

ASSESSMENT OF WETLANDS AND WASTELANDS IN OBI LOCAL GOVERNMENT AREA OF BENUE STATE, SOUTH CENTRAL NIGERIA

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ABSTRACT

This study assesses wetlands and wastelands in Obi Local Government Area of Benue State so as to determine the impact of man's activities in the environment overtime with the objective of determining the wetland and wasteland in the study area between four epoch periods 1986, 2000, 2013 and 2019, determining the trend of wetland and wasteland coverage between 1986 and 2019 and predict the wetland and wasteland coverage in 2039. Landsat MSS 1986, ETM+ 2000, OLI/TIRS 2013 and OLI/TIRS 2019 were used. The assessment was done during the dry season. ENVI 5.3 was used for composing and subsequent classification of the image and ArcGIS 10.4 was used for visualizing, calculating area covered including the masking out of the study area from the Landsat imagery used. The projection from 20 years time was estimated. The results showed that that wetland feature increased between 1986-2000, 1986-2013, 1986-2019 and 2013-2019 while it decreased between 2000-2013 and 2000-2019. Wasteland on the other hand, decreased from 1986-2000, 1986-2013, and 1986-2019 while it decreased between 2000-2013 and 2000-2019. Generally, the wastelands area covered from 1986-2019 showed a decrease of 1529.280 ha and wetlands area increase of 1530.855 ha and the wasteland projection change rate from 2019-2039 (20 years) was 1213.200 ha (decrease) and wetland was 1215.75 ha (increase). The decrease in wetlands and wastelands in the affected years was as a result of human influence and activities in the study area.

Keywords: *Assessment • Prediction • Change Detection • image classification • Projections •*

INTRODUCTION

One of the major factors that influences land use changes is Population growth. As population increases, the rate of development increases as more land were used to build houses, infrastructural facilities and basic amenities and for agricultural purposes. Pressure on human settlement expansion in an unused land was as a result of Population increase, causing changes in land use thereby favoring human settlements as found by Naibbi et al. (2014). Land use plays a major role in human's life in a way that many disciplines focused on land issues (William and Riebsama, 1993). Land use change is fundamentally a spatial process, resulting from the collective outcome of a myriad of socio-economic, institutional, biophysical and ecological processes (Wu and Wu, 2013). As human activities driven Land use changes, so it significantly affect the food security, global agricultural sustainability and forest product supply systems (Popp *et al.*, 2014). Wetlands and river basins were rated among the most useful plant and animals in the globe. They are the most needful for the development of agriculture, environmental conservation since they have relationship with important ecosystem functions and processes and useful and economically viable products (Ekebuike *et al.*, 2016). Wetlands are well known because of their useful impact on plants and animals in water and have classified and protected according to the Ramsar Convention of 1971, articles 1.1 and 2.1 (Galbraith *et al.*, 2005). One of the significant causes of wetland deterioration and loss is urban use, which occurs in KwaZulu-Natal at Pietermaritzburg in which wetlands are used for road construction and industrial purposes as stated by (Mercer, 1991).

Improper use of wetland such as the use for livestock grazing especially in Limpopo province, leads to destruction of wetland (Dale *et al.*, 2000). Wetlands are converted to drained land for settlement purposes so as to maintain time to time increase in population growth in South Africa. Four important areas of change detection when monitoring natural resources are; discover the changes that have occurred, point out the nature of the changes, determining the area covered by the change and investigating the spatial pattern of the change (Macleod and Congation, 1998). Flood accumulation and spread over, sediments retention and nutrients, aquifer recharge, water quality improvement, aesthetic and educational benefits are functions of wetland (Kindscher, 1998; USEPA, 2009; Obiefuna *et al.*, 2013). Wetland varieties had value to humans, support their livelihoods in many ways by producing large amount ecosystem services which serve as source food for a wide range of species as highlighted by (USEPA, 2011). Landed areas covered by water or area where water present at or close to the surface of the soil annually or at different periods of the year is 'wetland' (Obiefuna *et al.*, 2013) and in terms of spatial extent, could undergo changes and the species diversity of the plants and animals getting their livelihood from the wetland. In the 20th century, worldwide area covered by wetland has decrease between 64-71%, thereby constituting risk to wetland diverseness as alerted by (Davidson, 2014).

Wetland as seen as wasteland by the people was as a result of poor economic values of wetlands, thereby culminating massive destruction of this highly productive resource as opined by (Odiye *et al.*, 2011). Wastelands are known to result from inherent or imposed disabilities related to location, environment, or soil, as well as financial and management constraints (Bal *et al.*, 2018). Wastelands are referred as degraded land and presently laying unutilized (except fallow land) due to essential deformation related to places, environment, soil as well as present financial confinement (National Remote Sensing Agency, 1987). This becomes a major environmental issue posing threats to the existence of human being and surrounding environment (National Remote Sensing Agency, 1987). Increasing in human and animal persuasion on land, provision of food through vegetation and other uses has elongated to areas under high ecological stress and unbearable environment, causing increase in rate of soil erosion and immoderate land deterioration (Bal *et al.*, 2018). Wasteland as "deteriorating land that can be classify under a vegetative cover with logical effort and land also is a degraded land due to inadequate water, soil management and on account of natural causes" (National Wastelands Development Board, 1987). Land degradation due to desertification, salinity of soil, water logging, flooding, droughts, increase in rate of soil erosion due to removal of trees and arbitrary agricultural practices have resulted in the origination of wastelands by (Bal *et al.*, 2018). Their research also opined that some possible reasons for generating of wasteland in the country are as a result of water erosion, wind erosion, water logging, salinization/alkalization, acidification, glacial, anthropogenic etc. Many researches have been carried out on mapping of wasteland using remotely sensed data (Gupta *et al.*, 1998; Nathawat et al, 2010; Sastry *et al.*, 2011; Kumaraswami *et al.*, 2011; Unnamalai and Namasivayam, 2012).

