World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Application of Remote Sensing and GIS in Examining The Rate of Urban Expansion in Oyi Local Government Area of Anambra State - Nigeria from 2005-2023

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World Journal of Advanced Research and Reviews, 2025, 26(03), 1419-1428

Publication history: Received on 27 April 2025; revised on 12 June 2025; accepted on 14 June 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.26.3.2301

Abstract

Urban expansion constitutes one of the key agents of land-use change with the impact felt at local, regional and global levels. Such impact includes spatial growth on agricultural lands. This study assessed the rate of urban expansion into agricultural lands in Oyi Local Government Area of Anambra state, Nigeria, using remote sensing and geographic information techniques. Two imageries of Landsat 7 images of 2005 and 2015 and that of Landsat 8 of 2022 Enhance Thematic Mapper (ETM^+) on Path 189 and Row 056 were acquired during the same season to ensure uniform reflectance of geographic features in other to reduce error during image analysis. Layer stacking of the different bands of the images of same spatial location was done using ArcGIS 10.4 software, the images were georeferenced using projected coordinate system (PCS), Universal Transverse Mercator (UTM) coordinate system, Datum World Geodetic survey (WGS) 1984; Northern hemisphere, Zone 32. The findings revealed that from the image classification analysis of 2005, bare surface covers 17.52km^2, farm land covers 35.23km^2, forest covers 41.56km^2 and settlement covers 27.05km^2 of 121.381km^2 of the entire study area. For the 2015 bare surface covered 15.73km^2, farm land covers 19.79km^2, forest covers 32.25km^2 and settlement covers 28.48km^2 of 121.381km^2 of the study area and for the image classification analysis of 2022, bare surface covers 20.96km^2, farm land covered 18.14km^2, forest covers 38.69km^2 and settlement covers 43.57km^2 of 121.381km^2 of the study area. The comparison of these results shows that agricultural land in the study area was lost to urban expansion. From the foregoing, it is recommended that urban spreading to agricultural land should be controlled as this will have serious repercussions on food security.

Keyword: Urban Expansion; Land Use Change; Agricultural Lands; Remote Sensing; GIS

1. Introduction

The process of expansion is a worldwide phenomenon which could be seen in the history of all urban centres'. It is one of the important areas of man's interaction with his environment and appears to have direct effect on the available agricultural lands, and food security. The continued increase in human population, loss of agricultural lands, and the changing global climate are factors that may influence the ability of societies to sufficiently grow food to feed the world's population (Brown, 1995; Bender, 1997).

The world is rapidly urbanizing and it has witnessed a tremendous shift of its population from being predominately urban in the last two decades (categorization of agro-ecological zones Bulletin Vol. 6, P.7, 2000). The world's population is estimated to be 7.01 billion and by the year 2030, more than 60% of this population will be living in urban areas especially in the developing countries, consuming close to three-quarters of the world's natural resources, and generating three quarter of its pollution and waste (Peters, 2000; Redman and Jones, 2005). This growth will require unprecedented investment in new infrastructure and create serious challenges for political and social institutions.

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Urban expansion, according to Manish, Aruna, and Vivek (2012) is the horizontal or vertical outward extension of urban areas over the adjacent agricultural lands; it is a process which consumes many hectares of prime agricultural lands from their surroundings every year. It comes about through the transformation of non-urban land (for example, farmland) into urban land (such as residence, parks, shops and factories). Such a transformation of land is one way, and once transformed, it also involves both the internal reorganization and outward expansion of the physical structure of urban areas which results in loss of prime agricultural farmlands and natural beauties (Shishay, 2011).

Urbanization is particularly rapid in the developing world, where globalization, major economic restructuring and lack or rural employment opportunities are provoking an exodus from rural area to urban centres'. Although much of the focus has been on the growth, infrastructural and environmental problems of megacities (those over 10 million in population), the reality is that most urbanization is taking place in the small to medium sized cities, and not just large or megacities (De Sherbinin and Martine, 2007). These pose numerous challenges to the environment, notably the conversion of agricultural land to urban "built up" areas (De Sherbinin. 2007).

Rapid expansion of urban centres' in the world at large and specifically in developing countries has continued to pose great challenges such that evokes interest from ecologists, planners, civil engineers, sociologists, administrators and policy makers on how much expansion is taking place, the effects on agricultural land and possible solution. The sudden transformation of agricultural land in these areas has posed a serious threat to food scarcity, high cost of living and a lot of criminal activities within the study areas. This study focused mainly on the rate at which agricultural land has been expanded into urban areas.

