Greener Journal of Environmental Management and Public Safety
ISSN: 2354-2276

Submission Date: 22/08/2016
Accepted: 27/08/2016
Published: 01/10/2016

DOI: http://doi.org/10.15580/GJEMPS.2016.4.082216133

Geospatial Assessment of Vegetation Degradation of Otammiri River Basin, South East, Nigeria

By

Onyebuchi Chinedu
Okeke Henry
Mohammed SO
Abayomi Alaga
Ogbole John

Research Article (DOI: http://doi.org/10.15580/GJEMPS.2016.4.082216133)

Geospatial Assessment of Vegetation Degradation of Otammiri River Basin, South East, Nigeria

Onyebuchi Chinedu, Okeke Henry, Mohammed S.O, Abayomi Alaga, Ogbole John

Cooperative Information Network
National Space Research and Development Agency
Obafemi Awolowo University, Ile Ife.

Corresponding Author's Email: cconyebuchi@ gmail. Com

ABSTRACT

Vegetation assessment is a prerequisite to achieving optimum utilization of the available land resources. Lack of knowledge on the best way to preserve our natural vegetation and economic importance of vegetation has contributed to the degradation of our natural resource (vegetation). This study aims at assessing the level of degradation and changes in vegetation extent and quality of the Otammiri river basin, delineate the basin area and determine the changes in vegetation using geospatial technology. The study was carried out in Otammiri River Basin in South Eastern part of Nigeria. Shuttle Rader Topographic Mission (SRTM) data of 2007 with resolution of 30m and multidate landsat images of 1986, 2001 and 2014 of 30m resolution was obtained from United State Geological Survey (USGS). The basin area was digitized from the SRTM data which enables the delineation of the basin area, converted into a shape file and overlaid on the satellite image to subset the study area. Supervised classification using maximum likelihood was then performed to extract landuse classes in the study area which comprises of vegetation, bareland, waterbody, builtup, wetland and cultivated lands. The results obtained showed that vegetation degradation has occurred extensively for the period of twenty eight years of this study (1986-2014). This was attributed to the high demand of land for settlement as a result of demographic increase, over grazing, slashing and extensive agriculture. Based on the findings, it is recommended that awareness should be taken to the grass root to educate the local farmers and the inhabitants of the study area on the implication of vegetation degradation as well as proving to the researchers the capability of geospatial technology in assessing and monitoring our natural environment.

Keywords: vegetation degradation, river basin, remote sensing, GIS.

1.0 INTRODUCTION

Background

In developing countries where a large proportion of human population depends almost entirely on vegetal resources for their livelihood and major source of sustenance, there is increasing concern for sustainable management of the land resources (particularly natural vegetation) (Hassan and Asima, 2010).

Vegetation is a general term for the plant life of a region; it also refers to the plant cover provided by plants. When there is a decline in the available vegetal biomass, this leads to vegetation degradation and other associated effects. In contrast to deforestation, this has been defined as "the clearance of forest for agriculture or other purposes". Plants are the major source of organic matter and are the basis of bioenergetics functioning of the entire biosphere. In addition, vegetation creates special climatic conditions in the surface layer of the atmosphere, stabilizing role in the energy distribution of a given ecosystem and changes daily and annual variation in temperature and humidity, lowering the amplitude of their oscillations, affect surface and subsurface runoff, the evaporation of moisture, promotes absorption of melt water, improves the treatment of mineral nutrition of soil, and have positive effect on the water balance of land. Also vegetation enriches the soil with organic substances, contributing in the formation and characterization of hydro basin, which are converted with the participation of microorganisms in humus, preserve the water shade and checkmate hydro volume. Considering the listed and many other importance of vegetal resource, the need to measure, study and proffer possible mitigation measures is imperative and cannot be over emphasized.

Vegetation degradation refers to "the temporary or permanent reduction in the density, structure, species composition or productivity of vegetation cover" (Grainer, 1993). Vegetation degradation is also regarded as a reduction in the available biomass, and decline in the vegetative ground cover, as a result of deforestation, overgrazing which contributes majorly to soil degradation particularly with regards to soil erosion and loss of soil organic matter. The term also applies in situations where the reduction is not only in the quantity of biomass but also in quality. Hence, vegetation degradation is the process of lowering the quality of vegetated land.

Vegetation has numerous benefits/roles it plays in a river basin. The root opens up the soil spaces for water retention and drainage, the canopy intercepts rain and reduces the force at which it strikes the ground thereby reducing erosion.

River basin in Nigeria was established in the year 1976 with its objectives to provide water for irrigation and domestic water supply, improve navigation, to engender big plantation farming and also to bridge the gap between the rural and urban centres migration by taking development to the grass root and discourage migration from rural areas to urban areas (www.ewash.com, 2009). Nigeria has eleven (11) river basins created in 1976 by the Federal Government of Nigeria. They include ; the Sokoto – Rima Basin , Sokoto , Hadejia – Jama'are Basin , Kano , the Lake Chad Basin , Maiduguri , the Upper Benue Basin , Markurdi , the Anambra – Imo River Basin , Owerri , the Niger Basin , Ilorin , the Niger Delta Basin , Portharcourt , the Benin – Owena Basin , Benin – City , and the Oshun – Ogun Basin , Abeokuta (www.ewash.com, 2009) within this regional hydro basin other sub-basin exist for.

Due to high demand for land for settlement, industrialization, construction and many anthropogenic activities, Otammiri river basin which is a sub-basin within the regional Anambra-Imo basin has lose its ecological balance and function with adverse secondary succession due to vegetation degradation and other anthropogenic activities thereby exposing the basin to environmental treat and causing decline to the basin such as increase in surface soil temperature and modification of the entire environment thereby causing the basin to undergo depletion.