Geographic information systems (GIS) are useful tools used for capturing, detecting, assessing, mapping, and monitoring the wastelands (Bal *et al.*, 2018). Remotely sensed imagery serve as a source of primary data for wetland change detection and used together with reliable and secure data such as topographic maps, coastal navigation charts, soils information, and historic imagery or studies as viewed by (Dahl, 2006). Moreover, determination and description of wetland home by remote sensing image analysis serve as the existence for achieving following wetland status and mode of change (Dahl, 2006). United States and Canada used remote sensing techniques perfectly to detect and observe wetlands (Aldrich, 1979; Lillesand and Kieffer, 1987; Patience and Klemas, 1993; National Research Council, 1995; Tiner, 1996; Dechka *et al.*, 2002; Watmough *et al.*, 2002; and Li and Chen, 2005). The capacity of geoinformation has also been used in Nigeria for wetland studies. The effects of city growth on wetlands deterioration in Eleyele Lake, Ibadan, Southwest Nigeria has been investigated by (Tijani *et al.*, 2011). Spatial changes of wetland of Lagos/Lekki Lagoons, Lagos State, Nigeria was investigated by (Obiefuna *et al.*, 2013). Mmom and Fred-Wagwu (2013) investigated the landuse and land cover change detection in parts of Port

Harcourt City using a GIS. The Spatio-temporal analysis of wetland decrease in the Lagos Coastal region, southwestern Nigeria was examined by (Taiwo and Areola, 2009). Change detection and hydrological consequences in the lower Ogun flood plain was investigated by (Odunuga and Oyebande, 2007). Wetland valuation purposes in Lagos metropolis and Niger Delta, Nigeria were compared Orimoogunje *et al.*, 2009) examined the geospatial mapping of wetlands capability in Ilesa, Southwestern Nigeria.. Geographic Information System is a powerful tool that can be use in handling spatial data at various scales, excess point data such as information based on soil, rainfall, temperature and socioeconomic data and to carry out a combined data analysis on different resources of any country and to be delivered at a favourable outcome for different problems (Bal et al, 2018). Wasteland areas are mapped using geo-rectified SoI topomap and updated on IRS satellite and Google Earth images to identify the change in their categories through GIS software's (Pushpavathi and Basavarajappa., 2009). Remote Sensing technology with limited fieldwork provides an edge to characterize the specific land cover patterns through GIS analysis (Basavarajappa *et al.*, 2013).

MATERIALS AND METHODS

The Study Area

Obi local government area is situated between longitude 8° 8'E and 8° 30'E and latitude 6° 50'N and 7° 10'N. It was created in October 10th, 1996, and located in South Central Benue State. Its headquarters is located in Obarike-Ito. Obi was derived from the Obi stream that move steadily in the area and parts boundary with Ado, Otukpo and Oju Local government areas of Benue State and consists of twelve wards. It covers a landmass of 195 Sq km with a population of 98,550 as at 2006 population census. The people of Obi people communicate in Igede language and their major occupation are farming producing yams, cassava, groundnut, and maize. Major mineral resources present in this local government area are Limestone, Crude oil, Tin Ore, Banxite and Copper.

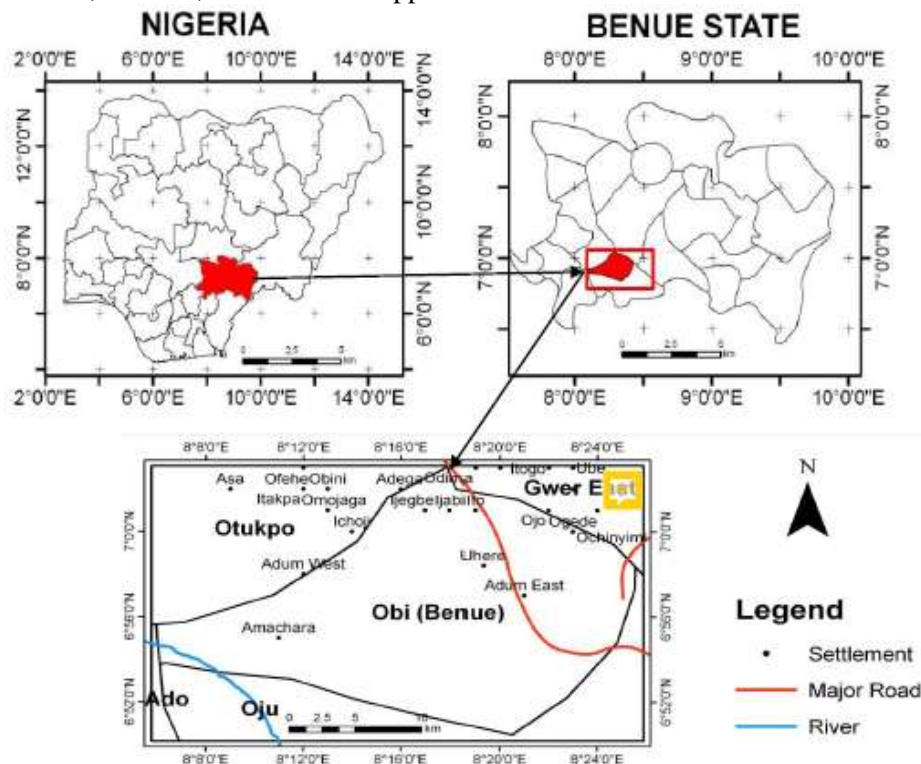


Figure 1: Map showing Settlement within the Study Area

Method of Data Acquisition

For the study, Landsat satellite images of path 188 row 55 covering Benue State were acquired for the four Epochs period; 1986, 2000, 2013, and 2019 with less cloud cover. Moreover, vegetation cover change may directly connect to land use change (Naibbi *et al.*, 2014). Images 1986 and 2000, 2013 and 2019 were obtained from GLCF Earth Explorer and were used for the study. Obi Local Government Area was clipped out using the Benue state administrative boundary shape file obtained from OSGOF. These were brought to Universal Transverse Mercator (UTM) projection zone 32 N.

