



Land Degradation Risk Assessment of Selected Wetlands in Yewa North Local Government Area of Ogun State, Nigeria, Using Geospatial Techniques

Lawal^{1*}, K. O., Tobore¹, A. O., Osinuga¹, O. A. Jayeola², E. O., Senjobi¹, B. A.,
Adejuyigbe¹, C. O. and Adedeji³, O. H.

¹*Department of Soil Science and Land Management*

Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

²*Departamento de Biología Animal, Biología Vegetación y Ecología*
Universidad de Jaén, Jaén, Spain

³*Department of Environmental Management and Toxicology*
Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

*Correspondence Author: Email: lawal.kadirio@pg.funaab.edu.ng

Abstract

Land degradation reduces the ability of the land to perform various biophysical and chemical functions. Therefore, this study assessed the land degradation risk in Yewa North Local Government area using geospatial methods. A semi-detailed soil survey was used to obtain distribution of various soil types in the studied locations (Sawonjo and Ibese). Three profile pits were examined in each location, making a total of six profile pits, and geo-referencing with a GPS device. Soil samples were collected according to their pedogenic horizons and 25 surface samples were collected at the depth of 0-20 cm with soil auger for Laboratory analyses. Analysed soil properties were subjected to spatial analysis function using Arc-GIS 10.5 software and matched with standards to assess land degradation risk using Inverse Distance Weighted method. Results showed that 18.57% (1.3 ha) was low, 54.29% (3.8 ha) moderate and 27.14% (1.9 ha) high in soil salinity in Sawonjo while 22.86% (1.6 ha) was low, 35.71% (2.5 ha) moderate and 41.43% (2.9 ha) high in soil salinity at Ibese. Extent of compaction indicated that 31.43% (2.2 ha) was moderate and 68.57% (4.8 ha) high in Sawonjo while 28.57% (2.0 ha) low, 34.29% (2.4 ha) moderate, 24.28% (1.7 ha) high and 6.3% (0.9 ha) was very high at Ibese. Conclusively, high water table, poor drainage channels, discharge of effluents from industries and constant use of heavy machineries were the major causes of physical and chemical degradations. Thus, for sustainable wetland uses, organic amendments (poultry droppings, cow dung, compost, biochar) and use of light machines should be considered.

Keywords: Land degradation, GIS, Soil salinization, Soil compaction, Wetland.

Citation: Lawal, K. O., Tobore¹, A. O., Osinuga, O. A. Jayeola, E. O., Senjobi¹, B. A., Adejuyigbe, C. O. and Adedeji, O. H., 2024

Land Degradation Risk Assessment of Selected Wetlands in Yewa North Local Government Area of Ogun State, Nigeria, Using Geospatial Techniques. Journal of Plant Science and Crop Production (JOPS), 1: 53-65



Introduction

Wetland is one of the most valuable natural resources for production of food, fuel and many other essential goods that are required to meet increasing human population and animal needs (Alaguraja *et al.*, 2010). However, similar to any other ecosystems, wetlands show a great diversity in their physical, biological and chemical characteristics (Thenkabail and Nolte, 2016). The soils are highly heterogeneous as a result of the hydromorphic environment in which they are formed (Aki, 2012).

Recently, the importance of wetlands has gained rapid attention especially due to increasing human population and needs (Cohen *et al.*, 2016). Nevertheless, they are still regarded as waste land which can be traced to lack of understanding on its importance for crop and animal production, and other essential uses like recreational activities (McCartney *et al.*, 2004; Tiner, 2015). According to Millennium Ecosystem Assessment (2015), Wetland degradation may increase in the next 50 years if wetlands ecosystem services and functions are not efficiently and effectively managed and monitored. Ojanuga (2006) stated that, many suitable wetland soils around the world especially in developing countries like Nigeria are becoming unsuitable for agricultural production due to intensive agriculture and other anthropogenic activities. The complex nature of these soils, arduous agronomic task on management coupled