1.1. Problem Identification

While bad times and difficulties affect the development of a city, good times and economic prosperity aren't always a good thing. All of the processes that transform urban areas have an impact on the people living in them. Housing issues can arise both from growth and decline, especially along low-income populations. Housing affordability and food scarcity are the common problems in growing areas, when demand is high, prices usually increase.

Cities in developing countries are experiencing the most rapid spatial expansion of all regions which is largely a result of necessity, people move to the city in search of better employment and opportunities (Menon, 2004). This leads to an increase in size well beyond the limits of the city, and the preferences of living at the outskirts of the city, with open spaces at reasonable distances from cities. Often, these expansions are situated on agricultural land and lead to urban problems associated with food supplies (Redman and Jones, 2005). Urban expansion is one of the foremost threat facing agricultural lands in Nigeria. It occurs in ever widening bands surrounding large urban centres', it often emanates from disconnected developments and single family homes that are established outside urban areas well beyond city limits, but usually commuting distance to the urban core (Atu, Offiong, Eni, Eja, and Esien, 2012).

Researchers have been concerned about the rate at which rural areas are being transformed into urban areas using remote sensing and geographic information systems. Remote Sensing and Geographical Information System techniques have equally recorded remarkable success in Nigeria's urban growth and dynamics studies. Adebayejo and Abolade (2006) used satellite imageries of 1978 and 1995 and updated topographical maps of 2003 to study urban expansion of Ogbomoso town, Oyo state. While Oyinloye, (2010) studied the spatial growth of Akure, Ondo state using the satellite imageries of 1972, 1986 and 2002. The results of both cities showed that there has been a rapid conversion of agricultural areas to urban (non-agricultural) land uses. Urban expansions of these cities have destroyed fertile agricultural land uses which cannot be recovered; the residential land use continues to spread to and beyond the hitherto distant location relative to the city core.

Olayiwola and Igbavboa (2014) monitored the growth of Benin City between 1987 and 2008 using the contemporary remote sensing and geographic information system (GIS) techniques. The results showed that Benin City was expanding rapidly leading to an inverse spillover effect on the vegetation resources of the area, thus an imminent threat to the micro climate and food production in the area.

Ifeoluwas, Debo, Ahmed and Tobi (2011) in their research employed Remote Sensing and GIS to analyze urban expansion and land use change in Akure Nigeria, using Landsat TM satellite imageries of 1986, 2002 and 2007 combined with administrative and boundaries map; and population data of the area. The changes detection Analysis shows a rapid change in built up and arable land is noted to have increased by more than 30% and the dense forest depleted terribly from about 49.19% in 1986 to 20.29% in 2002, and 15.32% in 2007. Solid minerals discovery, sitting of the Federal University and other tertiary institutions are among the reasons attributed to these changes.

