AJLP & GS
African Journal on Land Policy and Geospatial Sciences

e-ISSN : 2657-2664, Vol. 5, Issue 5, November 2022

https://revues.imist.ma/index.php/AJLP-GS/index

https://doi.org/10.48346/IMIST.PRSM/ajlp-gs.v5i5.31755 Category of the manuscript: Articles

Received in: 4 April 2022 Revised in: 25 August 2022 Accepted in: 11 September 2022

DIGITAL MAPPING OF SOIL SALINITY IN KAMPE-OMI IRRIGATION SCHEME

[1]Titus Adeyemi Alonge, [2]Olumuyiwa Idowu Ojo, [3]Modupe Adebola Adejumobi, and [4]Jeremiah Oludele Ojediran

[1,2,3]Department of Agricultural Engineering, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.

[4]VC Office, Bells University of Technology, Ota, Nigeria

Corresponding author:
Professor Olumuyiwa Idowu Ojo
E-mail: oiojo@lautech.edu.ng; olumuyiwaojo@gmail.com
ORCID of the author(s): orcid.org/0000-0002-5912-3932;

ABSTRACT

Soil salinity being a problem of irrigated agriculture reduces the productivity of agricultural land adversely. Detection of soil salinity by conventional means of soil survey requires a great deal of time

Goal and objectives:

Remote sensing data and GIS techniques minimize time consuming and offer the possibility for monitoring and mapping salt affected land. This study assessed and digitally mapped out soil salinity level in Kampe – Omi between the periods of 10 years (2005 - 2014).

Methodology:

Sampling and the surface electrical conductivity of the soil (EC) was determined for the samples. The images were geo referenced with obtained imageries using supervised classification method. NDVI vegetation indices were applied for such classifications, thus the study area were classified into High, Medium, and low-saline levels based on reflectance values.

Results:

The representation gave the results variance of colours, which are still not above the threshold level for saline soils. The NDSI map developed reveals that OL 18 and OL 20 has very low salt content which occupied a total area of 17 % of the area in consideration, which medium saline soils covered 46 % while the high saline soils occupied 7 % of the study area. The extent of the soil salinity level in the study area was found to be lower generally and not highly visible. The study depicted that using remote sensing data and ground data; soil salinity can be monitored and mapped.

Keywords:

Mapping; GIS; RS; Kampe-Omi; Irrigation

1. INTRODUCTION

Irrigated agriculture is important to the national economy of a country as it contributes significantly to the production of food. The main objective of irrigated agriculture is to enhance crop production for food sufficiency, particularly in semi-arid and arid zones (Rhoades, *et al,* 1999). It has contributed positively to food security, poverty alleviation, and rural development. In addition, it protects plant against frost, suppresses growing of weeds in grain fields and prevents soil consolidation. Most irrigation schemes are faced with problem of soil deterioration resulting from increased level of soil salinity and rise in water table. Soil salinity affects soil chemical, physical and biological characteristics of the soil, fertility and sustainable productivity unless it is properly monitored. Geo-informatics involves a combination of special techniques, technologies and tools for the acquisition, processing, management, analysis and presentation of geospatial data (Ehlers, 2008). It is a combined method to GIS and remote sensing. Remote sensing and GIS are well-established information tools, since they give reasonable pictures of the entire process in spatial and temporal terms. They both provide a cost effective and adequate understanding of landscape dynamics, detect, identify, map and monitor differences in land use and land cover pattern over long period of time (Rimal, 2011). The application of Satellite Remote Sensing (SRS) and GIS has been proved useful and successful in many fields such as natural resources management, agriculture and environmental issues and water resources. Remote sensing approaches are very effective for detecting, monitoring and control of soil salinity. Remotely sensed data are used to assessed soil salinity either on bare soils with salt crust or through biophysical properties of vegetation as these are affected by salinity (Abd-elwahed, 2005).

2. GEO-INFORMATICS TECHNIQUES APPLICATION

Geo-informatics is an important tool used to address environmental issues like ground water mapping, ground water movement, river restoration, flood prediction and soil salinity management on a local, regional, national or even global scale (Ojo*et al.,* 2018). According to Yoo *et. al*., (2004) GIS can be used to analyze situation, model and stimulate different scenarios for prediction, project information to enhance decision-making and policy in salinity. It can also be employed in making a suitable decision in critical scenario, evaluating the effects of land use/cover, soil type, vegetation, topography, water quality and geology (Bello, *et al.,* 2018). Geo-informatics employs GIS and Remote Sensing (RS) to tackle different issues within the field as it enhance the possibility of a three dimensional approach for distributed models. This possibility allows all of these data to be used simultaneously to develop a more comprehensive model. Such models could assist geographers to gain a deeper understanding of the movement of different surface (or subsurface) soil, waters and their interactions (Ziliaskopoulos and Waller, 2000). Baiyinbaoligao *et. al.* (2011) employed geo-informatics (GIS and remote sensing) techniques for modeling the rainfall-runoff process in the Kuronagi River based on two rainfall stations. Since they used ESRI's ArcView version 8.3 and its Spatial Analyst extension module to carry out the flow direction, flow accumulation, and stream network as features. A 50 m DEM spatial data issued by Japan Geographical Survey Institute in 1996 was used to produce the digital basin of the Kuronagi River (Baiyinbaoligao *et. al.*, 2011). The approaches vary from a simple sensitivity analysis of hydrology to the changes observed in climate inputs to the study of palaeo climatic data, spatial shifting of current climates towards polar region. Because of its physically based nature, the latter approach is arguably the most attractive. Ojo (2013) used geo-informatics techniques to map salinity in Vaal hart's irrigation scheme, South Africa and also to project future scenario with good results to use as good samples. Therefore, this study assessed and digitally mapped out soil salinity level in Kampe – Omi between the periods of 10 years (2005 - 2014). After sampling and the surface electrical conductivity of the soil (EC) was determined for the samples.