Remote Sensing and GIS are effective technologies for detecting, assessing, mapping and monitoring vegetation changes. Remote sensing techniques are important in acquiring useful data of the earth with the use of sensors that distort electromagnetic energy. These remotely collected data are analysed to obtain information about the objects, areas and phenomena being investigated (Schowengerdt, 2007; Lillestand *et al*., 2008). Multi-spectral imagery can be used for quantification and monitoring of vegetal resources over time. Remote sensing has proved effective in studying deforestation and changes in vegetation cover. Remote sensing, coupled with GIS and global positioning system (GPS) provides the capabilities to assess the forest degradation time- and cost-effectively, more so in inaccessible areas. It can play an important role in the generation of the forest cover-related information (Kushwaha, 1990; Rathore et al., 1997). Reliable information on vegetation degradation can help in effective management, biomass / carbon assessment and conservation (Souza et al, 2003). It can also be used for fire risk assessment, since degraded vegetation is highly prone to fire (Holdsworth and Uhl, 1997).

Therefore, this study is assessing vegetation change in the Otammiri River Basin between 1986 to 2014 (28 years).

2.0 MATERIALS AND METHODS

STUDY AREA

Location

Otammiri River Basin is located between Latitude 5° 0′ 00″ N and 5º 40′ 00″ N and Longitude 6º 50′ 00″ E and 7º 30′ 00″ E. The river runs south from Egbu past Owerri and through Ihiagwa, Nekede, Eziobodo, Olokwu, Mgbirichi and Umuagwo to Ozuzu in Etche, in the Rivers State, from where it flows to the Atlantic Ocean. The length of the river from its source to its confluence at Emeabiam to Uramiriukwa River is 30 kilometers.

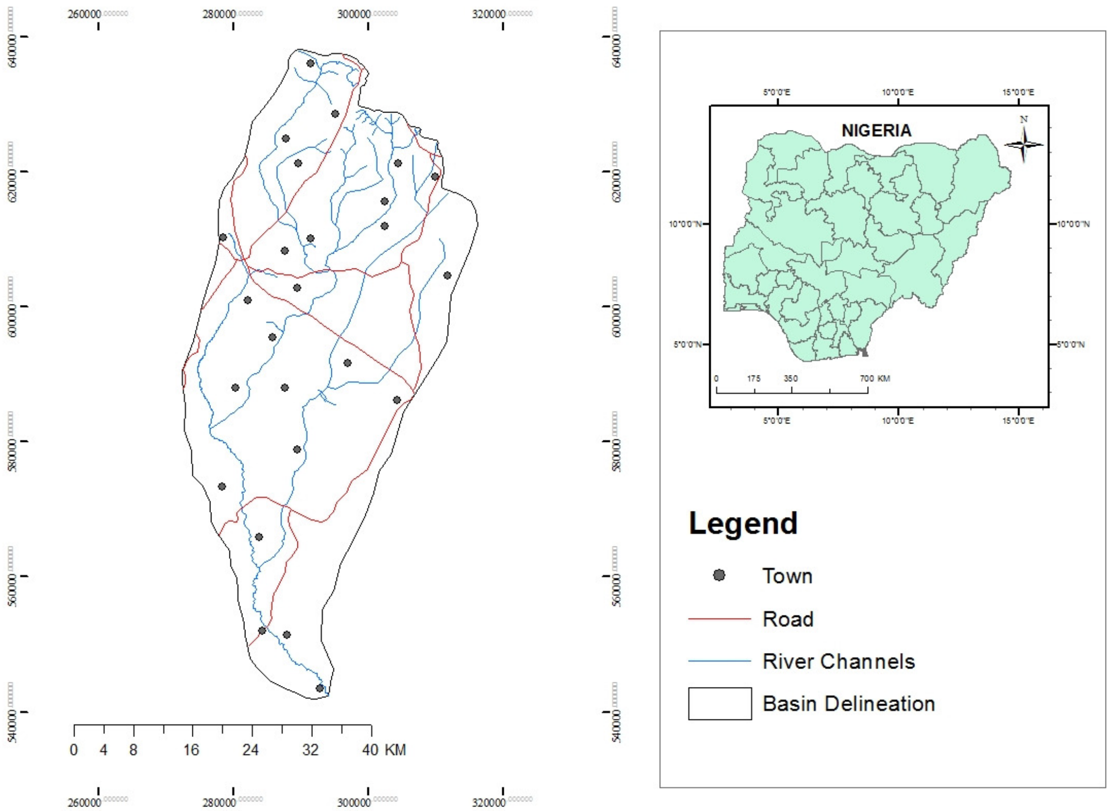

Figure 1: Map of the study area

Relief and Drainage

The area is low lying being generally about 300m above sea level. The main stream draining the study area is the Otamiri River. The area presents a more or less dendritic pattern of drainage. The Otamiri River has the Oramiriukwa stream as its major tributary and at Nekede the Otamiri confluences with the Nworie River. The river is of great significance to the people of Ihiagwa as it serves as a source of water for domestic use, fishing, sand and gravel mining. South of Owerri the river flows through an alternating sequence of sands, sandstones and clay-shales.

Climate and Vegetation

The vegetation and climate of the study area has been delineated to have two clearly different seasons both of which are dry and rainy season (Okoli, 2004). The dry season happens between November and March, while the rainy season happens between April and October. Although the season changes at times as a result of climate change. The region experiences a mean annual temperature of 27 ºC and an annual rainfall of 200 – 300cm with most of the rainfall in the rainy season from April to early November (Iloeje, 1979). The area experiences two air masses – the Tropical Maritime Air mass which originates from the Southern high pressure belts, crosses the equator which picks up moisture from over the Atlantic and enters Nigeria from the South, then ushering in rainy season, and the Tropical Continental Air mass which enters the country from the Northeast and carries little or no moisture and as such is responsible for the dry sea.