with inadequate information on these soils in Nigeria has also contributed to their mismanagement leading to degradation (Ukabiala, 2012). Waterlogging, salinization, soil compaction, indiscriminate effluent discharge from industries, and use of heavy machineries during land clearing are some of the major drivers of land degradation. Land degradation leads to a gradual decrease in soil productivity, hindering sustainable development and consequently food gap are expected (El-Gammal *et al.*, 2015). The alarming losses in economic revenues and agroecosystem services have revealed an urgent need for monitoring of land degradation and analyses of its causes in order to advise decision makers on spatial targeting of land rehabilitation measures (Dubovyk *et al.*, 2013). Therefore, this study aims to address the land degradation risk of selected wetlands in Yewa North Local Government Area of Ogun State using GIS technique. Global Positioning System, laboratory analyses, remote sensing and GIS were the main methods and software used to achieve the set objective.

Materials and Methods

Description of study area

The study was carried out in Yewa North Local Government Area (LGA) of Ogun State (Figure 1). It lies between Latitudes 6°58' to 6°60' North and Longitudes 3°2' to 3°4' East. The study area consists of two locations (Sawonjo and Ibese), selected within the wetland areas of



Yewa North LGA. The climate of the area is characterized by the averagely hot, humid tropical climate zone of southwestern Nigeria. It has two recognizable seasons, specifically, the rainy season (April to October) and dry season (November to March). The temperature is proportionately elevated throughout the dry season with the average around 30 °C (Olayinka *et al.*, 2016). The harmattan, which brings in the north-easterly winds from December to February, has relieving effects on the dry season high temperature. Low temperatures are however, recorded throughout the rains, notably, between July and August when the temperature

could be as low as 24 °C (Adejuwon and Odekunle, 2006). The onset of the rainy season ranges from March to April and the rainfall pattern is bimodal reaching its peak in July and September. The length of the rainy season is about 200 days ending in late October. The rain is convectional and can occasionally occur with heavy showers. The rain of the second modal is small showers and frontal. The spatial occurrence of annual rainfall ranges from 960 to 1200 mm and vegetation in the area consists of the Southern Guinea Savanna characterized by semi-deciduous shrubs and trees (Olayinka *et al.*, 2016).