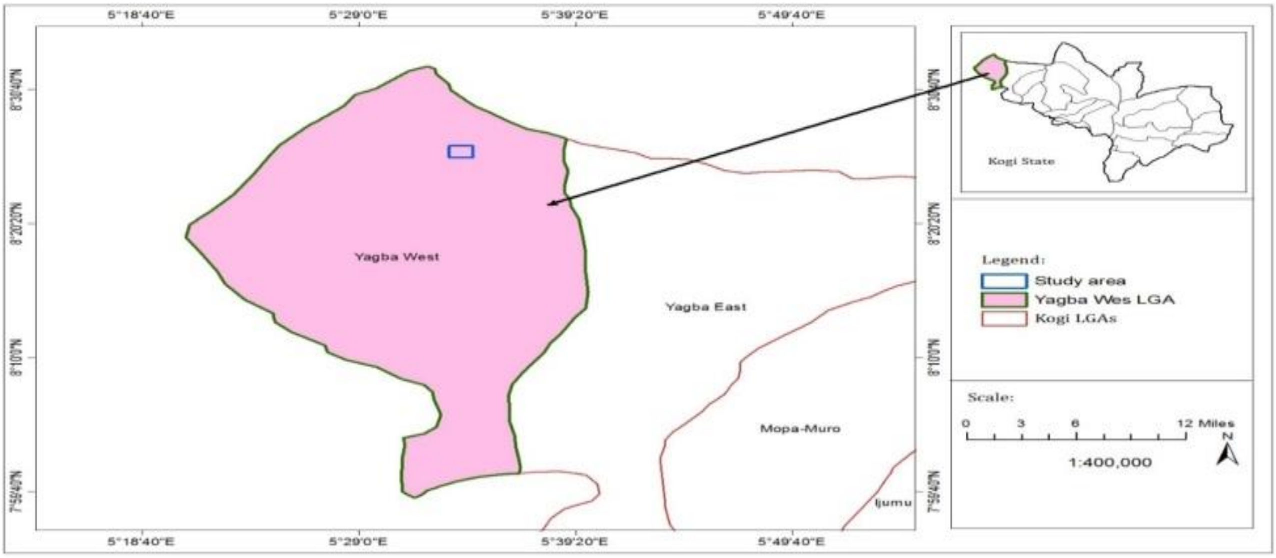
3. METHODOLOGY

Therefore, this study assessed and digitally mapped out soil salinity level in Kampe – Omi between the periods of 10 years (2005 - 2014). After sampling and the surface electrical conductivity of the soil (EC) was determined for the samples.

3.1 The Study Area

Kampe - Omi irrigation scheme is located in Yagba West Local Government Area of Kogi State, Nigeria. According to Adeniran *et al.*(2010) it is about one hundred and forty six kilometers (146 km) from Ilorin, the capital of Kwara State. It lies on longitudes 6^{o} 37^{1} to 6^{o} 42' E and latitudes 8^{o} 34^{1} to 8^{o} 38'N. The study area falls within guinea savannah region of Nigeria, the slope of the land enhance water flow by gravity to various fields for irrigation purposes. According to Oriola (2012) Kampe Omi scheme consists of lithosols, cambisols, luvisols, eroded soils, alluvial and arenosols soils. The soils are majorlycoarse textured, ranging from loamy to sandy loam in the surface horizons and from sandy loam to clay in the subsurface horizon (Adejumobi *et al.,* 2014). The scheme was designed to serve purposes such as irrigation of farmlands, generation of hydro-power and its supply, but it is being restricted to only the irrigation of farmlands (Adeniran *et al.,* 2010). The scheme has an area of 4,100 ha expanse of irrigable land. Construction of dam in the scheme has an impounding capacity of 250 million m^3 of water, with 39 Km main canal length , about 300 Km of feeder and supplementary drainage system (Oriola, 2012). Basin irrigation is mainly practiced in the scheme while crops being cultivated are maize, vegetables sweet potato, sorghum, okra and rice. The map of the study area in relation to Nigeria and Kogi State is as shown in Figure 1.

Figure 1: Map of the study area (Source: Alonge *et al*., 2018)



3.2 Data Acquisition

Soil samples were collected and analyzed for Electrical Conductivity (ECe) using handheld Garmin GPS, the readings were imported into ArcGIS 9.0 environment for analysis to generate soil sampling location map overlaid with raster image of the scheme. The total area under consideration is 388.45 ha. Enhance Thematic Mapper plus (ETM+) Land satellite image year 2014 for KOIS was acquired from Global Land Cover Facility (GLCF) hosted by Maryland University, USA, Values were downloaded into ArcGIS 9.0. Satellite Imagery Enhanced Thematic Mapper plus (ETM+) acquired has a 30 m resolution and was analysed using supervised classification. Two commonly used Geo-reference approaches were used; Georeferenced corners: Specifying the coordinates of the lower left (as Xmin, Ymin) and upper right corner (as Xmax, Ymax) of the raster image and the actual pixel size. Geo-reference tie points specifying reference points in an image so that specific row/column numbers obtain a correct X, Y coordinate. For this study, Landsat data wasgeo-reference to Universal Transvers Mercator (UTM) zone 43, with the ellipsoid and datum in WGS 84.The analysis was carried out in order to consider variation in soil salinity to assess the level of salinity and its spatial distribution on the scheme. ArcGIS 9.0 GIS software was used for data pre-processing and processing, and enhancement of image while Environment for Visualizing Images (ENVI) 4.5 software was used for supervised classification using maximum likelihood method as shown in Figure 2.