Table 1: Characteristics of Landsat Satellite Images Used

S/N	Data	Year	Date Acquired	Spatial Resolution	Source	Bands
1	Landsat MSS	1986	14/10/1986	30m	GLCF	5,4,3
2	Landsat ETM+	2000	17/10/2000	28.5m	GLCF	5,4,3
3	Landsat OLI/TIRS	2013	10/11/2013	28.5m	GLCF	6,5,4
4	Landsat OLI/TIRS	2019	10/11/2019	28.5m	GLCF	6,5,4

(Source: GLCF and USGF Earth explorer, 2019)

Methods

Raster Band Composite: The goal of raster band composition is to produce a color composite image from four bands of the Landsat satellite data to allow for display and visual analysis. The Band 5, 4, 3 and band 6, 5, 4 were used to achieve the false color composite.

Development of a Classification Scheme

A classification scheme was developed for this study area and the classification scheme developed revealed where the land use land cover classification was identified by a single digit. For the best false color composite to be achieved, the Optimal Index Factor was used which was based on the amount of total variance and correlation between different band combinations. For the purpose of this study, the supervised classification was performed using the maximum likelihood method and two land cover classes were identified which are the wastelands and wetlands.

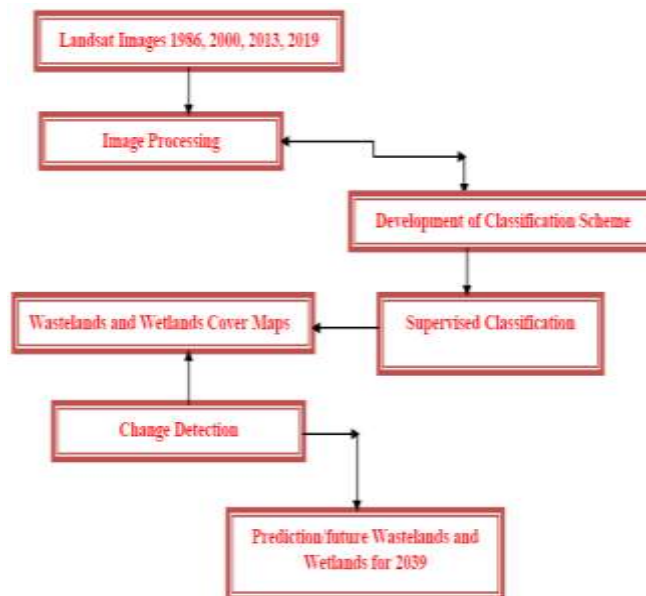


Figure 2: Methodology workflow for the study

Image processing

In this study, the data processing ranged from image pre-processing to image post processing. After the acquisition of the Landsat images MSS 1986, ETM+ 2000 OLI/TIRS (2013 and 2019) from GLCF earth explorer. The images were open in the ENVI 5.3 software environment where operations like layer stacking, mosaicking, pansharpening as well as masking were performed on the image figure (3, 4 (a & b)). The bands 5, 4, and 3 was combined for landsat 4-5 MSS image and ETM+ while the bands 6, 5 were combined for Landsat 8 OLI/TIRS images and are done to prepare and enhance the image for a better

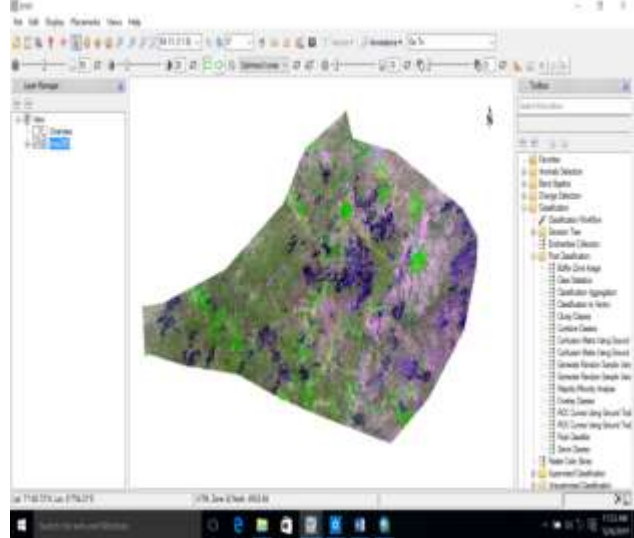
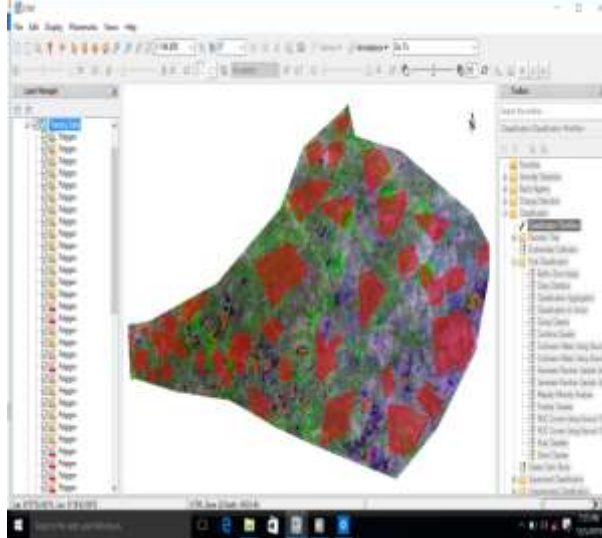


Figure 3a: Image processing for the wetlands 1986 **Figure 3b: Image processing for the wastelands 2000**