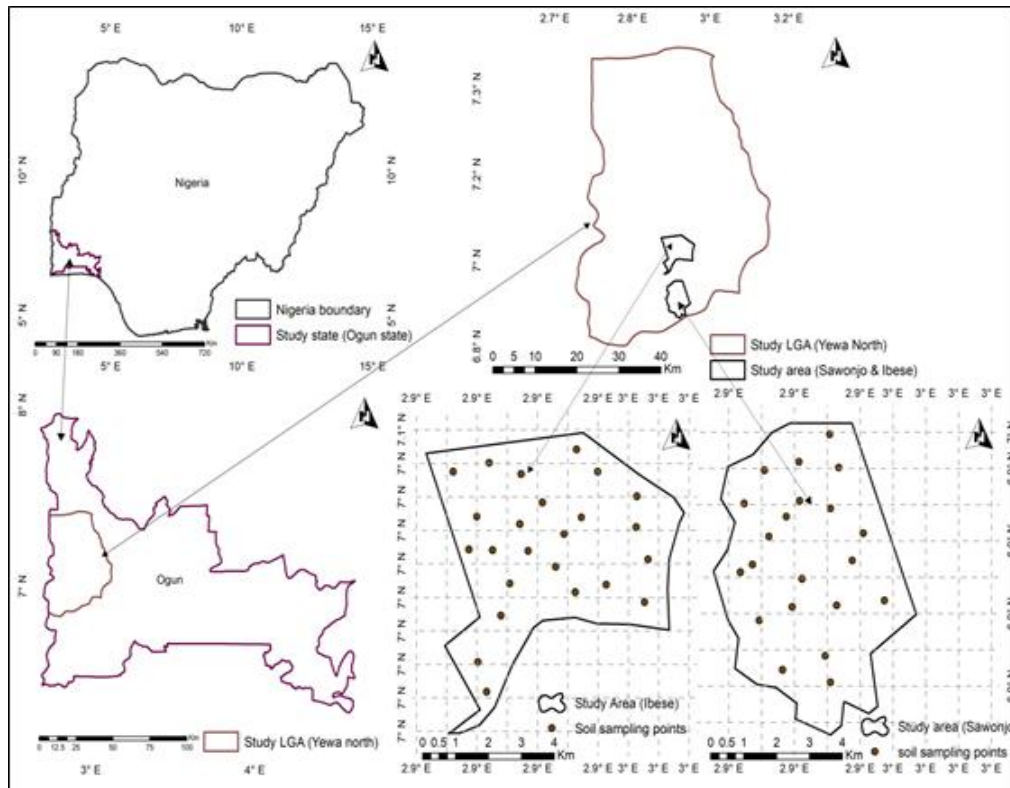


Figure 1: Map of the study area

Geology of the study area

The local geology of the study area is made up of sedimentary rock sequence of Dahomey Basin, which extends from the eastern part of Ghana through Togo and Benin Republic to the western margin of the Niger Delta (Obaje, 2009; Oli *et al.*, 2019). The structure of the basin is a simple monocline against the basement which underlain the sedimentary rocks at varying depths. The dips are reportedly 1° or less to the south and southwest (Obaje, 2009). The sequence of the rocks

underlying the study area is as follows: Abeokuta Formation which is Cretaceous in age (Senonia) and this formation lie conformably on the sedimentary parent material in the north and Ewekoro formation in the north-east. It is the oldest sedimentary formation, having thickness of 250–300 m. It consists of arkosic sandstones and grits, tending to be carbonaceous towards the base (Olabode, 2015). Overlain the Abeokuta Formation is Ewekoro/Oshosun/Akinbo Formation which is Paleocene. This



consists of a series of sandstone, shales, limestones and clays varying between 100 to 300 m in thickness. This formation is followed by Ilaro Formation (Tertiary age - Eocene). It consists of fine to coarse sands alternating with shales and clays (Olabode, 2015). Ilaro Formation is overlain by Coastal Plain Sands (Pliocene) and Recent Alluvium (Quaternary age) of Benin Formation which is youngest. The formation consists of sandstones and shales of upper Ilaro Formation, sequence of predominant continental sands and some lenses of shales and clays which is about 107.7 m thick (Olabode and Mohammed, 2016).

Vegetation and land use

Sawonjo and Ibese occupy vast area of land with very sparse vegetations majorly grasses and shrubs. The land has been allotted to villagers to manage for a long period of time. It is not totally flat and common crops planted in the areas are vegetables, pepper, plantain, banana, and maize. The areas have experienced industrializations over time with the most prominent being Dangote factory. Soil excavation is also prominent in these areas because of the high sand content in the soil (Olabode and Mohammed, 2016).

Field survey

A reconnaissance soil survey was first carried out to get familiar with different

wetlands in Yewa North LGA. The soils were assessed using a semi-detailed scale map with flexible grid soil survey technique to obtain distributions of various soil types. Three representative soil profile pits measuring 2 m by 1.5 m by 2 m were dug in each location making a total of six profiles, and geo-referencing using Global Positioning System device. Soil samples were collected from different pedogenic horizons encountered. Twenty-five (25) surface soil samples were collected at the depth of 0 –20 cm with the aid of soil auger and undisturbed soil samples were collected with soil cores for bulk density determination. Soil samples collected were then analysed in the Laboratory after air-drying at room temperature using standard laboratory procedure.

About 8 ha were mapped out for this study in each study location.

Soil degradation assessment

Land degradation risk was assessed following the methodology developed by FAO (1979) and UNEP (1991). This was done by matching soil characteristics with land degradation indicators. Table 1 illustrates the risk of land degradation which depends on the electrical conductivity and bulk density.