Soil

The sands and sandstones are mainly deposits of continental upper delta plain environment. It is predominantly sandy with little shale which is more abundant towards the base. The sands and sandstone are coarse grained pebbles, sub angular to well round and whitish and at times yellowish in colour probably because of limonite coating and bears lignite streaks and wood fragments. As a result of the dense humid forest cover in the area, the soils are generally deep, and sandy as a result of the area being located in a low land area. Soil erosion has caused the populations in the study area to lose its natural resource as erosion flows heavily without any bridge due to incessant dredging of sand happening in this basin which has leads to a lot of gully erosion the study area. There is decrease in arable land and its quality as a result of soil loss and depletion.

METHOD OF DATA ANALYSIS.

3.3.1 EXAMINATION OF THE STUDY AREAS

In order to achieve the objectives of the study, Ground truthing were carried out to acquaint the researcher to the study area (Otammiri River Basin) to know whether the area has actually undergone degradation in vegetation. Also to observe the landuse activities that are going on within the study area as well as landcover so as to know how other landuse features has taken over vegetation in the study area. Comparison was also made from the feature observed in the satellite image to know exactly what is in place during the different time interval of the research (i.e. from 1986 to 2014). Landsat images of 1986, 2001 and 2014 were obtained from United State Geological Survey (USGS). The images were in two scenes (part 188 row 55 and part 188 row 56), radiometric correction was performed to filter the image as well as to enhance visualization. The images were mosaicked together using ERDAS 9.2 software, Layer stacking was performed for all the images using 432 band combinations for all landsat 7 images and 543 for landsat 8 images. The basin area was vectorized and converted to shape file to enable the researcher delineate the basin area. The basin area was then overlayed on the satellite image to enable the researcher subset the study area from the satellite image will. Supervised classification using maximum likelihood was performed to identify the feature classes that were classified, from the landuse classification, six different landuses were identified as follows, Built-up, Bareland, Cultivated land, Wetland, Vegetation and Water body. Composition of the landuse map was then performed in ArcGis 10.1 software. Based on the classification, the change in vegetation was calculated in Microsoft excel by generating the statistical diagram showing the level of degradation in vegetation extent for each of the classes which shows the level of vegetation degradation in the study area over the period of 28 years (1986 – 2014).

DATA TYPE

s/n	Data name	Sheet no/year	format	Resolution/scale	Source
1	SRTM DATA	2007	digital	30m	USGS
2	Landsat image	1986, 2001 and 2014 (P188R56 and P188R57)	digital	30m	USGS

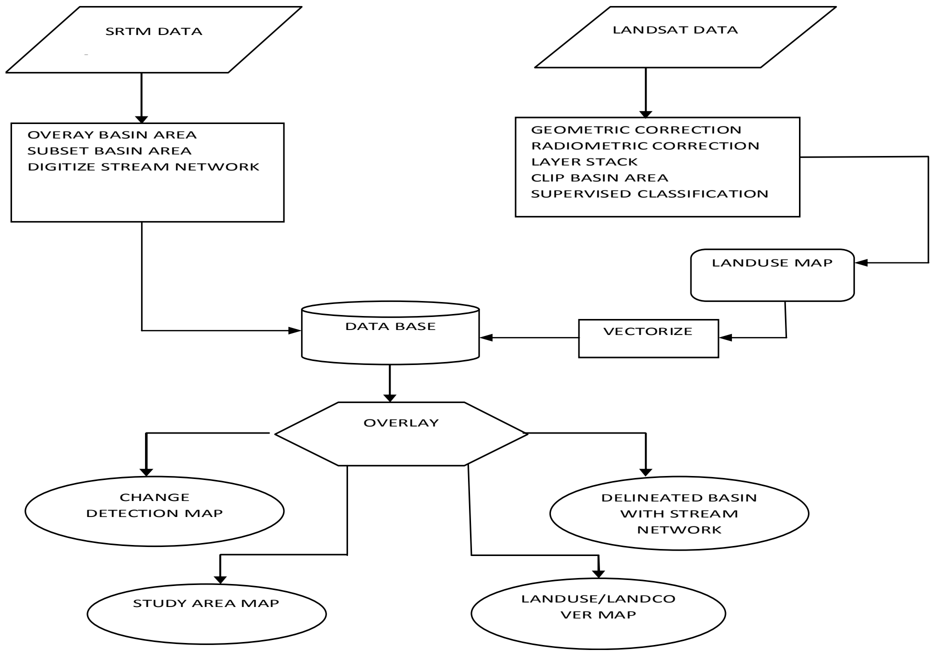

Figure 3: Methodology flow chart

RESULTS

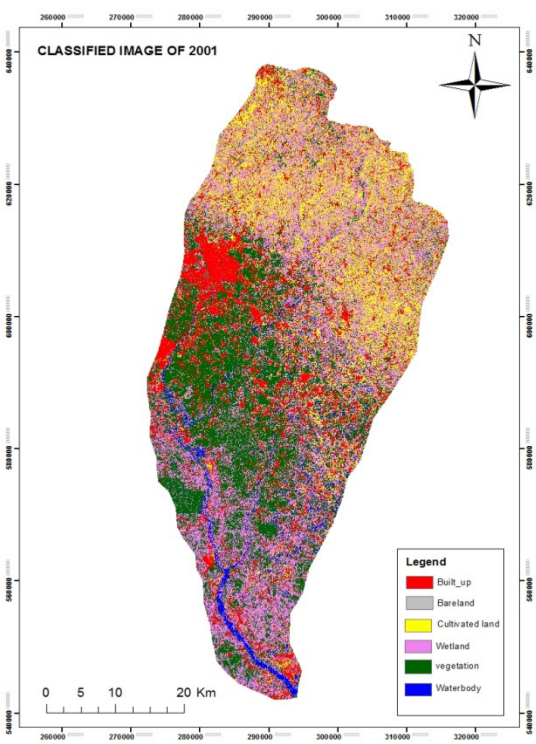

Figure 4: landuse map of 1986.