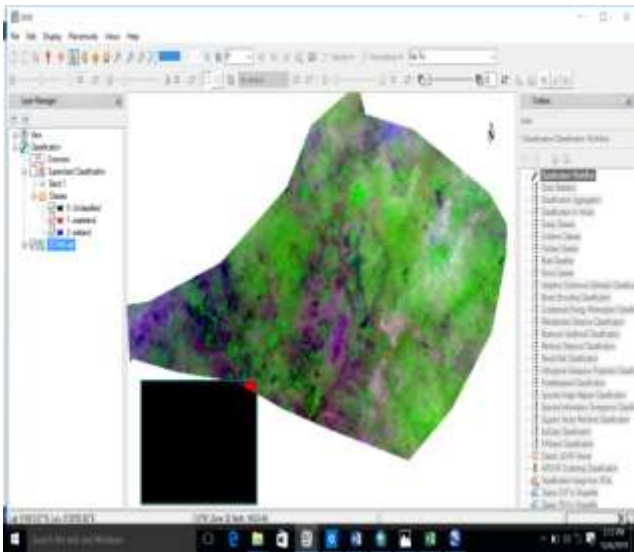
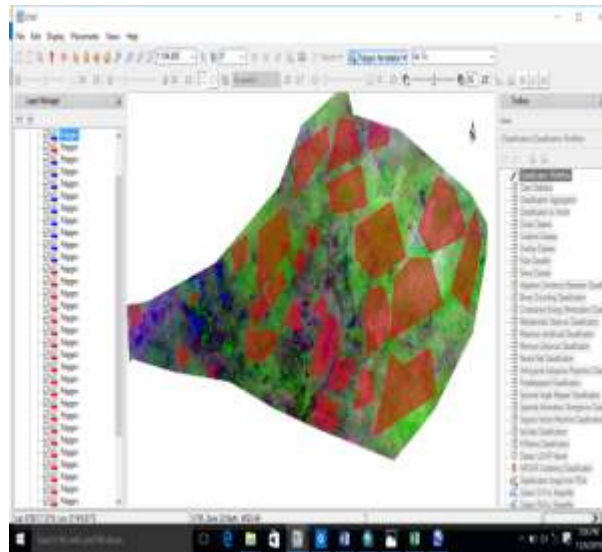


Figure 4a: Image processing for the wetlands 2013 **Figure 4a: Image processing for the wastelands 2019**

classification. Thereafter the classification took place where the supervised method of classification was used. After the classification, the post process operation took place where the change detection analysis was done. Final wastelands and wetlands maps were produced with ENVI 5.3. The prediction of future changes was also done to know how much a feature has changed overtime in chart form using Microsoft

Excel. Area of each image in hectares was computed for both the wastelands and wetlands from their attribute table.

RESULTS AND DISCUSSIONS

The results generated for this study was as a result of image processing and analysis. Figure (5 a & b and 6 a & b) presents the wetland and wasteland cover maps for the period of 1986, 2000, 2013 and 2019 respectively. Table 3 and figure 7 (a & b) shows the land cover statistics for the period studied. Table 4, figure 8 (a & b) describes the Land Cover Change and their Rate of Change. Table 5 and figure 9 describe the Projection Changes in the Next 20 Years.