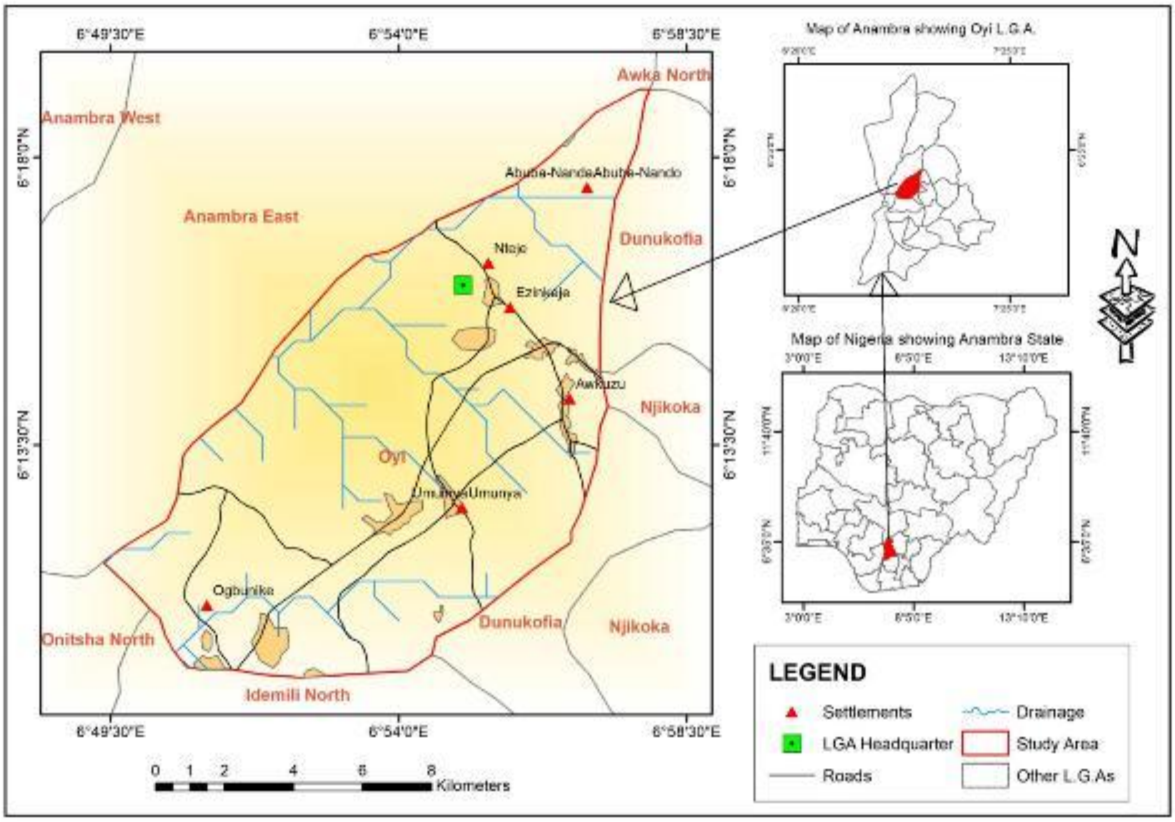
In similar vein, Etim and Dukiya (2013), used questionnaire, remotely sensed images and GIS analysis to assess the level of Abuja's urban encroachment on agricultural land in Kuje area council of FCT. The result reveals that urban encroachment into agricultural land is alarming at the rate of 15.7 km^2 annually, and a total of 509 km^2 of agricultural land have been lost to urbanization within 35 years under review. This encroachment is attributed to the continuous increase in developmental activities of migrants from all over the country which is geometrically increasing the demand for accommodation and other urban needs.

The study area, Oyi LGA, a prominent semi-urban centre in Anambra state has been experiencing tremendous urban expansion since 2010. Developmental activities such as buildings, road constructions, industrial expansions, increased commercial activities, presence of institutions, and various anthropogenic activities over the years has resulted in increased population, landscape consumption, modification and alterations which has affected various land uses in the area most especially the agricultural lands. These land use types tend to contend strongly with agriculture for space, and because they generate higher rents, they always edge out agriculture.

Though, previous attempts have been made to monitor and document the growth of Oyi LGA; in all of these studies as cited in the work, none used Remote Sensing and GIS techniques to assess the spatial dimension of urban expansion on agricultural land. This motivated the interest of the researchers to assess the rate of urban expansion on agricultural land in Oyi LGA, Anambra state.

1.2. The Study Area

Oyi local government area (see figure 1) is situated in the south-east geopolitical zone of Nigeria with its headquarter at Nteje, Anambra State. It is situated about 25 kilometers north-east of Onitsha by land route. Its geographical coordinates are Latitude 6° 10'36'' North and Longitude 6°51'43" East. Oyi has two main seasons, the wet season and dry season with a tropical monsoon climate. It has high temperatures and a lot of rainfall throughout the year.



Source: GIS Laboratory, Abia State University, Uturu – Nigeria.

Figure 1 An insert map of Nigeria showing the study area.

The major soils in the area are alluvial and hydromorphic, they are basically underlain by basement complex of pre-cambrian to upper Cambrian period which have strong influence on their morphological characteristics. The soils have high water table with well decomposed organic matter content. The soil encourages agricultural activities (Fawole, 2009). The natural savannah vegetation broadly consist of rainforest and wooden savannah and its well suited for the cultivation of root crops, grains and wide variety of food crops like yam, sweet potatoes, cassava, maize, beans, rice, sorghum, millet, sugarcane, fruits, vegetables, etc. and rearing of livestock such as cattle, goat, and sheep.

