OC/KCl%	Total N

Horizon	Dept (cm)	particle sizes						
		Sand	Silt	Clay				
A	0-8	88	6	6	LS	6	1.06	
BA	8-28	88	4	8	LS	5.9	0.32	
BT1	28-56	56	6	28	SCL	5.8	0.37	
BT2	56-117	50	4	46	SCL	5.7	0.29	
BT3	117-183	48	4	48	SCL	5.5	0.14	
	Exchangeable Cations				mg/100g Soil	Cec		
		CA	MG	K NA			BS%	
		2.5	0.09	0.02		5.5	48	
		0.64	0.04	0.02		2.5	28	
		0.92	0.05	0.02		5.7	17	
		1.8	0.05	0.02		8.7	21	
		2.1	0.08	0.02		11	20	

Table 1 contain chemical and physical properties of soil mapping unit 18d, 21c, 22c, 17a,and 15e describing the soil texture, PH, inorganic minerals contents and base saturation percentage for water and oxygen at different depth.

Table 2: General Characteristic of SOIL in the Six Area Council

Object id	**Area council**	**Acode**	**Geology**	**Relief**	**Soil**	**Crop suita**	**Chemical p**
1	Bwari	22c	Undifferentiated Basement Complex	Undulating plains with scattered rock outcrops and hills	Shallow and moderately deep to deep well drained and some- what poorly to poorly drained soils; loamy sand to sand loamy and sometimes gravelly surfaces over sandy clay loam to sandy clay and sometime	Savannah Woodland, beans Cassava,Sorghum, mellon and maize. Sorghum,Maize,Millet and Vegetables, beans and groundnuts, mellon savannah woodland	6.1
2	Bwari	18d	Undifferentiated Basement Complex	Gently undulating plains with scattered rock outcrops and inselbergs	Generally deep well drained with few poorly drained soils; loamy sand surfaces over sandy loam to sandy clay loam and sometimes gravelly subsoils.	Sorghum,Maize,Millet and Vegetables, beans and groundnuts, mellon savannah woodland	5.9
3	AMAC Gwagwalada Kuje and KWali	22c	Undifferentiated Basement Complex	Undulating dissected plains	Deep to very deep and very shallow to moderately deep well drained soils; sand, loamy sand to sandy loam surfaces over sandy loam to sandy clay loam and	Maize, Guinea Corn and Shear Butter, groundnuts and yam, water mellon, mellon, Potatoes and cassava	5.4

					sometimes gravelly subsoils.		
4	Gwagwalada, Kuje,AMAC, etc	21c	Undifferentiated Basement Complex	Undulating dissected plains	Deep to very deep and very shallow to moderately deep well drained soils; sand, loamy sand to sandy loam surfaces over sandy loam to sandy clay loam and sometimes gravelly subsoils.	Maize, Guinea Corn and Shear Butter, groundnuts and yam, water mellon, mellon, Potatoes and cassava	5.4
5	Bwari	18d	Undifferentiated Basement Complex	Gently undulating plains with scattered rock outcrops and inselbergs	Generally deep well drained with few poorly drained soils; loamy sand surfaces over sandy loam to sandy clay loam and sometimes gravelly subsoils.	Sorghum,Maize,Millet and Vegetables, beans and groundnuts, Mellon savannah woodland	5.9
6	Kwal, Abaji and Kuje	15e	Nupe Sandstone	Nearly level to gently undulating plains	Deep well drained and few somewhat poorly drained soils; loamy sand to sandy loam surfaces over sandy loam to sandy clay loam and sometimes gravelly subsoils.	Millet, Maize and Groundnut yam and soya beans	6.0
7	Abaji, Kuje, Abaji, Kwali	17a	Shales	Gently undulating plains	Mostly deep well drained, few poorly drained soils; loamy sand to sandy loam surfaces over sandy clay loam to sandy clay and few ferruginised subsoil.	Cassava, yam, millet, groundnuts, soya beans, garden egg and potatoes.	6.5

Table 2 described the soil geology, types, relief, and crop suitability for the various soils and approximate pH for the different mapping units