Table 1: Classes of soil degradation risk

Hazard type	Indicator	Unit	Risk class			
			Low	Moderate	High	Very high
Salinization	EC	dS/m	<4	4 – 8	8 – 16	>16
Compaction	Bulk density	gcm ⁻³	<1.2	1.2 – 1.4	1.4 – 1.6	>1.6

Source: FAO (1979) and UNEP (1991), EC = Electrical conductivity

Statistical analysis

The results of the soil analyses were subjected to spatial analysis function using ArcGIS 10.5 software. Spatial interpolation is commonly used to produce continuous information when data are collected at distinct locations (e.g. soil profiles). The inverse distance weighted (IDW) is an interpolation method, which weighs the surrounding known values to derive estimations for an unmeasured location. However, the weights are based not only on the distance between the known points and the unmeasured point but also on the overall geostatistical relationships among the known points (Ali and Moghanm, 2013). The interpolated soil properties include electrical conductivity (EC); soils pH; and bulk density using the IDW method. The mean was used to determine the average distributions of variables. Soil properties were assessed for their variability using Coefficient of Variation (CV%) and compared with variability classes proposed by Tabi and Ogunkule (2007) where CV values of 0-15, 16-35

and >35% are rated as slight, moderate and high respectively.

Results and Discussions

Variability of surface soil properties of Sawonjo and Ibese

Table 2 and 3 represents the variability of surface soil properties of Sawonjo and Ibese. At Sawonjo, the soil pH ranged from extremely acid to neutral, with an average value of 5.6, the acidic nature of the soil could probably be because of flooding, the soil becomes highly reduced, leading to leaching of soil nutrients such as P, K, Ca, Mg and Na which may result in decreased soil pH (Ogg *et al.*, 2017). The soil texture indicated a high sand content with values between 750 and 930.00 gkg⁻¹, clay content ranged from 60.00 – 140.00 gkg⁻¹ while the mean value for silt content was 62.00 gkg⁻¹. The high sand texture could be attributed to the flood plain which is characterised by deposition of sand. Similar soil texture range was reported for some wetland soils in Imo State (Ukabiala *et al.*, 2016). Values of electrical conductivity (EC) ranged from



6.00 to 15.99 dSm^{-1} , having a mean value of 10.40 dSm^{-1} . The high values of EC may be attributed to the origin of parent material (sedimentary rocks) and as a result of high amount of soluble salts deposited in the soils during erosion and flooding (Smith *et al.*, 2007) while bulk density varied from 1.42 to 1.47 gcm^{-3} . The high values of bulk density may be due to the effect of using heavy machinery on the surface layer (El Baroudy, 2010). The highest coefficient of variation (CV) value 41.02% was recorded in silt content with lowest CV value of 1.40% in clay content. This variation might be attributed to the degree and stages of weathering of the soil. In Ibese, the data indicated that the texture of the soils had high sand content (700-900 gkg^{-1}) which could also be attributed to the flood plain, with silt content that ranged from 20.00 to 120.00 g kg^{-1} and maximum clay value that was

180.00 gkg^{-1} . Values of soil pH ranged from strongly acid to neutral (5.4 to 7.0). This strongly acid pH is an indication that significant amount of exchangeable Al^{3+} and H^{+} are present and this can affect plant growth (Udo *et al.*, 2009). The value of EC ranged from 5.00 to 15.99 dSm^{-1} , with a mean value of 10.40 dSm^{-1} while bulk density varied from 1.31 to 2.17 gcm^{-3} with a mean value of 1.45 gcm^{-3} . The highest coefficient of variation value (50.90%) was recorded in silt content, with lowest value of 5.67% in sand content. This could also be attributed to the degree and stages of weathering of the soil. The slight variability recorded in EC reflects pH variability, because pH asides soil depth, water content, salinity level, CEC and temperature is one the factors that affect EC level in soils (Asongwe *et al.*, 2016; Osinuga *et al.*, 2020).