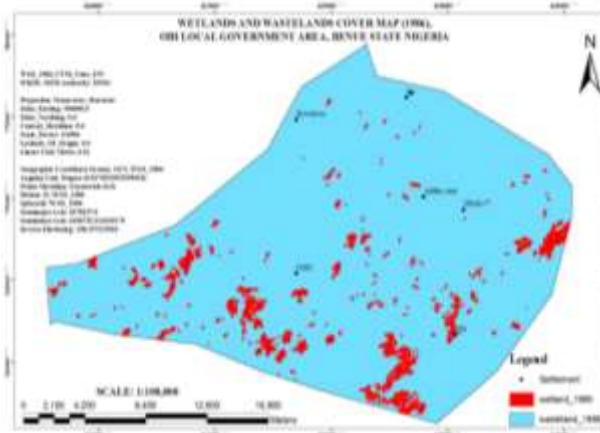


Figure 5a: Extracted from Landsat Image of 1986

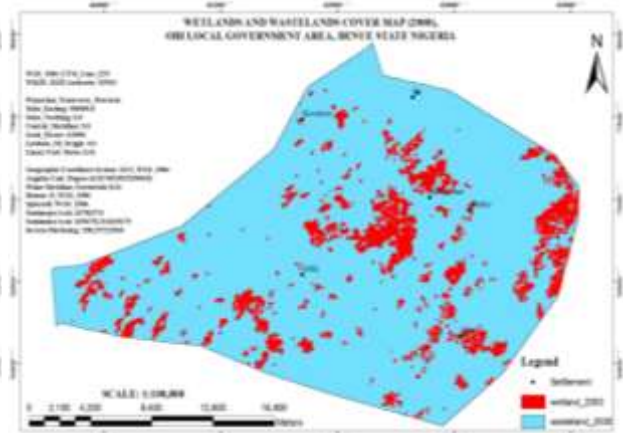


Figure 5b; Extracted from Landsat Image of 2000

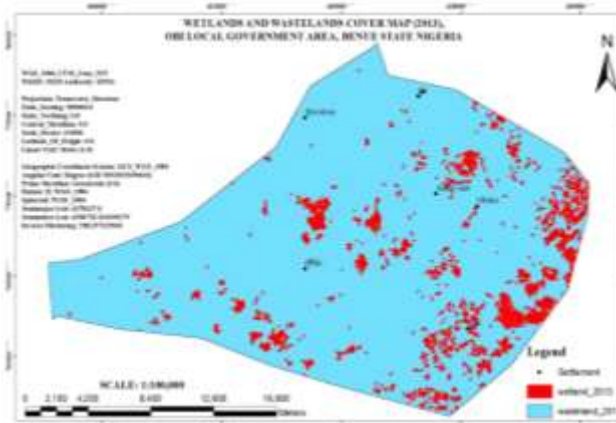


Figure 6a: Extracted from Landsat Image of 2013

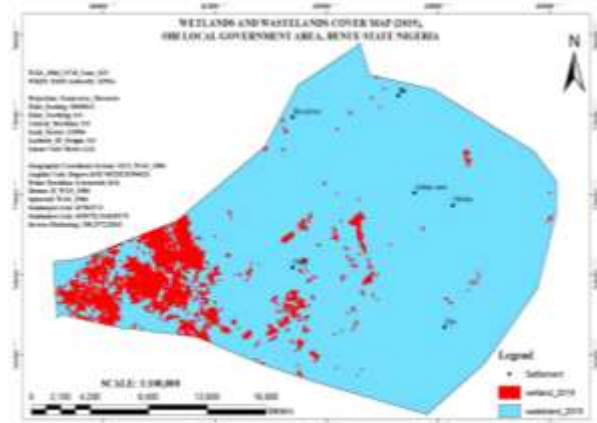


Figure 6b: Extracted from Landsat Image of 2019

Table 2: Land Cover Statistics in 1986, 2000, 2013, 2019

Feature class	Area (1986) Ha	1986 (%)	Area (2000) Ha	2000 (%)	Area (2013) Ha	2013 (%)	Area (2019) Ha	2019 (%)
Wasteland	43665.300	94.83	41157.519	89.39	42499.980	92.30	42136.020	91.51
Wetland	2379.690	5.17	4897.380	10.61	3545.820	7.70	3910.545	8.49
Total	46044.990	100	46044.990	100	46044.990	100	46044.990	100

Note: Ha denote Hectares

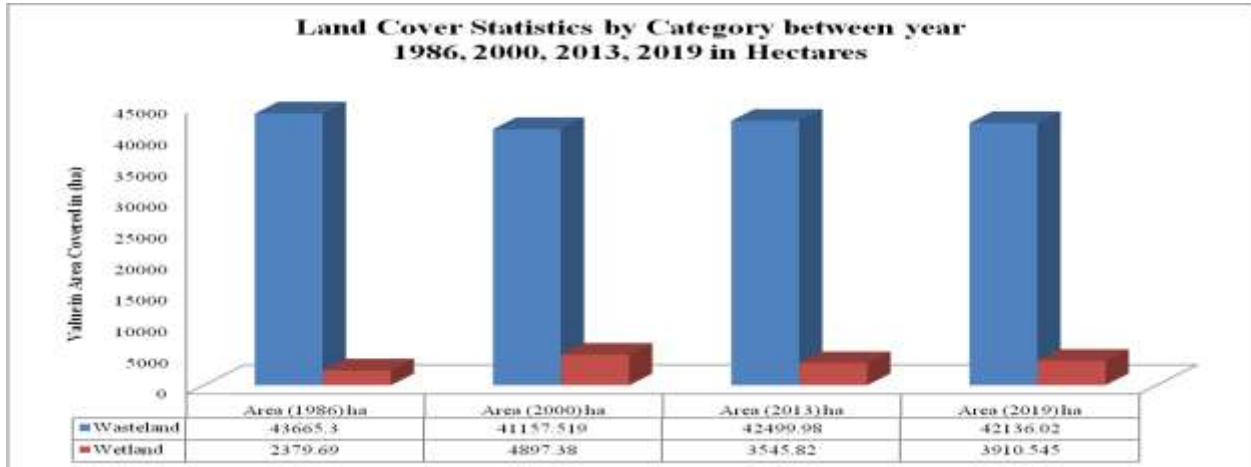


Figure 7a: Wetland Wasteland Area in square meters by Category from 1986-2019

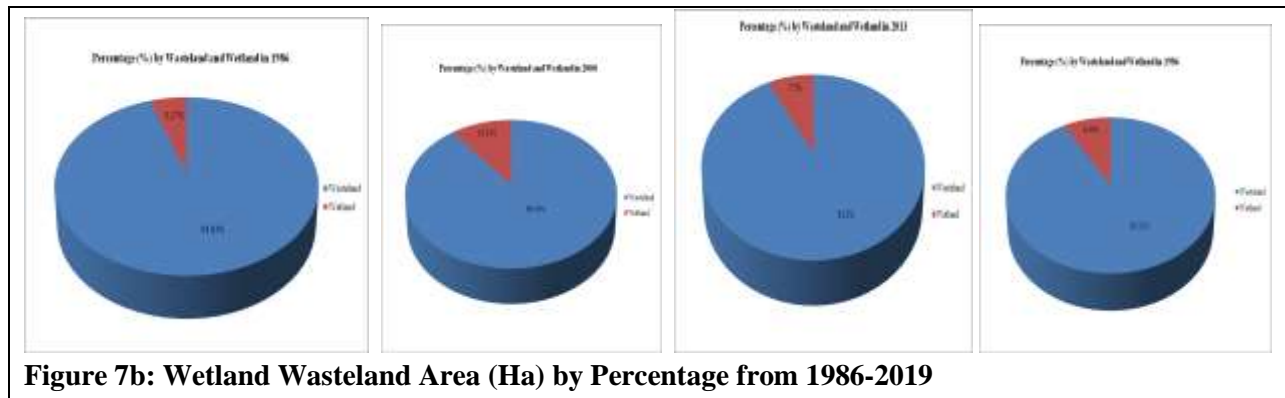


Figure 7b: Wetland Wasteland Area (Ha) by Percentage from 1986-2019

From table 2 and (figure 5, 6, 7 (a & b)) above, it showed that wastelands covers 43665.3 ha (94.83%) between 1986, 41157.519 ha (89.39%) by 2000, 42499.980 ha (92.3%) by 2013 and 42136.020 ha (91.51%). This means that more wasteland is covered in 1986 than 2000 and later increase in 2013 and then reduces again in 2019. Wetlands covers 2379.690 ha (5.17%) by 1986, 4897.380 ha (10.61%) in 2000, 3545.820 ha (7.7%) by 2013 and 3910.545 ha (8.49%) by 2019 which implies that wetlands covers more area in 2000 than 1986 and later reduce from 2000-2013 and then increase again by 2019. The increase and decrease in both the wastelands and wetlands feature can be attributed to human anthropogenic activities within the study area.

Land use/ land Cover Change Calculation

The land use/ land cover change statistics was obtained using the following formulae

- (a) Change between the study years are obtained by subtracting the land cover coverage in square meters of a previous year from a later year.