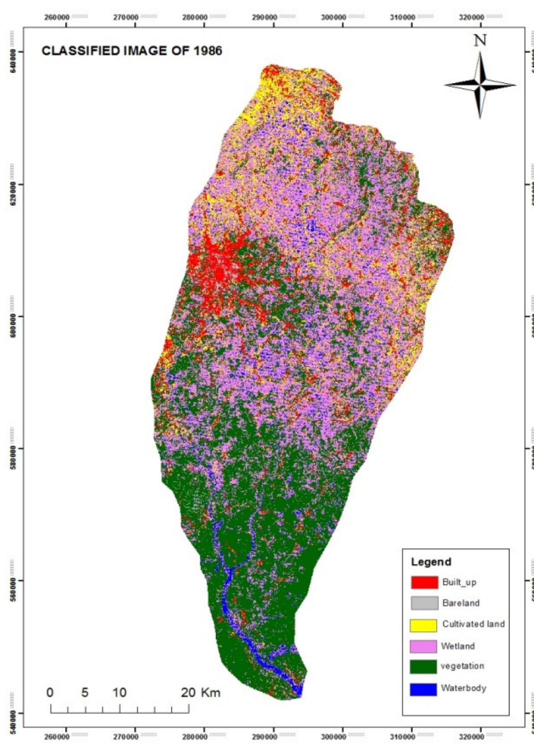

Figure 5: landuse map of 2001

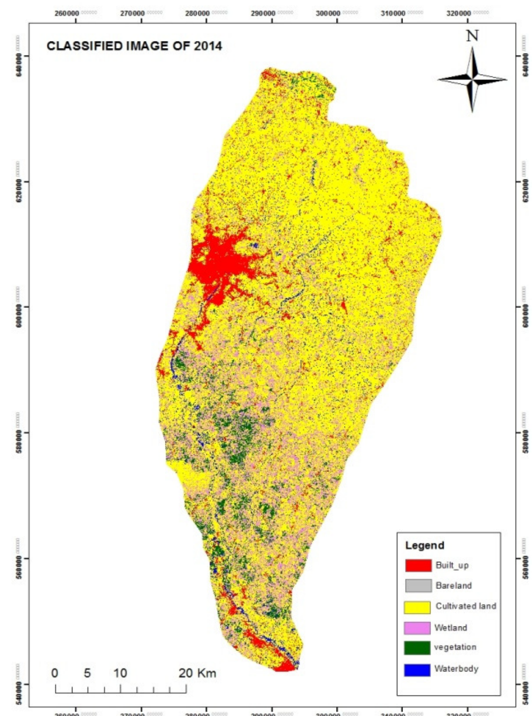

Figure 6: landuse map of 2014

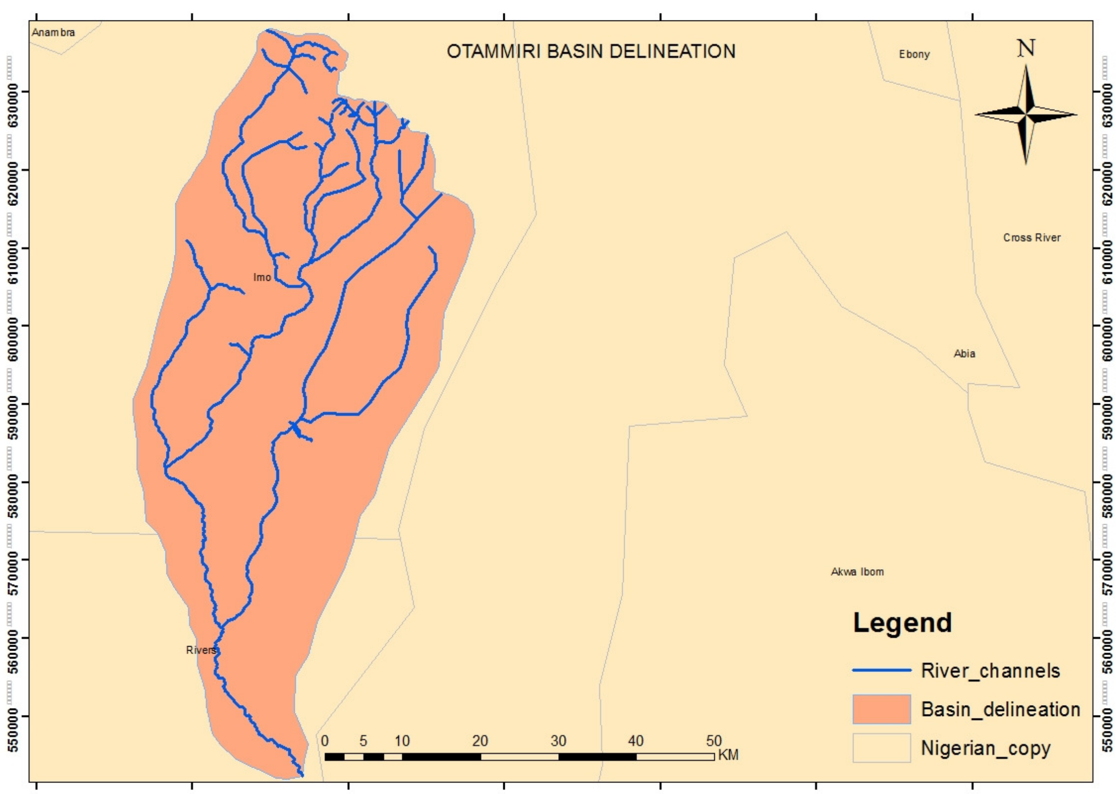

Figure 7: Otammiri delineated basin with drainage network

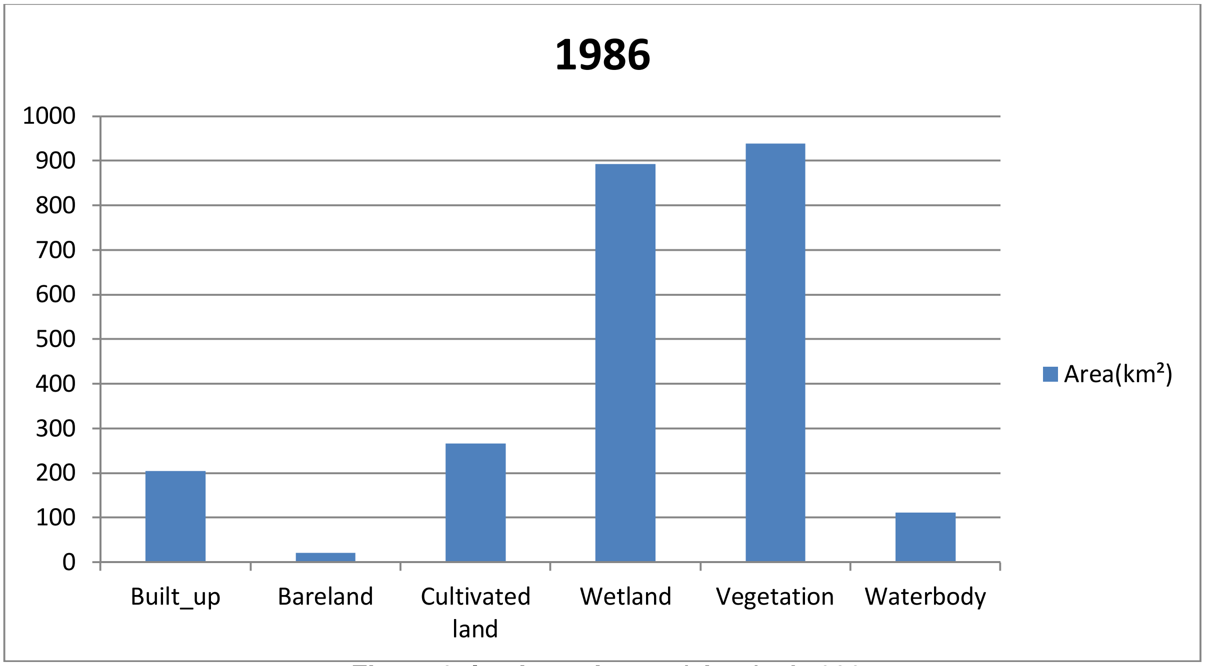

Figure 8: landuse change (chart) of 1986

Table 3: Trends and Landuse Landcover Distribution of Otammiri River Basin between 1986 – 2001

Landuse Classes	1986 (km^2)	2001 (km^2)	Magnitude of Change	Annual Frequency of Change	Percentage of Change
Built-Up	205.01	372.56	167.55	11.17	29.00
Bareland	20.62	423.64	403.02	26.87	90.72
Cultivated Land	265.92	858.95	593.03	39.54	52.72
Wetland	893.07	1.46	-891.61	-59.44	-99.67
Vegetation	938.16	704.71	-233.45	-15.56	-14.21
Water body	110.91	72.36	-38.55	-2.57	-21.03

The Magnitude of Change, Annual Frequency of Change and Percentage of Change analysis highlights the trend and rate of Landuse Changes over the period under investigation. The change reflects how landuse types have influenced vegetation change in the study area.

The Magnitude of Change is calculated using the equation:

Magnitude of Change = $A_2 – A_1$ (Tejuoso, 2006)

Where A_2 is the recent year and A_1 is the old year.

Annual Frequency of Change is calculated using the equation:

Annual Frequency of Change = OC/ ($Y_2 – Y_1$) (Tejuoso, 2006)

Where OC is the Observed Change; Y_1 is the starting year; and Y_2 is the ending year.

The Percentage of Change is calculated using the equation;

Percentage of Change = (OC / ASC) × 100 (Tejuoso, 2006)

Where OC is the Observed Change and ASC is the Absolute Sum of Change.