3.3 Methods

The methods used to include data preparation, image processing, mapping, and modeling. Satellite data pre-processing, processing and post processing were in the sequence as shown in Figure 2. The imageries were projected to common coordinates systems and were thereafter subjected to image processing procedures to correct for the atmospheric, radiometric, geometric errors and abnormalities of the instrument performance, loss of specific scan lines that requires de-striping. Data from satellite remote sensing is in form of Digital Numbers (DN). Pre-processing is an important and diverse set of image preparation programs that act to offset problems with the band data and recalculate DN values that minimize these problems before the proper analysis. The image processing procedures includes resample, stretch, color composite and principal component analysis (PCA). The post–processing was done by importing data analysed from processing stage into ENVI 4.5 using import command in ENVI pallet bar so as to produce Natural Differential Salinity Index Map (NDSI) of the study area as shown in Figure 2.

3.4 Image Processing

To process the images, the spectral respond pattern was first developed for easy identification of remotely sensed features using IDRISI 17.0 software. A simultaneous query of all the images included in a raster image group file, in order to obtain quantitative information from images, digital number was converted to physical quantities, radiance and brightness temperature.

$$L\lambda = \left(\frac{(L_{MAX}\boldsymbol{\lambda} - L_{MIN}\boldsymbol{\lambda})}{Q_{CAL}\lambda}\right) Q_{CAL} + L_{MIN}\boldsymbol{\lambda} \qquad 1$$

where;

$L\lambda$ = Spectral radiance at the sensor's aperture [W/ (m^{2}sr μm)]

The above expression does not consider the atmospheric effects, therefore there was need to convert images from radiance to reflectance measures, using equation 2 (Gyanesh *et al*, 2009).

$$\rho\lambda = \frac{\pi.TOAr.d^2}{E_{SUN}\lambda.Cos\theta_{sz}} \qquad 2$$

Where;

$\rho\lambda$ = Planetary TOA reflectance (unit less),

π = Mathematical constant approximately equal to 3.14159 (unit less),

$L\lambda$ = Spectral radiance at the sensors aperture [w/ (m^{2}sr μm)],

d^2 = The earth-Sun distance (Astronomical unit),

E_{SUN} = Meanexoatmospheric solar irradiance [w/ (m^{2}sr μm)],

θ_{SZ}= the solar zenith angle (degree),

The cosine of this angle is equal to the sine of the sun elevation θ_{SE}, therefore, θ_{SZ} = 90-θ_{SE}.