Equation 1: Later Year – Previous Year

- (b) Rate of Change were obtained by dividing the yearly total change area obtained in (a) by the number of years between the periods

Equation 2:
$$\frac{\text{Change}}{\text{Number of Years}}$$

Table 3: Land use/ Land Cover Change and their Rate of Change (Ha)

Feature class	1986 - 2000	1986 - 2013	1986 -2019	2000 - 2013	2000 - 2019	2013 - 2019
Wasteland	-2507.781	-1165.320	-1529.280	1342.461	978.501	-363.960
Wetland	2517.69	1166.130	1530.855	-1351.560	-986.835	364.725

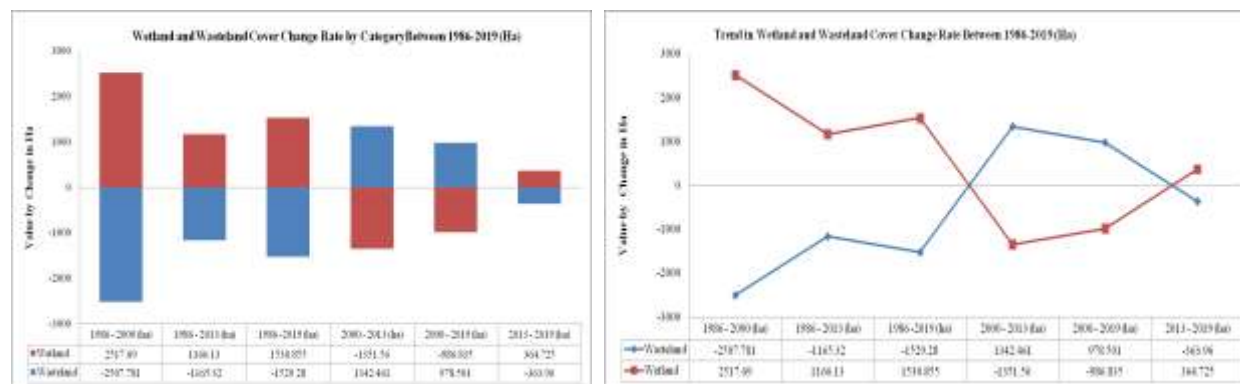


Figure 8: Wetland and Wasteland Area (Ha) by Category and Trend between the year 1986-2019

From table 3 and figure 8 above, it showed that wetland increased in four of the periods compared together. The wetland feature increased from 1986-2000 by 2517.690 ha, 1986-2013 by 1166.130 ha, 1986-2019 by 1530.855 ha and from 2013-2019 by 364.725 ha while it decreased from 2000-2013 by 1351.560 ha and 986.835 ha by 2000-2019. The increase could be due to more human activities involving water bodies such as fishing, agricultural activities etc. Moreover, the extent of human settlements in wetlands is a way of avoiding pressure on existing land use change (Tian *et al.*, 2015). And the decrease could be as a result of the water or wetland areas being converted into bareland or built-up areas. Construction of roads and houses in wetland are now common as this has been practised globally, thereby leading to wetland destruction and loss of biodiversity (Malekmohammadi and Blouchi, 2014). Wasteland on the other hand, decreased from 1986-2000 by 2507.781 ha, 1986-2013 by 1165.320 ha, 1529.280 ha by 1986-2019 and 2013-2019 by 363.960 ha while it increased from 2000-2013 by 1342.461 ha and 978.501 ha by 2000-2019. It was observed that the period in which wetland increased was the same period which wasteland decreased which is also the same for increase in wasteland. This observation is only natural considering there are only two features of interest being discussed. Therefore, where one increases, the other is expected to decrease and vice versa. The same reason given for decrease and increase in wetland could also be given for wasteland. Another reason for the increase in wasteland could be as a result of more farming in the area because the area seems to have a long of grassland as well as vegetative lands.

Projection of Changes in the Next 20 Years

This was done using the formula below,

For the next 20 years;

$$\text{Changes} = \frac{\text{Changes between 2013 and 2019}}{\text{Time differences between 2013 and 2019}} \times \text{Time differences between 2019 and 2039} \dots$$

Area of feature in 2039 = change in Area from 2019-2039 + Area of the feature in 2019...

Table 4: Projection of Changes in the Next 20 Years

Class_Name	Area in Ha (2019)	2019 (%)	Area in Ha (2039)	2039 (%)	Changes in Ha
Wastelands	42136.020	91.51	40922.820	88.88	-1213.200
Wetlands	3910.545	8.49	5126.295	11.12	1215.750
Total	46044.990	100	46044.990	100	2.550

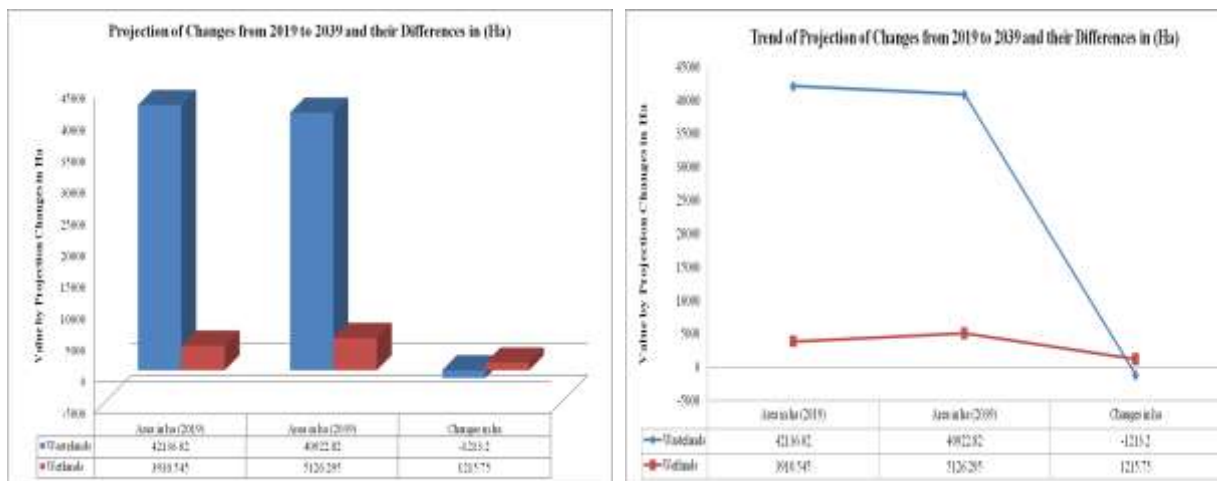


Figure 9: Projection of Changes in the Next 20 Years (2039) for the Wetland and Wasteland by Category

From table 4 and figure 9 above, it showed the projection of 20 years time (2039), then wastelands will cover 40922.820 ha (88.88%) which shows a decrease from 2019-2039 while wetlands covers 5126.295 ha (11.12%) which indicate that more wetland will be gained by 2039 than 2019.