Table 2: Variability of Surface Soil Properties in Sawonjo

	BD (gcm^{-3})	Sand	Silt (gkg^{-1})	Clay	pH_{water}	EC (dSm^{-1})
Minimum	1.42	750.00	10.00	60.00	4.4	6.00
Maximum	1.47	930.00	110.00	140.00	7.0	15.99
Mean	1.62	844.70	62.00	93.30	5.6	10.13
CV (%)	18.44	5.04	41.02	1.40	13.4	36.14

Key: EC = Electrical conductivity, BD= Bulk density



Table 3: Variability of Surface Soil Properties in Ibese

	BD (gcm^{-3})	Sand	Silt (gkg^{-1})	Clay	pH _{water}	EC (dSm^{-1})
Minimum	1.31	700.00	20.00	80.00	5.4	5.00
Maximum	2.17	900.00	120.00	180.00	7.0	15.99
Mean	1.45	825.30	52.00	128.70	6.2	10.40
CV (%)	9.20	5.67	50.90	24.98	10.8	15.35

Key: EC = Electrical conductivity, BD= Bulk density

Classes of land degradation risk

Figure 2, 3, 4 and 5 represents the results for assessment of land degradation in Sawonjo and Ibese. At Sawonjo, the results showed that electrical conductivity of the soils from ranged from 6.00 to 15.99 ds/m and the soil bulk density varied between 1.42 and 1.47 gcm^{-3} . The salinity extent showed that 1.3 ha, 3.8 ha and 1.9 ha of the land were low, moderate, and high respectively. While compaction extent showed that 2.2 ha and 4.8 ha were moderately and highly compacted respectively.

In Ibese, bulk density ranged from 1.31 to 2.17 gcm^{-3} , while electrical conductivity ranged between 5.00 and 15.99 dSm^{-1} . Salinity extent showed that 1.6 ha, 2.5 ha and 2.9 ha of the land were low, moderate and high respectively, while 2.0 ha, 2.4 ha, 1.7 ha and 0.9 ha were low, moderate, high and very highly compacted respectively. High rainfall, high water table, poor management of drainage channels, discharge of effluents from industries and constant use of heavy machineries in these areas were the major causes of physical (compactions) and chemical (salinization) degradations.

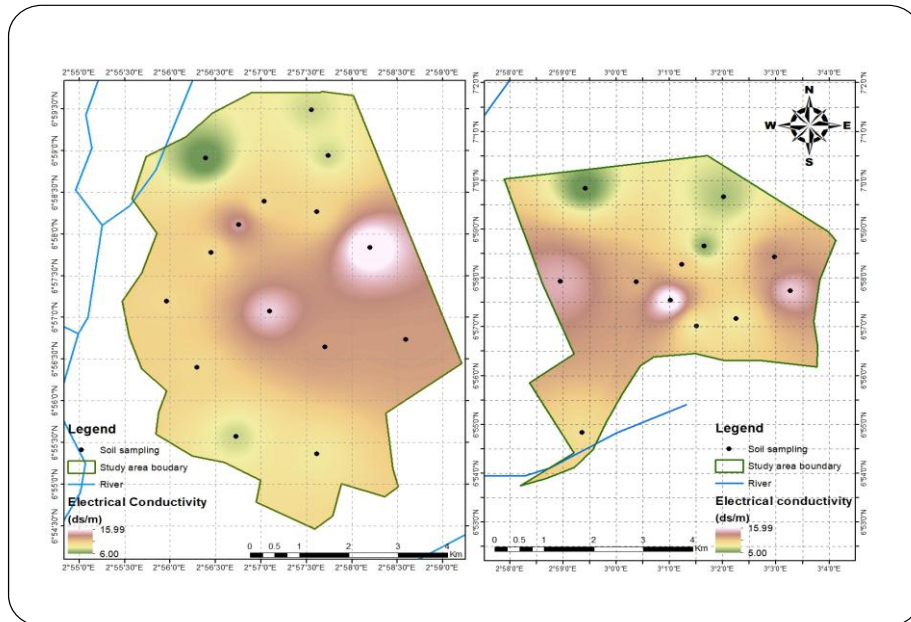


Figure 2: Spatial distribution of electrical conductivity in the soil of Sawonjo and Ibese