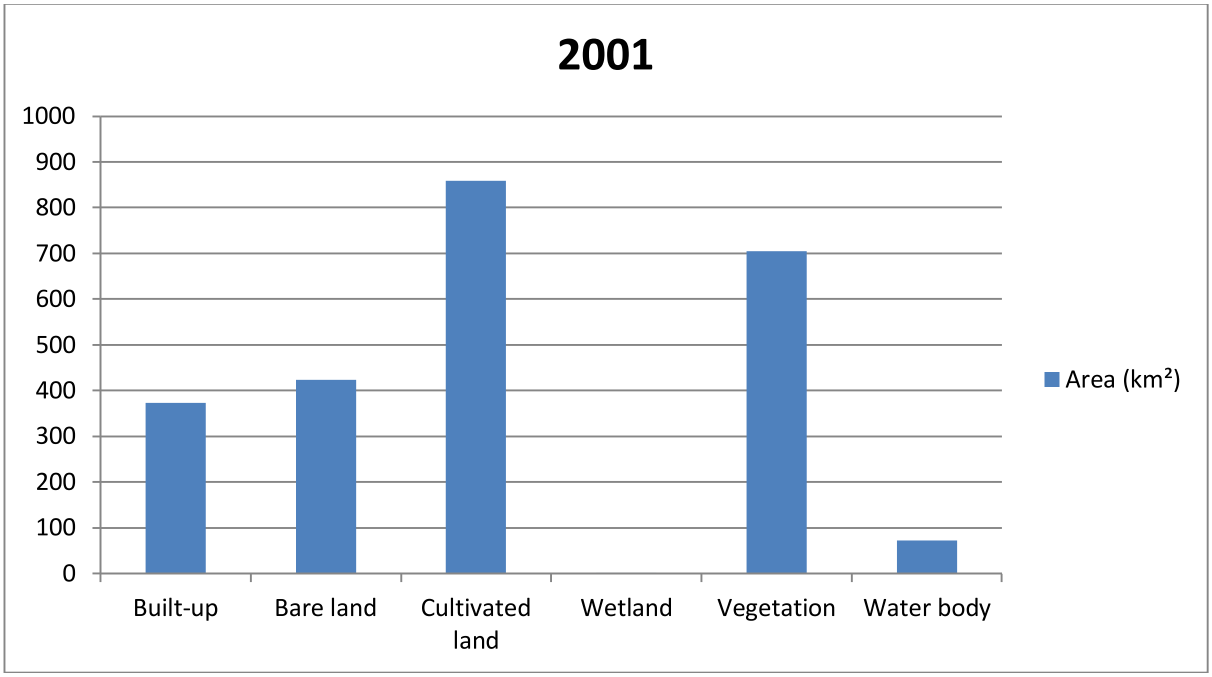

Figure 9: landuse change (chart) of 2001

Table 4: Trends and Landuse Landcover Distribution of Otammiri River Basin between 2001 – 2014

Landuse Classes	2001 (km^2)	2014 (km^2)	Magnitude of Change	Annual Frequency of Change	Percentage of Change
Builtup	372.56	203.45	-169.11	-13.01	-29.36
Bareland	432.64	671.52	247.88	19.07	22.62
Cultivated Land	858.95	187.02	-671.93	-51.69	-64.24
Wetland	1.46	529.19	527.73	40.59	99.45
Vegetation	704.71	157.75	-546.96	-42.07	-63.42
Water body	72.36	119.42	47.06	3.62	24.54

The Magnitude of Change, Annual Frequency of Change and Percentage of Change analysis highlights the trend and rate of Landuse Changes over the period under investigation. The change reflects how landuse types have influenced vegetation change in the study area.

The Magnitude of Change is calculated using the equation:

Magnitude of Change = $A_2 - A_1$ (Tejuoso, 2006)

Where A_2 is the recent year and A_1 is the old year.

Annual Frequency of Change is calculated using the equation:

Annual Frequency of Change = OC/ ($Y_2 - Y_1$) (Tejuoso, 2006)

Where OC is the Observed Change; Y_1 is the starting year; and Y_2 is the ending year.

The Percentage of Change is calculated using the equation;

Percentage of Change = (OC / ASC) × 100 (Tejuoso, 2006)

Where OC is the Observed Change and ASC is the Absolute Sum of Change.

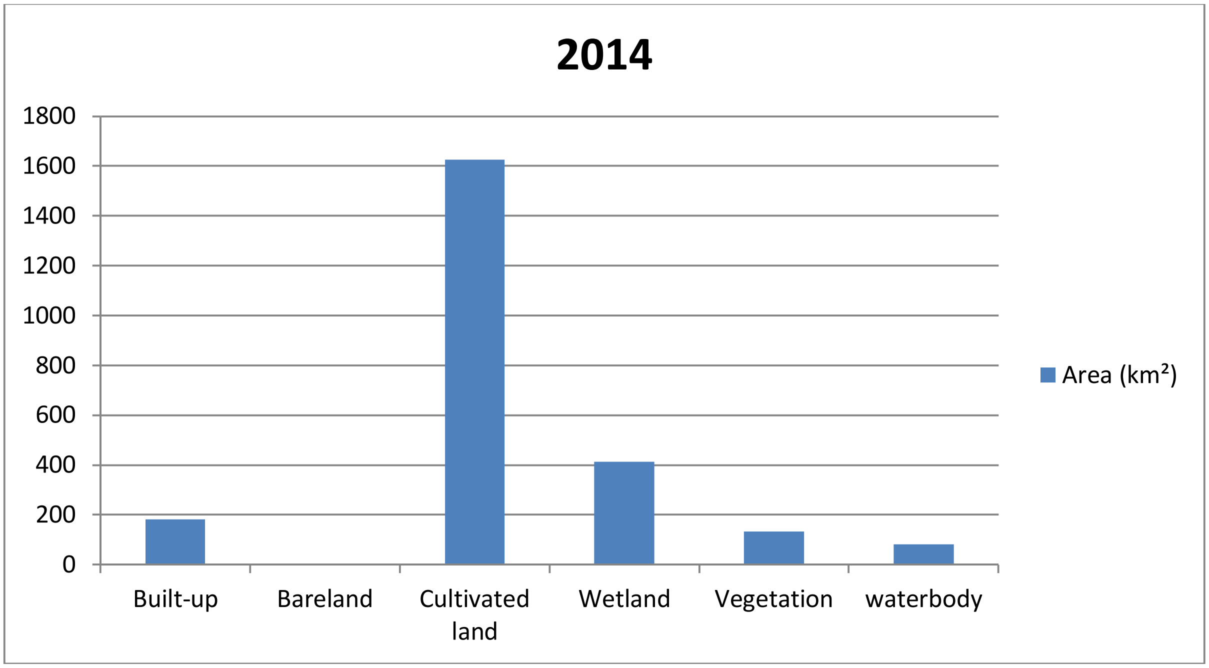

Figure 10: landuse change (chart) of 2014

Table 5: Trends and Landuse Landcover Distribution of Otammiri River Basin between 2001 – 2014

Landuse Classes	2001 (km^2)	2014 (km^2)	Magnitude of Change	Annual Frequency of Change	Percentage of Change
Built-Up	372.56	203.45	-169.11	-13.01	-29.36
Bareland	432.64	671.52	247.88	19.07	22.62
Cultivated Land	858.95	187.02	-671.93	-51.69	-64.24
Wetland	1.46	529.19	527.73	40.59	99.45
Vegetation	704.71	157.75	-546.96	-42.07	-63.42
Water body	72.36	119.42	47.06	3.62	24.54

The Magnitude of Change, Annual Frequency of Change and Percentage of Change analysis highlights the trend and rate of Landuse Changes over the period under investigation. The change reflects how landuse types have influenced vegetation change in the study area.