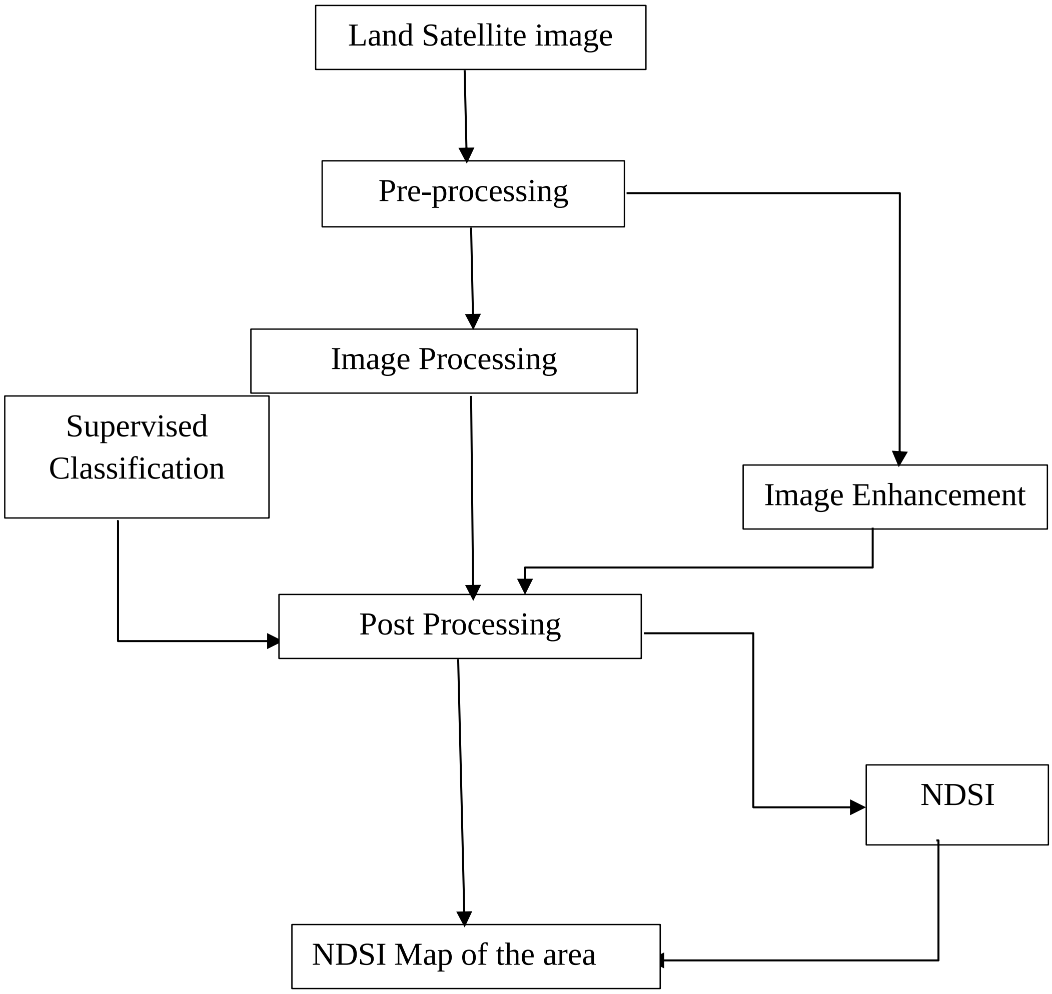


Figure 2: Classification of salt affected area by satellite image

3.5 Supervised classification

Maximum likelihood classification method was employed in supervised classification as recommended by Ojo (2013) and Ochieng *et al.,* (2011). In supervised classification, the image pixels' categorization process was achieved by stating to the computer algorithm, numerical descriptors of the various feature class present in the image. Supervised classification method involved three basic stages: training stage, classification stage and accuracy assessment stage. In supervised classification of salt affected soils of the area, training set was developed and three classes were stated. Training sets layer was generated for the data set (Landsat ETM+) while fieldwork data and image interpretation of all the images was used to create training set. Maximum likelihood classifier decision rule is depends on a normalized (Gaussian) estimate of the probability density function of each class as described by (Asiribo, 2009). The maximum likelihood classifier evaluates both the covariance of the category spectral response patterns and variance quantitatively when grouping an unknown pixel. After the probability in each group wasevaluated, pixel was then ascribed to the one with the highest probability value if the probability values are all below a threshold set by the analyst (Rozanov *et. al.*, 1991).

3.6 Analysis of NDSI

The raster calculation for the NDSI was processed for completely downloaded scene covering the study area; this was exported as raster image to ENVI 4.5 for further processing and map generation. In ENVI, the NDSI for the whole scene was clipped with the study area extent using extract analysis tool, the NDSI image of the area was change from natural white and black stream of colors to Hue Saturation Value (HSV) color stream. This enhanced better knowledge of the obtained result. The result generated was used to assign the appropriate class and colour for the number of classes that are distinguishable after merging similar class using the reclassify tools. The formula for NDSI calculation is shown in equation 3.3 (Jackson and Huete, 1991; Ojo, 2013):

$$\text{NDSI} = \frac{Band\ 3 - Band\ 4}{Band\ 3 + Band\ 4} \qquad 3.3$$

Where;

Band 3 is the red band,

Band 4 is Near Infrared band (NIR) and

Normalized Differential Vegetation Index (NDSI) was applied on Landsat.

The flowchart in Figure 2 showed the complete procedures applied to create the natural differential salinity index map of the study area with the acquired Landsat image. Band 3 (0.63 - 0.69 µm) senses in a strong chlorophyll absorption region and strong reflectance region for most soils. It has discriminated vegetation and soil. Band 4 (0.76 - 0.90 µm) functions in the best spectral region to differentiatedifferent types of vegetation and conditions. Water is a strong absorber of near IR; this band has delineated water bodies distinguished between dry and moist soils.