CONCLUSION

This study has assessed the wetlands and wastelands in Obi Local Government Area of Benue State using remote sensing satellite imagery in image capturing and Geographical Information System analyzing Spatial-temporal data. Landsat image 4-5 TM, 7 ETM+ and 8 OLI/TIRS prove to be the best remote sensing image that can be used in classifying and land use and land cover. Post classification comparison of the classified images revealed the expansion pattern of the town in different directions, the transformation of wetlands into wastelands and that of wastelands into wetlands. Most of the changes are due to human activities in the area. There is a possibility of this growth to continue based on the analysis of the changes in the next 20 years that was calculated to observe how each of the features classified would have changed overtime. From the analysis of the findings, based on the projection by 2039, it showed that wastelands area will be decrease between 2019 and 2039 by 1213.200 (ha), while wetland area will be increase by 1215.75 (ha). Focusing on this change, we can draw a conclusion that more wastelands will transform into wetlands in the future.

REFERENCES

Ajibola MO, Ogungbemi AO, and Adenipekun MT (2012). A Comparison of Wetland Valuation Purposes in Lagos Metropolis and the Niger Delta, Nigeria. *Ethiopian Journal of Environmental Studies and Management* 5 (4) (Suppl.1):452-460.

Aldrich, RC (1979). Remote sensing of wildland resources: A state-of-the-art-review. USDA Forest Service, General Technical Report Rm-71, Rocky Mt, Forest and Range Experiment Station, Ft. Collins, Co. 56P.

Bal Krishan Choudhary, Garg, VK and Puneeta Pandey (2018). Applications of Remote Sensing and GIS in Wasteland mapping. Environmental Sciences, Paper No: 6.

Basavarajappa HT, Parviz Tazdari and Manjunatha MC (2013). Integration of Soil and Lineament on Suitable Landfill Sites Selection and Environmental Appraisal around Mysore City, Karnataka, India using Remote Sensing and GIS Techniques, International Journal of Civil Engineering and Technology (IJCIET), 4(6), pp 177-185.

Dahl TE. (2006). Remote Sensing as a Tool for Monitoring Wetland Habitat change. U.S. fish and wildlife service, Branch of Habitat Assessment, Fish and Wildlife Resource Centre, 555 Lester Ave. Onalaska. 8P.

Dale VH, Brown S, Haeuber R, Hobbs NT, Huntly N, and Naiman, RJ et al., (2000). Ecological principles and guidelines for managing use of land', Ecological Application, 10(3), 639-670. <https://doi.org/10.2307/2641032>

Davidson NC (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. Marine and Freshwater Research 65(10):934-941. <http://dx.doi.org/10.1071/MF14173>

Dectika JA, Franklin SE, Watmough MD, Bennett RP and Ingstrup DW (2002). Classification of wetland Habitat and vegetation communities using multitemporal ikonos imagery in Southern Saskatchewan. Can. J. Remote Sensing 28(5):679-685.

Ekebuike AN, Igbokwe JI and Igbokwe EC (2016). Remote Sensing and GIS Mapping of Wetlands of Anambra River Basin, Nigeria. International Journal of Innovative Research and Development. Vol. 5 Issue 10. Pp 85-93

Galbraith H, Amerasinghe, P and Huber-Lee A (2005). The effects of agricultural irrigation on wetland ecosystems in developing countries: A literature review, Comprehensive Assessment Secretariat, Colombo.

Global Land Cover Facility (GLCF) (2019). <http://earthexplorer.usgs.gov>

Gupta, K (1998). Inventory of Degraded Lands of Palamau District, Bihar - A Remote Sensing Approach, Journal of The Indian Society of Remote Sensing, Vol.26, No.4, pp 161-168

Kindscher K, Fraser A, Jakubauskas ME and Debinski DM (1998). Identifying Wetland Meadows in Grand Teton National Park Using Remote Sensing and Average Wetland Values. Wetlands Ecology and Management 5:265-273.

Kumaraswami G Mruthyunjaya Reddy K and Mehar Baba G (2011). Large Scale Wasteland Mapping using IRS P6 LISS IV Data for Integrated Wasteland Development Programmes-A Case Study of Devarkonda Block, Nalgonda District, Andhra Pradesh, International Journal of Earth Sciences and Engineering ISSN 0974-5904, Vol. 04, No 08 - Spl issue, pp. 89-93.

Li J and Chen W (2005). A Rule-based Method for Mapping Canada's Wetlands Using Optical, Radar and DEM Data. International Journal of Remote Sensing, 26(22):5051- 5069. <http://dx.doi.org/10.1080/01431160500166516>.

Lillesand TM and Kieffer RW (1987). Remote sensing and image interpretation. 2nd edition John Wiley and Sons, N.Y. 721P

Macleod and Congalton (1998). A Quantitative Comparison of Change Detection Algorithms for Monitoring Eelgrass from Remotely Sensed Data. Photogrammetric Engineering & Remote Sensing. Vol. 64. No. 3. p. 207 - 216.

Malekmohammadi B and Blouci LR (2014). Écological risk assessment of wetland ecosystems using multi criteria decision making geographic information system', Ecological Indicators 41(1), 133-144. <https://doi.org/10.1016/j.ecolind.2014.01.038>

Mercer DC (1991). Recreation and wetland impacts, conflict and policy issues In Williams wetland a threatened landscape, Blackwell Inc., Cambridge.