The Magnitude of Change is calculated using the equation:

Magnitude of Change = $A_2 – A_1$ (Tejuoso, 2006)
Where A_2 is the recent year and A_1 is the old year.

Annual Frequency of Change is calculated using the equation:

Annual Frequency of Change = OC/ $(Y_2 – Y_1)$ (Tejuoso, 2006)
Where OC is the Observed Change; Y_1 is the starting year; and Y_2 is the ending year.

The Percentage of Change is calculated using the equation;

Percentage of Change = (OC / ASC) × 100 (Tejuoso, 2006)
Where OC is the Observed Change and ASC is the Absolute Sum of Change.

DISCUSSION

Based on the knowledge of the study area, reconnaissance survey and additional information from previous studies in the area, a classification scheme was developed after Anderson *et al,* (1976). The scheme gives a broad classification where each of the landuse classes was identified. The classification of the image was carried out in ERDAS 9.2 software, which involves creating training areas by using the tool box to make a polygon for each of the landuse class, creating signature editors (the signature editors were selected severally and later merged all of the classes to one class to attain uniformity). These polygons were drawn on the landuse class identified, for example built up class polygon was drawn or chosen in multiple training sites to make sure the training areas are selected across the image(i.e. some other examples of built-up should be found throughout the image). Training areas for other classes were created with the same method. After training the different landuse pixels, the Area of Interest (AOI) and the signature editor were saved and the input and output file were inputted in the modular to perform a supervised classification using maximum likelihood.

This study intends to show the impact of human activities on the Otamiri watershed area, which has made the watershed to be highly degraded in respect to vegetation and show how other landuse types, has taken over the vegetation in the study area. From the study, the entire vegetation in the watershed has been highly degraded, and this result was in line with the findings of Eddins, (2006); the term watershed refers to a ridge that divides areas drained by different river systems. A catchment basin is the geographical area draining into a river or reservoir. The classification of the study area reveals that the vegetations in this basin have been degraded from the analysis.

In the year 1986, the abundance of water body is about 110.91 km², Vegetation is about 938.16 km², cultivated land about 265.92 km², built-up is about 205.01 km², wetland is about 893.07 km² and bare land is about 20.62 km²(table 3). The result reveals how the entire basin area has been in abundance of vegetation and wetland, showing little of anthropogenic activities in the basin area as much people have not encroached the area even though the agricultural activities were occurring in this basin but was strictly for irrigation.

In the year 2001, the abundance of water body is about 72.36 km², Vegetation is about 704.71 km², cultivated land about 858.95 km², built-up is about 372.55 km², wetland is about 1.64 km² and bare land is about 423.64 km²(table 4). The result reveals how the entire basin area has been degraded from its original state in the previous years. The result shows that vegetation, water body and wetland has been affected as built-up, bare land and cultivated land has increase in the study area. This is attributed to increasing population in the study area who now demand more land for settlement, who have also engaged in farming more than in the previous years to enable them feed and survive. It was also recorded that most of the inhabitants within this period are local farmers who now reside close to the basin area for farming purpose. The areas that used to be wetland areas over the last fifteen(15) years has now been taking over by agriculture and built-up there by paving way for deforestation as people come in to build.

In the year 2014, the result shows that the abundance of water body is about 81.48 km², Vegetation is about 132.34 km², cultivated land about 1624.90 km², built-up is about 181.44 km², wetland is about 412.95 km² and bare land is about 0.57 km²(table 4). From the result, there is an increase in water body which is attributed to the dredging of Otammiri River carried out by Governor Ikedi Ohakim administration in 2010. Cultivated land was also on increasing side as the local farmer are making more input year by year together with the dredging which have course them now to cultivate more as the availability of water for irrigation has increased. Most of them now do not move to a certain distance now to get water for irrigation unlike the last decade and three years (in the year 2001). There is also a reduction in vegetation as more cattle are being taken to this basin for grazing because of the abundance in water as a result of the dredging which has influenced the Faluni's to pass through this basin area to enable their cattle feed on regenerated vegetation in the basin area.

CONCLUSION

In this study, attempt was made to assess the level of vegetation degradation on Otammiri river Basin, South East, Nigeria, using geospatial techniques.

The result of the study showed that the degradation in this basin has significant relationship with human negative impact on the basin. The study has shown that all these environmental degradation in and around the watershed of the confluence of the basin area could be attributed to human impact, therefore, since human impact has been so pronounced in the devastation of the study area, efforts should be made by government agencies, NGOs, policy makers and the residents of the area to reduce the impact on the basin. The aim and objectives of establishing river basin in Nigeria should be strictly implemented to enable the sustainability of our river basin.

RECOMMENDATION

However, there is no restriction of agricultural practices as well as building establishments near the river basin areas in Nigeria. Based on the findings; it is recommended that The residents should be educated on the possible consequences of the devastation on the river basin like flooding; erosion and possibly the rivers may go dry thereby causing the animals, economic trees as well as medicinal plants in the basin area to go into extinction. Building development along and around the river basin should be henceforth stopped to avoid further devastation. The agricultural activities going on around the basin area that are not of the aim of establishing river basin in Nigeria should be stopped as well as to reduce pollution effect on the river basin, which will renew the aquatic life of the river basin.

REFERENCES

Adeola A.O., Ogunleye A.J., Ojo L.O., and Aduradola A.M. (2004). Impact of activities on vegetation in Olokemeji Forest Reserve, Nigeria. Global Nest International Journal.