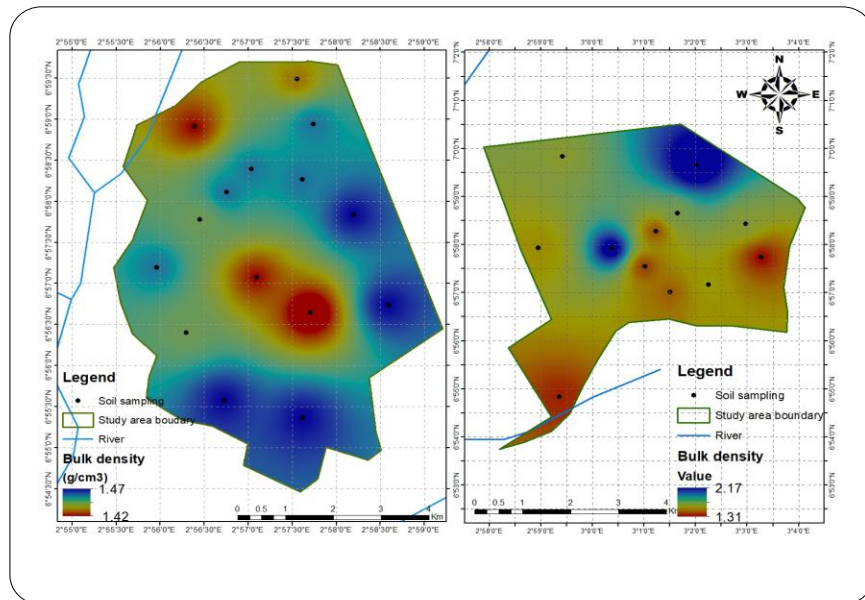


Figure 3: Spatial distribution of bulk density in the soil of Sawonjo and Ibese

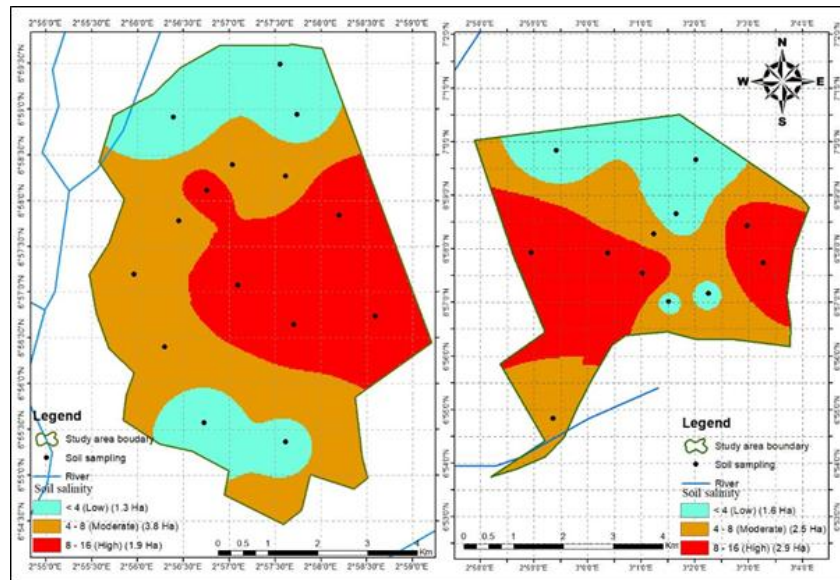


Figure 4: Classes of salinity extent in the soils of Sawonjo and Ibese

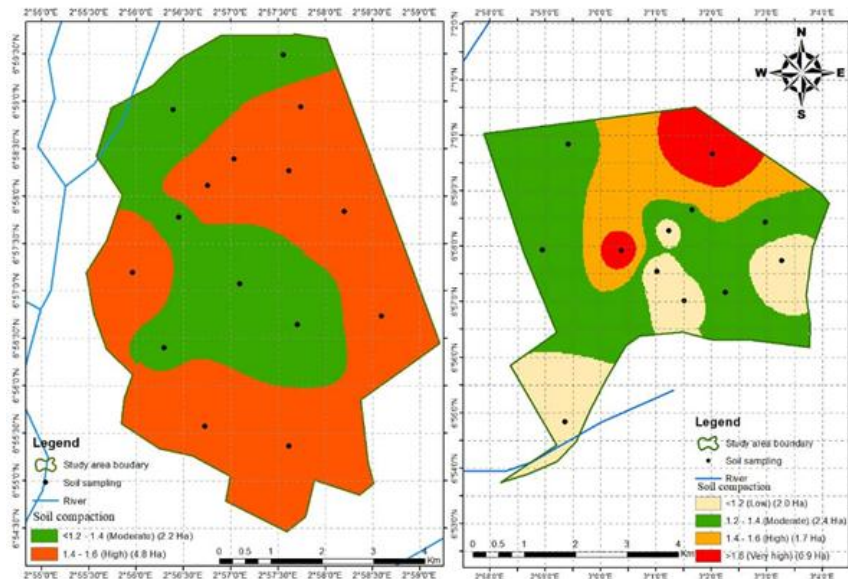


Figure 5: Classes of soil compaction extent in the soil of Sawonjo and Ibese



Conclusion

It can be concluded that the distribution of the soil properties i.e. EC and bulk density (BD) represented a wide variation over these soil types in the two locations. Furthermore, significant areas in both locations are subjected to a high risk of soil compaction and salinity. Moreover, processes of compaction and salinization changes from low to high in different soil types. Therefore, reducing soil compaction could be realized through avoiding field practices that have the potential to damage the soil structure. So, conducting field operations with heavy machines on wet soils should be minimized.

References

- Adejuwon, J. O. and Odekule, T. O. 2006. Variability and severity of the “little dry season” in southwestern Nigeria. *Journal of Climate* 19: 483-493.
- Aki, E. E. 2012. Characterization of wetland soils developed on limestones parent material in Cross River State, South Eastern Nigeria. *Global Journal of Agricultural Sciences* 1(11): 37-44.
- Alaguraja, P., Manivel, M., Sekar, M., Yuvaraja, D., Chakravarthi, P. and Deepasaraswathi, M. 2010. Mapping of land degradation in multi-temporal satellite data India using remote sensing and GIS Techniques. The 1st International Applied Geological Congress, 601. Iran: Islamic Azad University, 602pp.