4 RESULTS AND DISCUSSION

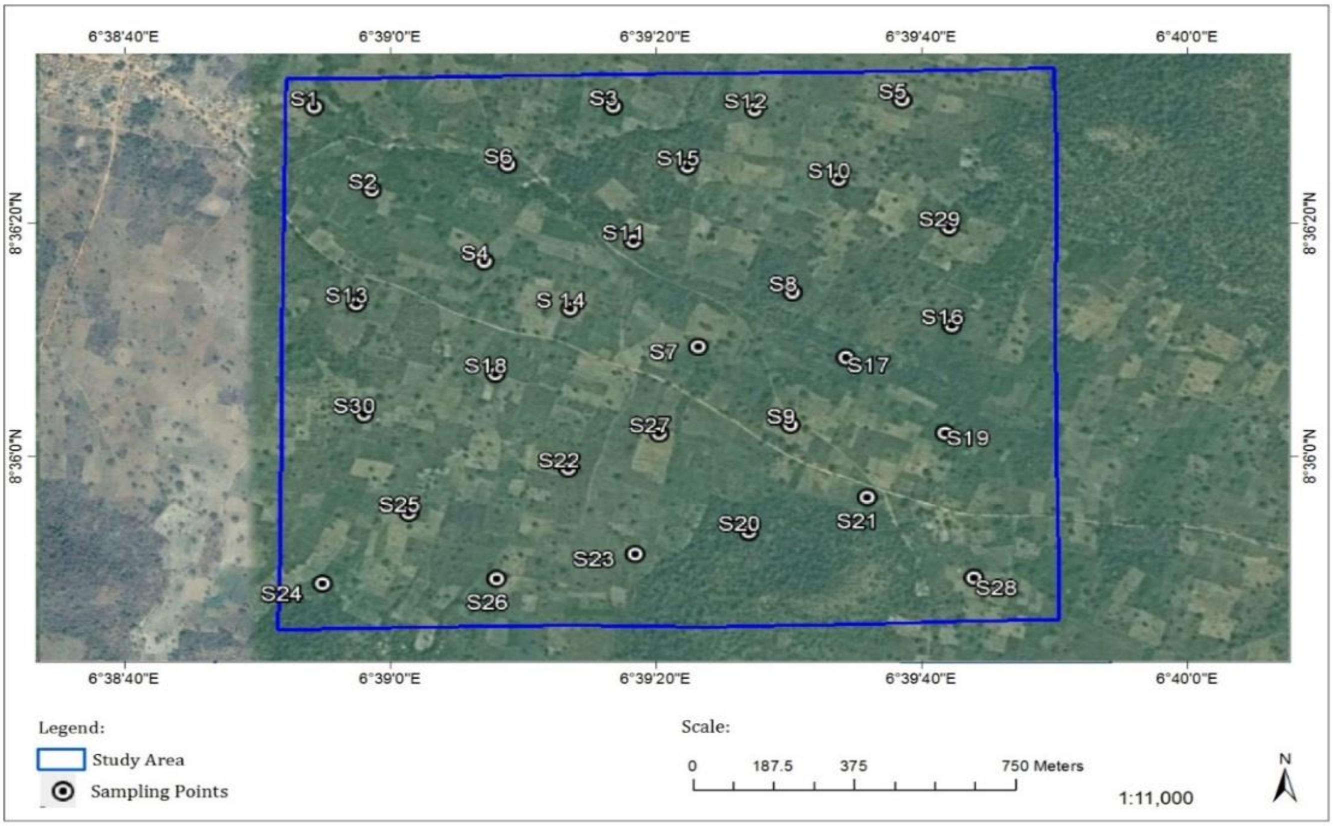
4.1 Soil Sample Analysis

Sampling point S_{22} with X-coordinate 6.653311, Y-coordinate 8.599293 has the least EC value of 0.04 ds/m, while the sampling point locations S_{14} and S_{29} with X-coordinate 6.653395, Y-coordinate 8.603634 and X-coordinate 8.66254, Y-coordinate 8.605717 respectively have the highest EC value of 0.5 ds/m. The maximum values of ECe obtained at S_{14} and S_{29} is because of high elevation in OL 18 and OL 20. In addition, the increase in ECe value of OL 20 is due to waterlogging in the area.

Ojo, (2013) reported that irrigated areas with high elevation and waterlogging are prone to soil salinity. The blue square area in soil sample location shown in Figures 4 indicated the study area under consideration. Sample points S_1 to S_{30} were tied to the corresponding area and coordinates on the raster image acquired, S_{10} was tied to x-coordinate 6.659905, y-coordinate 8.607062, S_{19} was tied to x-coordinate 6.662402, y-coordinate 8.600167, and S_{30} was tied to x-coordinate 6.648408, y-coordinate 8.600820. The circled area with black spot indicated the sampling points while the map scale used was 1:11000 m.This implies that soils on OL 18 are very low in salt content while OL 20 is slightly high in salt content. The pattern observed was upward trend, which indicates that salinity increases along the sampling point in the study area, this may be due to difference in elevation and waterlogging area.

Figure 3: Soil sampling locations

Table 1: Soil sampling location and ECe



S/N	Sampling Points	X-Coordinate	Y-Coordinate	ECe (dS/m)
1	S_1	6.647244	8.609180	0.20
2	S_2	6.648625	8.606906	0.16
3	S_3	6.654496	8.609091	0.25
4	S_4	6.651325	8.604939	0.13
5	S_5	6.661449	8.609176	0.30
6	S_6	6.651918	8.607561	0.27
7	S_7	6.656428	8.602565	0.09
8	S_8	6.658770	8.604016	0.06
9	S_9	6.658681	8.600429	0.22
10	S_{10}	6.659905	8.607062	0.35
11	S_{11}	6.654939	8.605449	0.29
12	S_{12}	6.657901	8.608963	0.42
13	S_{13}	6.648245	8.603817	0.45
14	S_{14}	6.653395	8.603634	0.50
15	S_{15}	6.656274	8.607446	0.10
16	S_{16}	6.662592	8.603082	0.37

17	S_{17}	6.660036	8.602238	0.30
18	S_{18}	6.651572	8.601879	0.15
19	S_{19}	6.662402	8.600167	0.06
20	S_{20}	6.657647	8.597563	0.48
21	S_{21}	6.660489	8.598460	0.25
22	S_{22}	6.653311	8.599293	0.04
23	S_{23}	6.654907	8.596991	0.22
24	S_{24}	6.647391	8.596226	0.42
25	S_{25}	6.649469	8.598142	0.31
26	S_{26}	0.651564	8.596347	0.26
27	S_{27}	6.655513	8.600223	0.20
28	S_{28}	6.663035	8.596264	0.27
29	S_{29}	6.662541	8.605717	0.50
30	S_{30}	6.648408	8.600820	0.44

4.2 Distribution of Salt Affected Area

The processing of soil salinity map with sampling location in ArcGISas shown in Figure 4, and while the spatial distribution of salt affected area in the study location is presented in Figure 5. These were developed based on the values of ECe obtained from laboratory analysis (Alonge *et al,* 2018). Low saline soils were shown in pinkish colour on the False Colour Composite, and were also shown in few red or pink mottled textures. Low saline soils areas were normally shown in light blue colour on the False Colour Composite as they also showed as fine texture with few mottled spots of other colour in the sample soils on the field as Ojo (2013) depicted that the reflectance of salt affected area is higher in much of the bands other than other features. On the Standard False Colour Composite 4-3-3, the highly salt-affected areas are mostly represented in very bright colour with some small amounts of other colours; in this case, there were absence of this. The textures of these areas were very fine, although there were traces of salt appearance on the study area, however, the distribution of the soil in the study area falls under low-saline soil classification compared to FAO standards of saline soil classification irrespective of their colors (Ochieng *et. al.,* 2013).