Geologically, Anambra was classified into eight geologic formations that include the Benin (Ogwashi-Asaba) formation, Nkporo/Enugu shale, Mamu formation, Ajali sandstone, Nsukka formation, Imo formation, Ameki formation/Nanka sand and Alluvium. The Ameki formation consists of fossiliferous greyish-green sandy clay with calcareous concretion and white clayey sandstones. The Anambra basin covers an area of about 40,000 km with a sedimentary sequence of 9 km in thickness.

1.3. Research Design/Sources of Data

The two Landsat 7 images of 2005 and 2015 and that of Landsat 8 of 2023 Enhance Thematic Mapper (ETM^+) on Path 189 and Row 056 were acquired during the same season to ensure uniform reflectance of geographic features in other to reduce error during image analysis. Layer stacking of the different bands of the images of same spatial location was done using ArcGIS 10.4 software, the images were geo-referenced using projected coordinate system (PCS), Universal Transverse Mercator (UTM) coordinate system, Datum World Geodetic surveyor (WGS) 1984; Northern hemisphere, Zone 32. This was done to ensure effective pixel to pixel registration between images which helps accurately represent the real world and for efficient image analysis during the overlay processes. Resampling was done using the nearest neighbour algorithm to keep the original brightness values of image pixels unchanged. These images were classified into land use classes which are Settlement, farm land, forest, bare surface Using ArcGIS 10.4 software, which is dependent on the observable features.

2. Methods of Data Collection

Satellite images were acquired using Landsat 7 (ETM^+) for two epochs which are 2005 and 2015 while Landsat 8 (ETM^+) was used for 2022 images. These images were acquired in the same period, to ensure consistency in the classification process as the sensor works on the principles of reflectance of geographic phenomenon.

2.1. Methods of Data Analysis

The methods employed: image analysis; image classification; overlay and polygonising analysis; and statistical representation. The three acquired images for which two are from Landsat 7 and one from landsat 8 (ETM^+) which are 2005, 2015 and 2022 images, with different bands, these bands of the three images were layer stacking using ArcGIS 10.4 for each particular epoch. Each of these images was classified using the same identifiable geographic features/classes which are forest, farm land, bare surface, and settlement.

The acquired satellite images were classified into land use classes which is dependent on the observable features and they are listed as: Settlement (these includes built-up areas like residential and commercial features, educational centers, hospitals, industries, motor roads, religious centers); Farmlands (all cultivated areas such as lands and crop fields); Bare surface (all open bare spaces as well as pitches) and Forest; (these include fallows, tick riparian as well as tick vegetative cover.

Once the geographic features identified from each image are quantified in terms of their classes, the images are paired up for an effective overlay. The classified images of which 2005 and 2015 classified image were been overlaid, while that of 2015 and 2022 classified image were equally overlaid, using the process under overlay analysis known as union in ArcGIS 10.4 Arc-tool box. The outcome of this analysis is polygonised, thus converting it from raster to polygon (vector) so that the change will be identified, quantified and calculated. The quantified/classified image of different epochs were compared in a statistical manner, using graph and table format. This was done using Microsoft excel.

3. Results

3.1. Image classification of 2005

The classified image of Oyi LGA in the year 2005, area covered by the identified geographic features in the fig. 2 below.