- Ali, R. R. and Moghanm, F. S. 2013. Variations of properties over the landforms around Idku lake. *Egypt Journal of Remote Sensing Space Science*, 91: 101.
- Asongwe, G. A., Yerima, B. P. K. and Tening, A. S. 2016. Spatial variability of selected physicochemical properties of soils under vegetable cultivation in urban and peri-urban wetland gardens of Bamenda municipality, Cameroon. *African journal of Agricultural Resources*, 11(2): 74-86.
- Cohen, M. J., Creed, I. F., Alexander, L., Basu, N. B., Calhoun, A. J., Craft, C. and Jawitz, J.W., 2016. Do geographically isolated wetlands influence landscape functions? *Proc. Natl. Acad. Sci.* 113 (8), 1978-1986.
- Dubovyk, O., Menz, G., Lee, A. and Khamzina A. 2013. Spatial targeting of land rehabilitation: a relational analysis of crop land productivity decline in Arid Uzbekistan. *Erdkunde*, 167: 181.
- El Baroudy, A. A. 2010. Geomatics-based soil mapping and degradation risk assessment of Nile delta soils. *Polish Journal of Environmental Study*, 1123: 1131.
- El-Gammal, M. I., Ali, R. R. and Abou Samra, R. M. 2015. GIS-based land degradation risk assessment of Damietta governorate, Egypt, *Egyptian Journal of Basic and Applied Sciences*, 2:3, 183-189.
- FAO. 1979. A provisional methodology for soil degradation assessment. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).
- McCartney, M., Rebelo, L. M., Senaratna, S. S. and de Silva, S. 2010. Wetlands, Agriculture and poverty Reduction. Colombo, Sri Lanka: International Water Management Institute. IWMI Research Report, p. 39.