4.3 Classification of Salty area using ECe

Low-saline portionofthe entire land was 338.44850 ha as the areas were represented in yellow, grey, blue, pink, and brown colour in the map. The blue region has ECe value ranged from 0.04 – 0.126 dS/m; it covers 3% of the total area as shown in Table 2. The area represented in grey region has EC value ranges between 0.126 – 0.202 dS/m it covers 14% out of the total area. The ECe value of the yellow portion ranges from 0.202 – 0.288 (dS/m), it covers 46% of the total area under study. The brown colored portion ranges from 0.288- 0.387 dS/m, it covered 30% of the area as well. The pink colour area has ECe value ranges from 0.387 – 0.5 dS/m as shown in Table 2, it was observed that the yellow portion with EC values of 0.202 – 0.288 covered the largest portion while the area with 0.04 – 0.126 dS/m covered the smallest part of the study area.

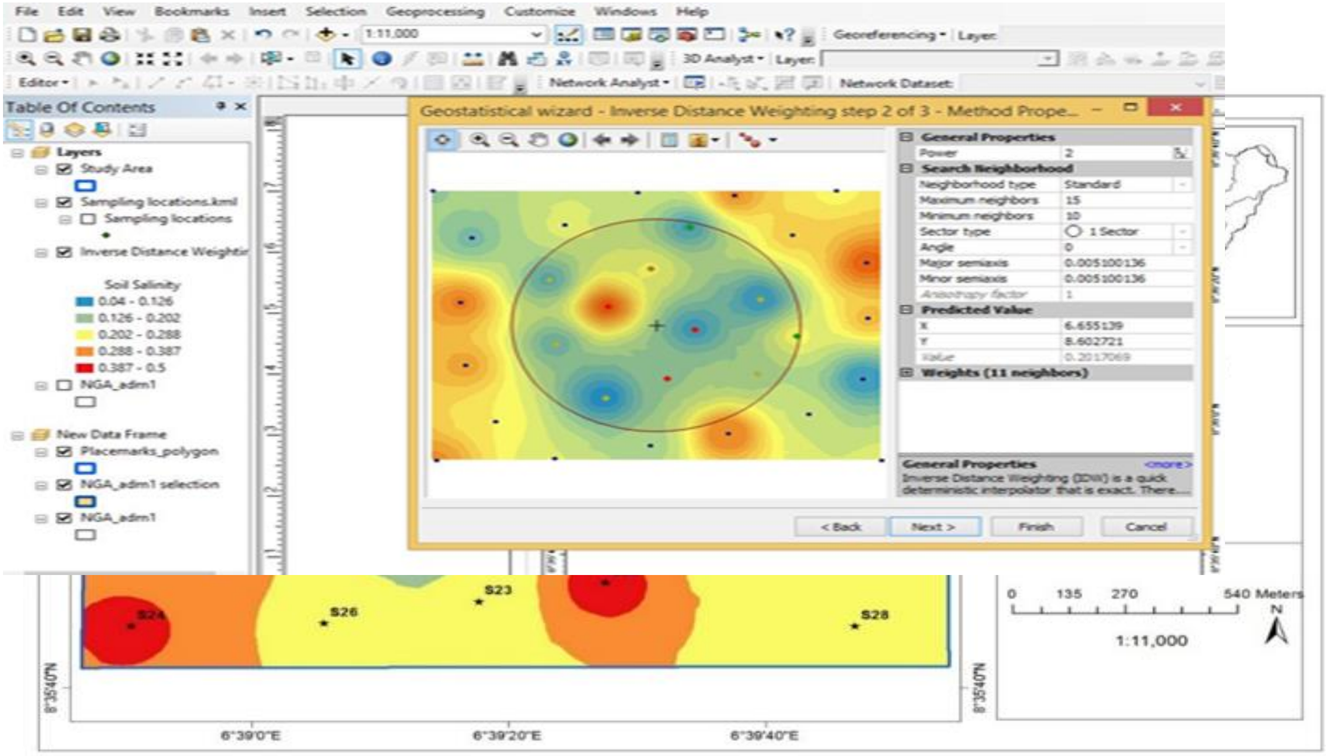


Figure 4: Processing of soil salinity distribution map with sampling location in ArcGIS

Figure 5: Soil salinity distribution (ECe) with sampling location of the study area

The results obtained were compared to FAO standard for soil salinity; it was shown that it was within the acceptable range of non-saline soils classification since the values were below 4 dS/m (Alonge, *et al*, 2018).

Table 2: Classification based on field ECe values

Salinity Classes	Salinity Ranges (dS/m)	Area (m^2)	Percentage	Map color representation	Salinity Status (%) low to moderate(< 4 dS/m)
1	0.04 – 0.126	94,110.53	3	Blue	
2	0.126 – 0.202	490,241.42	14	Grey	
3	0.202 – 0.288	1,556,885.03	46	Yellow	100
4	0.288 – 0.387	1,020,497.14	30	Brown	
5	0.387 – 0.500	222,750.89	7	Red	
	Total	3,384,485.00	100		

4.4 Supervised classification

The results from supervised classification of ETM+ data were displayed in Figure 6. Contrast, brightness enhancements, the false color composite of 4-3-3 and other remote sensing analysis were carried out using ENVI 4.5, while the images were analysed using band 3, 4 and 2 for each part. Based on visual interpretation of ETM+ satellite image, coupled with ground truth (Validation), the study area were classified into High, Medium, and low-saline levels based on reflectance values instead of ECe obtained from the field. The values were subjected to GIS representationfor enhanced visualization. The representation gave results variance of colours, which were not above the threshold level for saline soils. The NDSI map developed as shown in Figure 6 and it reveals that OL 18 and OL 20 have very low salt content. The area in blue, green, yellow, brown and dark brown means area that with low reflectance and low-saline region. In Table 3, the blues and green area was classified as low saline soils as they occupied a total area of 17 % of the area in consideration, while the yellow and brown areas also indicated medium saline soils while yellow area covers 46 % while the brown area covers 30 %.