Mmom PC and Fred-Wagwu FW (2013). Analysis of Landuse and Landcover Change around the City of Port Harcourt, Nigeria. *Global Advanced Research Journal of Geography and Regional Planning* 2(5):076 - 086.

Naibbi A, Baily B, Healey RG and Collier P (2014). Changing vegetation patterns in Yobe State Nigeria: An analysis of the rates of change, potential causes and the implications for sustainable resource management', *International Journal of Geosciences* 5(1), 50–62. <https://doi.org/10.4236/ijg.2014.51007>

Nathawat MS, Rathore VS, Pandey AC, Suraj Kumar Singh, and Shankar G. Ravi (2010). Monitoring & analysis of wastelands and its dynamics using multi- resolution and temporal satellite data in part of Indian state of Bihar, *International Journal of Geomatics and Geosciences* Volume 1, No 3, ISSN - 0976 – 4380

National Remote Sensing Agency (1987). Manual of procedure for wasteland mapping using remote sensing techniques, N R Sensing Agency, Hyderabad.

National Research Council (1995). Wetlands: characteristics and boundaries. Committee on Characterization of wetlands, Water Science and Technology Board. National Academy Press, Washington, D.C. 268p.

National Wastelands Development Board (NWDB) (1987). National Wasteland Development Board, Description, classification, identification and mapping of wastelands, New Delhi: Ministry of Environment and Forests, Government of India.

Obiefuna JN Nwilo PC Atagbaza AO and Okolie CJ (2013). Spatial Changes in the Wetlands of Lagos/Lekki Lagoons of Lagos, Nigeria *Journal of Sustainable Development* 6(7) 123-133.

Odine AI Shittu AM Ayinde IA and Olubanjo OO (2011). Assessment of the Economic Value of Selected Wetlands in Southwest Nigeria. *Africa Geoscience Review* 18(4) 91-101.

Odunuga S and Oyebande L (2007). Change Detection and Hydrological Implications in the Lower Ogun Flood Plain, SW Nigeria. In Owe, M., & Neale, C. (Eds). *Proceedings of Symposium on Remote Sensing For Environmental Change Detection*. International Association of Hydrological Sciences (IAHS) 316 91-99.

Orimoogunje OO, Oyinloye RO and Soumah M (2009). Geospatial Mapping of wetlands potential in Ilesa, Southwestern Nigeria. FIG Working Sheet 2009. Surveyors key role in Accelerated Development, Eilat, Israel, 3-8 May, 2009.

Patience N and Klemas V (1993). Wetland functional health assessment using remote sensing and other techniques: Literature search. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, SE Fisheries Science Center, Beaufort laboratory, Beaufort, NC. 60P.

Popp J, Lakner Z, Harangi-Rákos M and Fári M (2014). The effect of bioenergy expansion: Food, energy, and environment, *Renewable and Sustainable Energy Reviews* 32(C), 559–578. <https://doi.org/10.1016/j.rser.2014.01.056>

Pushpavathi. KN and Basavarajappa. HT (2009). Remote Sensing and GIS Applications for Wasteland Identification-A case study in Kollegal taluk, Chamarajanagar district, Karnataka, India, *Journal of Environmental Geochemistry*, 12(1 and 2), pp 13-18.

Sastry VJ Babu CH Mehar G, Baba and Mruthyunjaya Reddy A (2011), Change Detection in Wastelands using Remote Sensing and GIS Techniques for SPS Nellore District, Andhra Pradesh, *International Journal of Earth Sciences and Engineering* ISSN 0974-5904, Vol. 04, No 08 – Spl issue, December 2011, pp. 82-88, Cafet-Innova Technical Society.

Taiwo OJ and Areola O (2009). A Spatial Temporal Analysis of Wetland Losses in the Lagos Coastal Region, Southwestern Nigeria, using Multi-date satellite Imagery. Paper presented at IGARSS Annual Conference, Cape Town, South Africa, Sept. 2009 3:111-928

Tian B, Zhou YX, Thom RM, Diefender HL and Yuan Q (2015). ‘Detecting wetland changes in Shanghai, China using FORMOSAT and Landsat TM imagery’, *Journal of Hydrology* 529(1), 1–10. <https://doi.org/10.1016/j.jhydrol.2015.07.007>

Tijani MN, Olaleye AO and Olubanjo OO (2011). Impact of Urbanization on Wetland Degradation: A Case Study of Eleyele Wetland, Ibadan, South West, Nigeria. *Proceedings of the Environmental Management Conference, Federal University of Agriculture, Abeokuta, Nigeria, 2011*. 434-456.

Tiner RW (1996). Wetlands, In: *Manual of Photographic interpretation, second edition*. American Society for Photogrammetry and Remote Sensing, Falls Church, VA. 2440P.

Unnamalai R and Namasivayam D (2012). Common property resources and land degradation in Tamil Nadu, India, *Land degradation in Tamil Nadu, Indian Journal of Innovations Development*, Vol. 1, No. 2,

United States Environmental Protection Agency (USEPA) (2011). Functions of wetlands. www.epa.gov/wetland, Accessed on the 25th September, 2014.

USEPA (2009). What are Wetlands? *Wetlands*. Retrieved from www.epa.gov/owow/wetlands, Accessed on the 20th November, 2014.

Watmough MD, Ingstrup DW, Duncan DC and Schinke HJ (2002). Prairie Habitat Joint Venture Habitat Monitoring Program Phase 1: Recent Habitat trends in NAWMP targeted landscapes. Technical report series No. 321, Canadian Wildlife Service, Edmonton, Alberta, Canada. 93P.

William P and Riebsama W (1993). *Land, food and rural development in North Africa*, West View Press, San Francisco, CA.

Wu J and Wu T (2013). Ecological resilience as a foundation for urban design and sustainability, in S.T.A. Pickett, M.L. Cadenasso & B. McGrath (eds.), *Resilience in ecology and urban design*, pp. 211–229, Springer, Dordrecht.