- Millennium Ecosystem Assessment. 2015. Ecosystems and human Well-being: Wetlands and water Synthesis. Millennium Ecosystem Assessment, Washington, DC.
- Obaje, N. G. 2009. Geology and mineral Resources of Nigeria. *Springer-Verlag Berlin Heidelberg*, pp. 13-108.
- Ogg, C. M., Gulley, C. D., Reed, J. M. and Ferguson, C. A. 2017. Soil property trends and classification of alluvial floodplains, South Carolina Coastal Plain *Geoderma*. 305: 122-135.
- Ojanuga, A. G. 2006. Agroecological zones of Nigeria manual. FAO/NSPFS, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria, p. 124.
- Olabode, S. O. 2015. Subsidence Patterns in the Nigeria Sector of Benin (Dahomey) Basin: Evidence from Three Offshore wells. *Ife Journal of Science*, 17(2): 456.
- Olabode, S. O. and Mohammed, M. Z. 2016. Depositional Facies and sequence Stratigraphic study in parts of Yewa, Southwestern Nigeria: Implications on the Re-interpretation of tertiary Sedimentary Successions. *International Journal of Geosciences*, 7: 210-228.
- Olayinka, O. O., Adedeji, O. H., Oresanya, O. J. and Alabi-Thompson, O. F. 2016. Environmental and Health Impact of Cement Factory Production in Ibese, Ogunstate, Nigeria, *Applied Environmental Research*, 38(2): 93:110.
- Osinuga, O. A., Aiboni, V. U. and Oyegoke, C. O. 2020. Classification and Suitability evaluation of Soils along a Toposequence for Rice Production in Alabata, Southwest Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension*, 19(4): 43-50.
- Tabi, F. O. and Ogunkunle, A. O. 2007. Spatial variations of some physico-chemical properties of an Alfisol in Southwestern Nigeria. *Nigeria Journal of Soil Environmental Resources*, 7: 82-91.
- Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H. and Kumar, P. 2007. Agriculture in climate change mitigation. Contribution of Working Group III to the fourth assessment report of the intergovernmental panel on climate change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- Thenkabail, P. S. and Nolte, C. 2016. Capabilities of Landsat-5 Thematic Mapper (TM) data in regional mapping and characterization of inland valley agroecosystems in West Africa. *International Journal of Remote Sensing*, 17(8): 1505-1538.
- Tiner, R. W. 2015 Remote sensing of wetlands: applications and advances. Boca Raton, FL: CRC Press, pp. 3-18.
- Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O., and Esu, I. E. 2009. Manual of Soil, Plan and Water Analyses. Sibon Books Limited, Lagos, Nigeria, p. 183.
- Ukabiala, M. E. 2012. Characterization and classification of River Benue flood plain soils in Bassa Local Government Area of Kogi State, Nigeria. M.Sc Thesis, Kogi State University, Anyigba, p. 60.
- Ukabiala, M. E., Kefas, P. K., Akpan-Idiok, A. U., Philip, H. J., Ngasoh, F. G. and Kefas, A. P. 2016. Assessment of the



Lawal *et al.*



physicochemical characteristics, degradation rate and vulnerability potential of Ihitte/Uboma Soils, Imo State, Nigeria. *International Journal of Agriculture and Environmental Research*, 2(5), 1467-1479.

UNEP. 1991. Global assessment of soil degradation, United Nations environment Programme (UNEP), United Nations, GLASOG Project, p. 13.