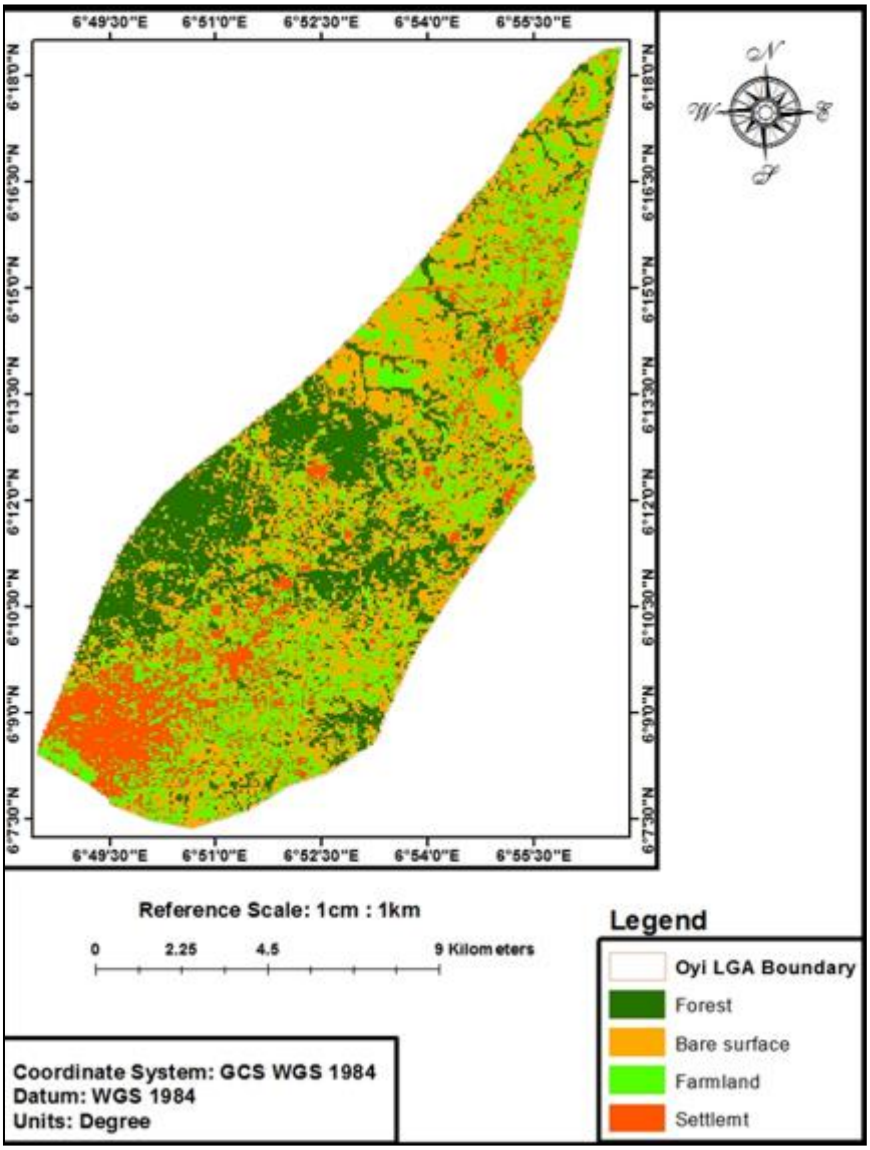


Figure 2 The classified image of Oyi L.G in the year 2005.

Table 1 Area covered by the identified geographic features in the 2005 classified image of the study area

Object ID	LULC Classes	Area Covered			
		Count (pixels)	Square meters (m^2)	Square kilometre (km^2)	Percentage (%)
1	Bare surface	19469	17522100	17.5221	14.44
2	Farm land	21623	35239985	35.239985	29.03
3	Forest	59675	41567530	41.56753	34.25
4	Settlement	34101	27046999	27.046999	22.28
	Grand Total	134868	121376614	121.376614	100.00

3.2. Image classification of 2015

The 2015 classified image of Oyi LGA is shown in fig. 3; identified geographic features in Table 2.