The dark brown portion was grouped as high saline soils; it occupies 7 % of the study area, thus confirming the study of Darvishsefat *et. al.,* (2000) that ECe values less than 4 dS/m falls under low saline soils irrespective of their colours. As salinity problem is dynamics in nature even varies with time and the image used was acquired in 2014, ground truth also done in 2015 gave indications of slight presence of salt in the area. However, the extent of the soil salinity level in the study area was found to be lower and not highly visible.

Table 3: Salinity data extracted based on NDSI values

Salinity Classes	Percentage	Map color representation	Salinity Status (%) low to moderate (< 4 dS/m)
1	3	Blue	Low
2	14	Green	Low
3	46	Yellow	Medium
4	30	Brown	Medium
5	7	Dark brown	High
	100		

NDSI values may be used to class saline soils as presented in Figure 6. Generally, the study irrigated soils has found both by field assessment in 2015 and satellite image (Landsat ETM + in 2014) to contain low-salinity. This is might be that the irrigated areas have not being actively cultivated as information stated that the scheme was commissioned in 1999. Therefore, the Kampe – Omi irrigation scheme managers, planner and famers should practice smart agriculture to avoid building up of soil salinity.

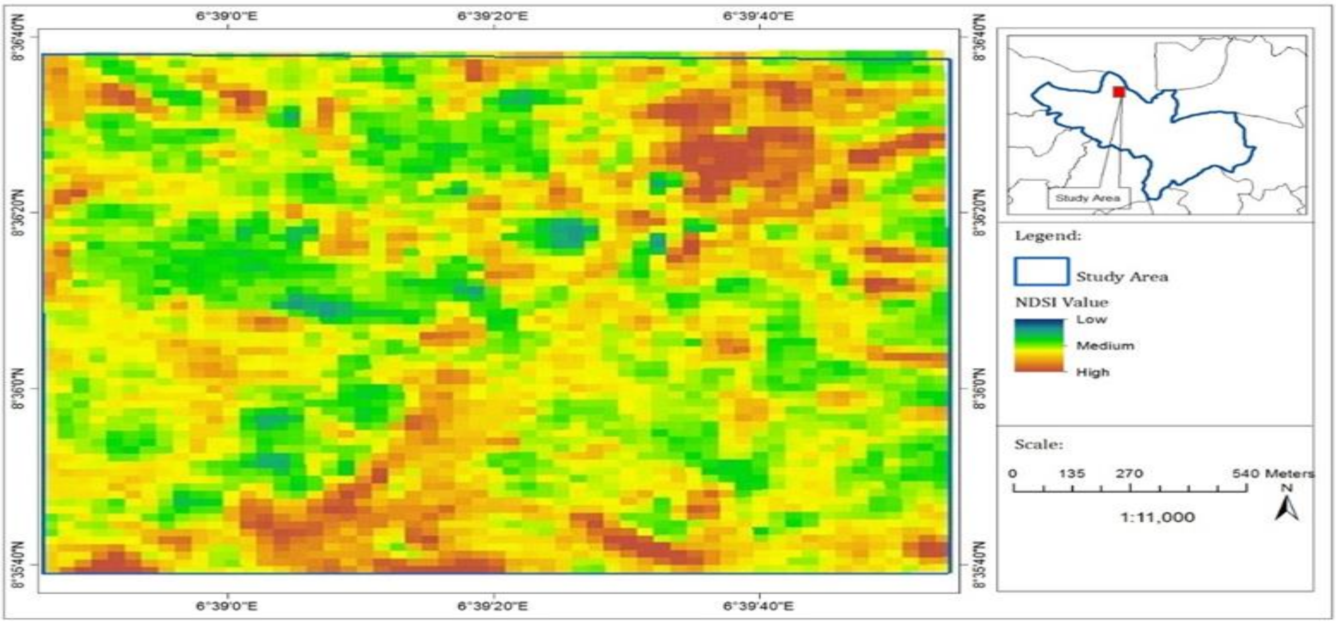


Figure 6: Map of NDSI indicating salinity level

5 CONCLUSIONS

Conventional data, remote sensing and GIS methods were used in mapping out of soil salinity in the study area. Based on the findings of the study in this area, the Normalized Difference Salinity Index (NDSI) coupled with ground truthing shown that the total study area wassalt affected but it is not visible on soil surface. In addition, the application of NDSI served as a good indicator of soil salinity measurement and mapping, which may help decision making and planning for reclamation of soil salinity and soil management. The following recommendations were made based on the objectives and findings of this study; Scheme project manager and planners should encourage the farmers on the proper drainage system management practice to control the building up of saline soils in the area. Future research should examine how cropping patterns established will prevent building up of salt on the study area. Future work should examine the depth of 30 – 60 and 60 – 90 cm to consider ECe of the subsoil and how these can be studied using hyper spectrometer for better accuracy. In addition, scheme manager, planners, farmers can use the soil salinity map developed.

6 ACKNOWLEDGMENTS

The authors acknowledged the support by the staff of Lower Niger River Basin Authority Ilorin headquarter and Ejiba office for providing the necessary data and other assistance in the study.

7 FUNDING

This study was not funded.