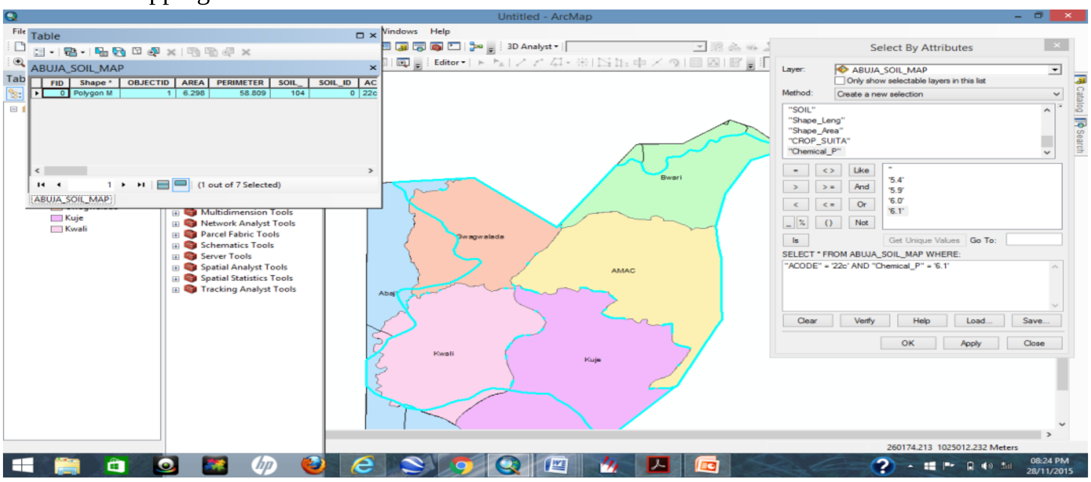

Figure 8: Query Results for All area Council Soil

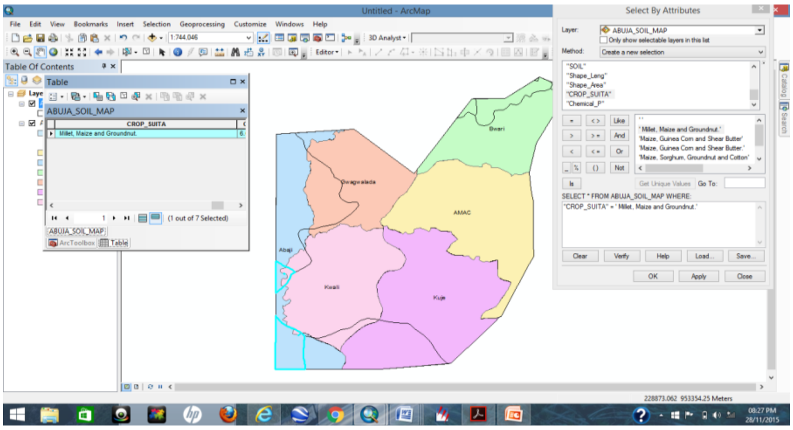

Figure 9: Results of for Soil Suitability for Millet, Maize and Groundnuts

Discussion of Results

The results derived from the satellite imageries are hill shade map, landform, and slope and aspect maps. The maps give the terrain configuration and geomorphology of the study area. These will serve as guide to develop confidence on the field data in compiling the database; it also helps to predict location within the studies that are suitable for irrigation site.

The soil maps which consist of the five mapping unit: 17a, 21c, 22c, 18d, and 15e described the various mapping units within the study area. Each mapping unit contains a data base describing the information in the soil.

Conclusion / Recommendations

The results from the studies show that remote sensing and GIS can be used to develop a digital soil map for the study area. The used of Landsat 7 ETM+ and SRTM of 2013, existing soil map and the existing survey data were used to perform remote sensing and GIS operation. ENVIS 4.7 was used for data processing while ArcGIS 10.1 was used for database creation and spatial analysis. The derived results from the remote sensing and GIS methods shows that the techniques is suitable for developing a database that will generate results for soil information within the different soil mapping units in the six area council of Abuja. These will help famers and soil user to have a clearer knowledge of the location of soil type suitable for crops cultivation. The digital soil map produced from the study is limited in terms of soil information because, the mapping unit used is too generalized when compare to the distance between mapping units. It is recommended that in the future, further studies should ensure that soil survey is carryout at a larger scale and precise mapping units.

References

[1]. Ali, R.R., and Kotb, M.M., (2010). The Use of Satellite Data and GIS for Soil Mapping and Capability Assessment in Egypt, Journal of Nature and Science,

[2]. http://www.sciencepub.net/nature

[3]. Ali, R.R. et al, (2010). Using Satellite Data and GIS for Establishing a Soil Database, a Case Study of Middle Egypt, Journal of Nature and Science, http://www.sciencepub.net/nature

[4]. Bashir N., Hamdi Z., Khaled J., Azwaia, Lybia, (2007). Soil Productivity Rating Index ModelUsing Geographic Information System, Libya, http://www.google.com/ accessed 3rd Oct 2015.

[5]. Budiman, M., Alex, B. M., Brendan, M., Yiyi, S., (2010): Digital mapping of soil carbon.19th World Congress of Soil Science, Soil Solutions for a Changing World, Brisbane, Australia 1 – 6 August, 2010.

[6]. Chesworth, W.,(2008). Encyclopedia of Soil Science, Dordrecht, Netherland: Springer, Xxiv, http://www.google.com/accessed 3rd Oct 2015.

[7]. Dobos, E., Carre, F., Hengl, T., Reuter, H.I., Toth, G., (2006): Digital Soil Mapping as a support to production of functional maps. University of Miskolc, 3515 Iskolc-Egyetemvaros, Hungary, office for Official Publications of the European Communities, Luxemburg.

[8]. Down, M. B., and Michael, C. D., (2011). Digital Soil Mapping in the Absence of Field Training Data: Using Terrain Data Attributes and Semi-automated Soil Signature Derivation to Distinguish Ecological Potential, Journal of Applied and Environmental Soil Science, Hindawi Publishing Corporation, pp 1-12, doi:10.1155/2011/421904.

[9]. Egwim, U. M, (2013). Digital Soil mapping for Groundnut Cultivation. a Case Study of Kano State, Nigeria. Paper Presentation on World Gis Day Conference 2013, http://www.google.com/accessed 3rd Oct 2015.