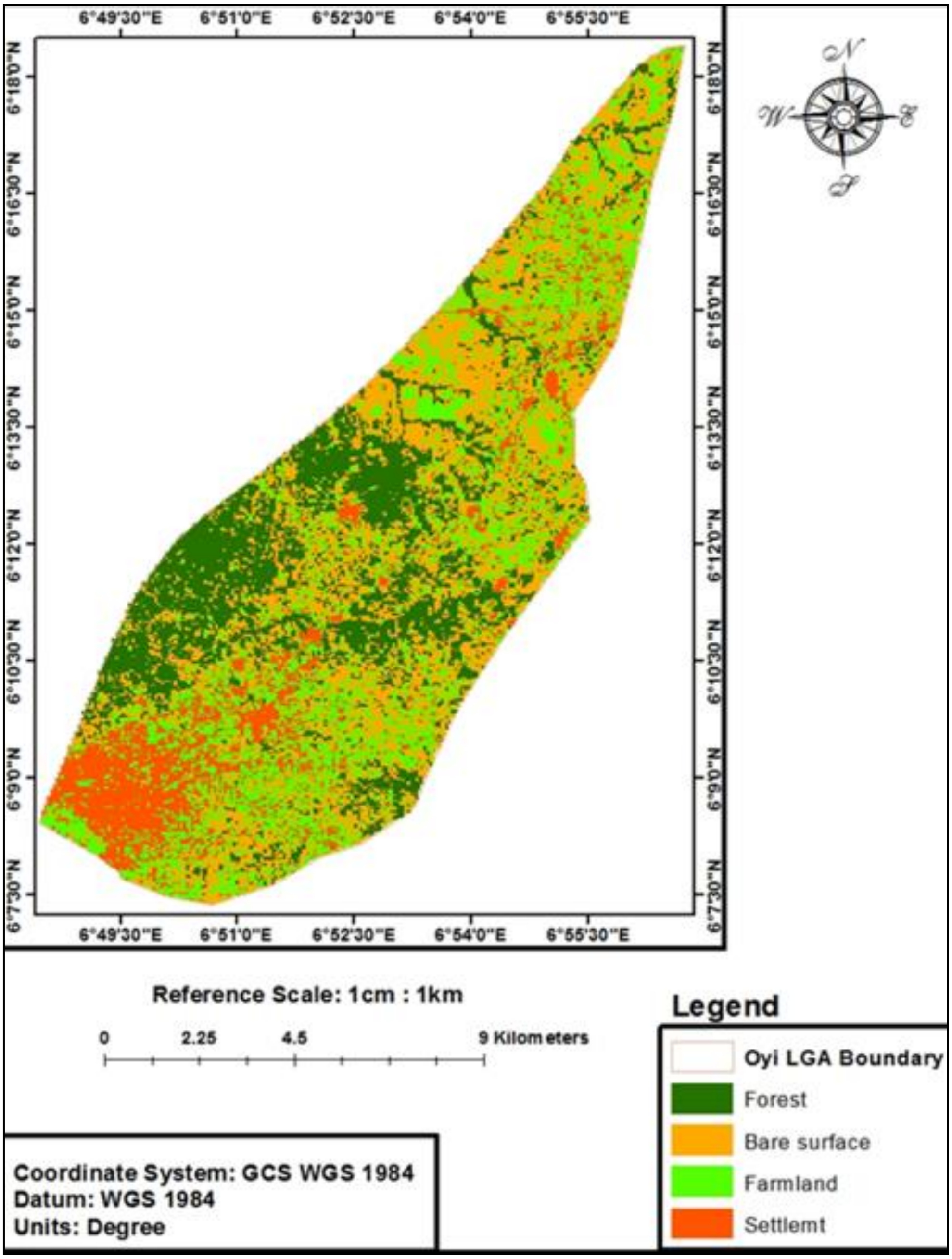


Figure 3 The classified image of Oyi L.G in the year 2015

Table 2 The area covered by the identified geographic features in the 2015 classified image of the study area

Object ID	**Identified geographic features**	**Area Covered**			
		Count (pixels)	Square meters (m^2)	Square kilometre (km^2)	Percentage (%)
1	Bare surface	17479	15731100	15.7311	16.34
2	Farm land	21997	19797300	19.7973	20.56
3	Forest	35838	32254200	32.2542	33.50
4	Settlement	31654	28488600	28.4886	29.59
	Grand Total	134868	121376614	96.2712	100.00

3.3. Image Classification of 2023.

For the year 2023, fig 4 shows the classified image, identified geographic features in Table 3.