8 CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

9 AUTHORS' CONTRIBUTIONS

Titus Adeyemi Alonge: field work and data collection, data analysis, data interpretation.
Olumuyiwa Idowu Ojo: field supervision, data interpretation, manuscript editing and supervision.
Modupe Adebola Adejumobi: field supervision, manuscript editing and supervision.

Jeremiah Oludele Ojediran: Editing of the manuscript and overall supervision.

10 REFERENCES

Abd-elwahed, M. S. (2005). Assessment of soil salinity problems in agricultural areas through Spatial and temporal Remote Sensing. *Egyptian Journal of Basic and Applied Sciences*, *4*(2), 23 – 30.

Adejumobi, M. A., Ojediran, J. O., and Olabiyi, O. O. (2014). Effects of Irrigation Practices on Some Soil Chemical Properties on OMI Irrigation Scheme. *Int. Journal of Engineering Research and Application*, *4*(10), 29–35. Retrieved from www.ijera.com

Adeniran, K. A., Amodu, M. F., and Adeniji, F. A. (2010). Water requirements of some selected crops in Kampe dam Irrigation Project. *Australian Journal of Agricultural Engineering*, *4*(1), 119 – 125.

Alonge, T.A., Ojo, O. I. and Adejumobi, M.A. (2018). Electrical conductivity based classification and mapping of salt affected soils in kampe-Omi irrigation scheme. GSL. 6(7),1075-1085.

Asiribo, O. E. (2009). An assessment of the roles of irrigation farming in the millennium development goals. *American-Eurasian J. Agric. & Environ. Sci.*, *4*(2), 445–450.

Bello, H. O., Ojo, O. I. and Gbadegesin, A. S. (2018): Land Use/Land Cover Change Analysis using Markov-Based Model for Eleyele Reservoir. *J. Appl. Sci. Environ. Manage,* 22 (12): 1917–1924. PRINT ISSN 1119-8362, Available at: https://www.ajol.info/index.php/jasem, http://ww.bioline.org.br/ja.

Darvishsefat, A. A., Damavandi, M. H., Jafari, M., and Zehtabiyan, G. R. (2000). Assessing of Landsat TM images for using in soil salinity classification. Journal of Desert., 5(2), 56–67.

Ehlers, M. (2008). Geoinformatics and digital earth initiatives : a German perspective. *International Journal of Digital Earth*, *1*(2007), 17–30.

El-sayed, S. M. (2006). Application of GIS and Remote sensing in Irrigation. *Tenth International Water Technology Conference, IWTC10 2006, Alexandria, Egypt*, *21*, 21–32.

ESRI. (2011). ESRI data and map. *Introduction to ARC View GIS. Environmental System Research Institute. Inc. USA. Fadem,* 1–7.

FAO, (Agriculture and food Security). (1988). Salt-Affected Soils and Their Management. *Bulletin*, *39*.

Jackson, R. D., and Huete, A. R. (1991). Interpreting vegetation indices. *Journal of Agricultural Science and Technology*, *5*(2), 46–55.

Ochieng, G. M., Ojo, O. I., Otieno, F. A. O., and Mwaka, B. (2013). Use of remote sensing and geographical information system (GIS) for salinity assessment of Vaal-Harts irrigation scheme , South Africa. *Enviromental System Research*, *2*(4), 1–12.

Ojo, O. I. (2013). *Mapping and Modeling of Irrigation Induced Salinity of Vaal-Harts Irrigation Scheme* *in South Africa.Unpublished D.Tech thesis. Dept of Civil Engineering Tshwane University of Technology, South Africa.*

Ojo, O. I., Ochieng, G. M., and Otieno, F. O. A. (2011). Assessment of water logging and salinity problems in South Africa : an overview of Vaal harts irrigation scheme. *WIT Transactions on Ecology and the Environment*, *153*(4), 477–484.

Oriola, E. O. (2012). Partnership In Irrigation System For Increased Efficiency And Agricultural Productivity In Nigeria. *Journal of Enviromental Research and Development.*, *6*(4), 3 – 11.

Rhoades, J. D., Chanduvi, F., and Lesch, S. (1999). Soil salinity assessment: methods and interpretation of electrical conductivity measurements. *FAO Irrigation and Drainage Paper*, *57*, 1–148.

Rimal, B. (2011). Application of remote sensing and Gis, land use / land cover change in Kathmandu Metropolitan city, Nepal. *Journal of Theoretical and Applied Information Technology.*, *23*(2/3), 80 – 86. Retrieved from www.jatit.org.

Rozanov, B. G., Targulian, V., and Orlov, D. . S. (1991). Soils: In the Earth as Transformed by Human Action, edited by B. Turner Cambridge and New York: Cambridge University Press.

11 KEY TERMS AND DEFINITIONS

Salinity: A water-soluble salt accumulates in the soil.

Electrical Conductivity (ECe): a measure of the amount of salts in soil (salinity of soil). It is an excellent indicator of nutrient availability and loss, soil texture, and available water capacity.

Satellite Remote Sensing: the use of satellite-borne sensors to observe, measure, and record the electromagnetic radiation reflected or emitted by the Earth and its environment for subsequent analysis and extraction of information

GIS: A Geographic Information System (GIS) is a computer system that analyzes and displays geographically referenced information. It uses data that is attached to a unique location.

Image Processing: a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it.

Image Enhancement: is the procedure of improving the quality and information content of original data before processing

Supervised Classification: In a supervised classification, the signature file was created from known, defined classes (for example, land-use type) identified by pixels enclosed in polygons