Barredo, J. I. and Sendra, J. B. 1998. Multi-criteria evaluation methods for ordinal data in a GIS environment. Geographical Systems, 313-327.

Campbell, J. B. 2002. Introduction to remote sensing. (3rd ed.), Taylor and Francis.

Chuvieco, E. and Huete, A. 2010. Fundamental of satellite remote sensing, Taylor and Francis Group, New York.

Clarke, K. C. 2001. Getting started with geographic information systems, (3rd ed.), Prentice Hall Series in Geographic Information Science, Prentice-Hall Inc., Upper Saddle River, New Jersey.

Dewan, A. M. and Yamaguchi, Y. 2009. Land use and land cover change in greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanization. Applied Geography, *29* (3): 390-401.

Ejiogu.A, (2009). Gender analysis of Rural Urban Migration in Imo State, Nigeria

Emeghara.E.E, (2010). Evaluation of the Impact of Anambra – Imo River Basin and Development Authority on Agricultural and Rural Development southern Nigeria.

Franklin, S. E. (2001). Remote sensing for sustainable forest management. Lewis Publishers. Boca Raton.

Fundamental of Remote Sensing 1999. Canada centre of remote sensing. http://www.unikiel.de:8080/castle/ch5/s414p010.htm (accessed on 4 October 2007).

Gao, J. (2009). Digital analysis of remotely sensed imagery. New York, the McGraw-Hill Companies, Inc.

Giridhar, M. V. and. Viswanadh, G. K. 2008. Evaluation of watershed parameters using RS and GIS. *Earth and Space Conference: Proceedings of the 11th Aerospace Division International Conference on Engineering, Science, Construction, and Operations in Challenging Environments* 323.

Grainer, A., 1993. Controlling Tropical Forest Deforestation. Earthscan Publications Ltd., London, 310 pp.

Gregorio, A. D. and. Jansen, L. J. M. 1998. Land Cover Classification System (LCCS): classification concepts and user manual, SDRN, FAO, Rome.

Hassan and Asima, 2010. Vegetation Change Detection of neka river in Iran using remote sensing and GIS. Journal of geography and geology. Vol.2 no.1

Landgrebe, D. A. 2003. Signal theory methods in multispectral remote sensing. Hoboken N. J. Wiley.

Lillesand, M. T. and Kiefer, W. R. 2004. Remote sensing and image interpretation. (5^{th} ed), John Wiley and Sons, Inc, New York.

Lillesand, M. T., KIefer, W. R. and Chipman, N, J. 2008. Remote sensing and image interpretation (6th ed). John Wiley and Sons, Inc, New York.

Mather, P. M. 2004. Computer processing of remotely sensed images. (3rd ed), John Wiley and Sons, Ltd.

Meyer, W. B. and Turner, B. L. 1994. Changes in land use and land cover: A global perspective. University Press, Cambridge.

Nwachukwu. (2013). Application of Geographic Information System in sustainable Groundwater Development in Imo River Basin, Nigeria.International journal of Water Resources and Environmental Engineering.

Iloeje, N.P, (1976). A New Geography of Nigeria. Longman Nigeria Limited Ikeja Nigeria.

Key, J., Yang, P., Baum, B. and Nasiri, S. 2002. Parameterization of shortwave ice cloud optical properties for various particle habits. *Journal of Geophysical Research,* 107: 4181-4191.

Okoro B.C, Uzoukwu R.A (2013). Stream Flow Models in Imo River Basin for Regional Water Resources Allocation. International Journal of Engineering and Science.Vol 2, p.p97- 103.

Richards, J. A. and X. Jia, 2006. Remote sensing digital image analysis (4th ed.): An Introduction. Verlag, Berlin, Heidelberg.

Rindfuss, R., Entwisle, B., Walsh, S. J., Prasartkul, P., Sawangdee, Y., Crawford, T. W. and Reade, T. 2002. Continuous and discrete: where they have met in Nang Rong, Thailand. In: Walsh, S. J. and Crews-Meyer, K. (eds.). Linking people, place and policy: A GIS science approach, Kluwer Academic Press, Boston.

James R. Anderson, Ernest E. Hardy, John T. Roach, and Richard E. Witmer, (1976) A revision of the land use classification system as presented in U.S. Geological Survey Circular 671. United States Government Printing Office, Washington.

Sabins, F. F. 1997. Remote sensing, principles and interpretation. (3rd ed). W. H. Freeman
and Company, New York.

Schowengerdt, R. A. 2007. Remote sensing, models and methods for image processing. (3rd ed), Elservier Inc. New York, USA.

Stellingwerf, D. A. and Hussin, Y. A. 1997. Measurements and estimations of forest stand parameters using remote sensing, VSP BV, Zeist, The Netherlands.

Tottrup, C. and Rasmussen, M. S. 2004. Mapping long-term changes in savannah crop productivity in Senegal through trend analysis of time series of remote sensing data. Agriculture. *Ecosystems and Environment*, 103(3): 545-560.

Wilson, J. P. and Fotheringham S. A. 2008. The hand book of geographic information science. Blackwell publishing, Victoria, Australia.

Zhiliang, C., Xulong, L., Xiaochun, P., Zhencheng, X. and Zhifeng, W. 2008. Land use/cover changes between 1990 and 2000 based on remote sensing and GIS in Pearl River Delta, China. *Proceedings of SPIE - The International Society for Optical Engineering*, 7144.

Cite this Article: Onyebuchi C, Okeke H, Mohammed SO, Abayomi A, Ogbole J (2016). Geospatial Assessment of Vegetation Degradation of Otammiri River Basin, South East, Nigeria. Greener Journal of Environmental Management and Public Safety, 5(4): 088-099, http://doi.org/10.15580/GJEMPS.2016.4.082216133