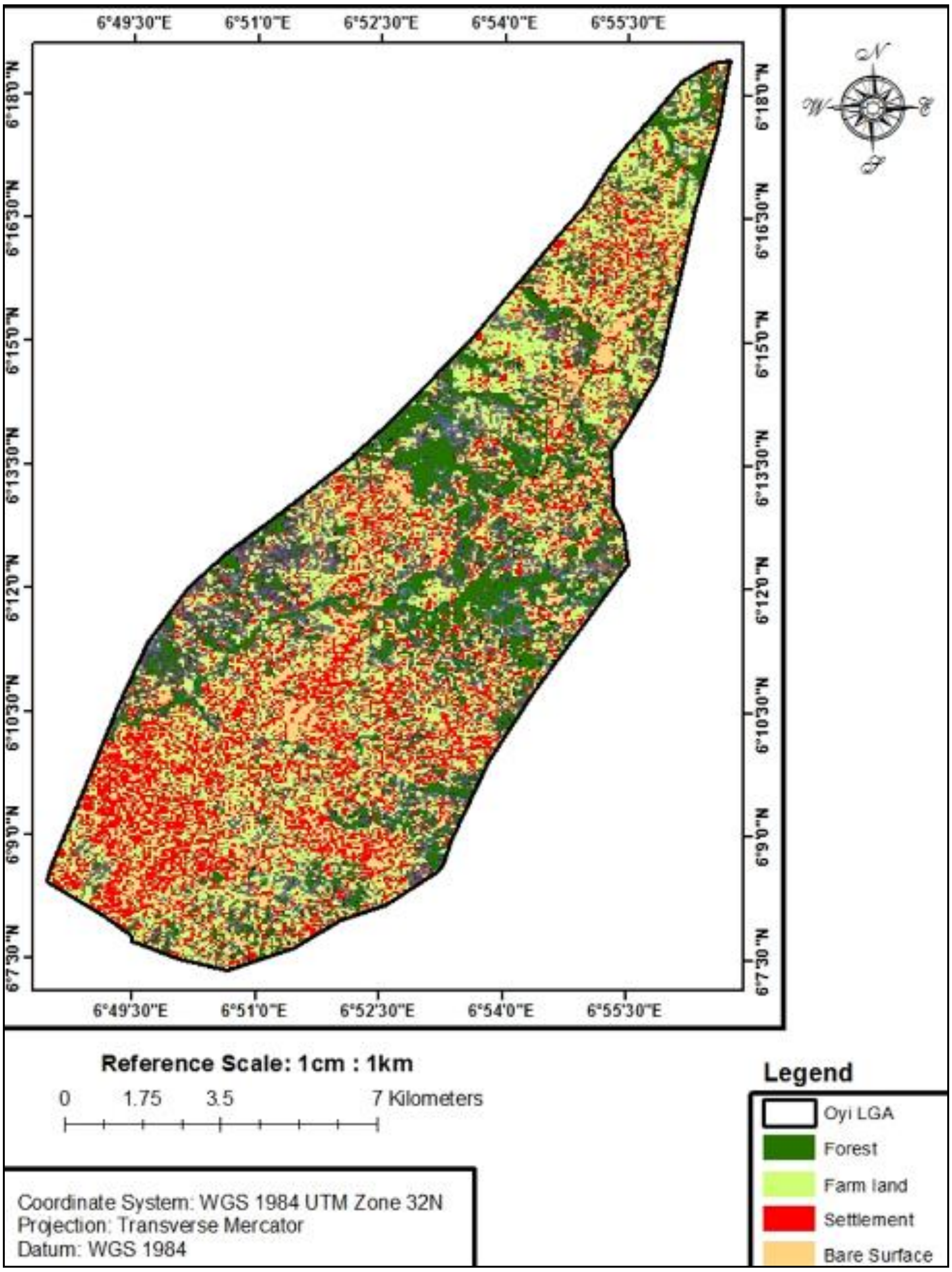


Figure 4 The classified image of Oyi L.G.A in the year 2023

Table 3 Area covered by the identified geographic features in the 2023 classified image of the study area

Object ID	Identified geographic features	Area Covered			
		Count (pixels)	Square meters (m^2)	Square kilometre (km^2)	Percentage (%)
1	Bare surface	23297	20967300	20.9673	17.27
2	Farm land	20160	18144000	18.144	14.95
3	Forest	42992	38692800	38.6928	31.88
4	Settlement	48419	43577100	43.5771	35.90
	Grand Total	134868	121381200	121.3812	100.00

3.4. Classified Images of all epochs and observed changes.

Table 4 Area covered by the identified geographic features from all the classified images of different epochs (2005 to 2023)

S/N	Geographic features	Area covered					
		2005 yr. Data		2015 yr. data		2022 yr. data	
		Km^2	%	Km^2	%	Km^2	%
1	Bare surface	17.5221	14.44	15.7311	16.34	20.9673	17.27
2	Farm land	35.239985	29.03	19.7973	20.56	18.144	14.95
3	Forest	41.56753	34.25	32.2542	33.50	38.6928	31.88
4	Settlement	27.046999	22.28	28.4886	29.59	43.5771	35.90
	Grand total	121.376614	100	96.2712	99.99	121.3812	100

Table 5 The quantified area covered and the changes observed from the identified geographic features for the 2005, 2015 and 2023, classified image of the study area.

Identified geographic features	2005 Classified image	2015 Classified image	Change observed for 2005 & 2015	Percentage of change observed	2015 Classified image	2023 Classified image	Change observed for 2015 & 2023	Percentage of change observed
	area covered (km^2)	area covered (km^2)	area Changed	area changed (%)	area covered (km^2)	area covered (km^2)	area covered	area changed (%)
Bare surface	17.5221	15.7311	1.79	7.13	15.7311	20.9673	5.24	20.85
Farm land	35.239985	19.7973	15.44	61.49	19.7973	18.144	1.65	6.58
Forest	41.56753	32.2542	9.31	37.08	32.2542	38.6928	6.44	25.64
Settlement	27.046999	28.4886	1.44	5.73	28.4886	43.5771	15.09	60.09
Grand total	121.381	121.381			121.381	121.381		100

4. Discussion of the Analysis

The result of the land use/land cover change as was analyzed using unsupervised classification method on ArcGIS 10.4, on the selected epochs of 2005, 2015 and 2023, the geographic features that were identified during the image classification are bare surface, farm land, forest and settlement, of which these selected periods made it a spatiotemporal analysis of 10 and 8 years interval respectively among the selected epochs. These changes involve loss or gain of the area covered by the identified geographic features within the given extent of the study area. Statistical means show that there were both positive/gain and negative/loss of identified geographic features.

5. Conclusion and Recommendation

This study provides insight on the impact of urban expansion of agricultural lands in Oyi Local Government Area, using Remote Sensing and GIS. Attempt was made to capture as accurate as possible the four major land use types in the study area as they changes through time. The study used Remote Sensing and GIS as an analytical tool with satellite images used for mapping and quantifying the land use types, rate and extent of urban growth, spatial loss and conversion of agricultural land to other land uses and urban expansion within the study period. As shown from the classified land use classes, land use types had changed significantly over the period under review (2005 - 2023). The statistics indicated that between 2015 – 2023, the growth rate of built up area occupied the largest share among other land use categories. It shows a rapid decline in forest and farmland. While it is recommended that there is the need to control urban spreading to agricultural land as this will have serious repercussion on food production. Although urban expansion cannot be stopped, with proper management and planning it can be directed in a desirable and sustainable way.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Adebyejo, A. T. and Abolade, O. (2006). Analysis of spatial changes in Ogbomoso city; Journal of the NITP, vol. 19 No.1, 40th Anniversary issue, 35-47

[2] Atu J.E.: Offiong R.A.; Eni D.I.; Eja E.I.; and Esien O.E. (2012). The Effects ofUrban Sprawl on Peripheral Agricultural Lands in Calabar, Nigeria. International Review of social sciences and Humanities vol.2 No.2 (2012), pp. 68-76

[3] Bender, W.H. (1997). How much food we will need in 21st century? Environment 39, 7-11

[4] Brown, L.R (1995). Who will feed China? W.W. Norton and company, New York, New York, USA.

[5] De Sherbinin A. (2007). "Population – Development –Environment Dynamics in the developing world "In de Sherbinin, A., A. Rahman, A Barbieri, J,C. Fotso ,and Y. Zhu (Eds.). 2009. Urban population – Environment Dynamics in the Developing World: Case Studies and Lesson Learned. Paris: Committee for International Cooperation in National Research in Demography (CICRED).

[6] De Sherbinin,A and Martinie, G(2007). Urban population, Development and environment Dynamics, CICRED Policy paper series, paper No. 3 Paris, CICRED.

[7] Etim N.E. and Dukiya J.J. (2013). GIS Analysis of Peri-Urban Agricultural Land Encroachment in (FCT), Nigeria. *International Journal of Advance Remote Sensing and GIS, Vol. 2, issue 1, pp. 303-315.*

[8] Fawole (2007). Constraints to production, Processing and Marketing of sweet-potato in Selected communities in Offia local government Area, Kwara State Nigeria. *Journal of Human Ecology, 22(1), pp 23-25.*

[9] Ifeoluwa A.B; Debo, Z.A; Ahmed, Balogun; and Tobi E.M (2011). "Analysis of urban expansion and land use change in Akure, Nigeria, using Remote Sensing and Geographic Information System (GIS) techniques". *Journal of Geography and Regional planning* Vol. 4(9), pp. 533-541.

[10] Manish K.T., Aruna S., and Vivek K. (2012). Mapping and evaluation of urban sprawl using an integrated approach of Remote Sensing and GIS Technique (Review). International Journal of Advanced Technology & Engineering Research volume 2, Issue 1, January 2012.

[11] Menon, N. (2004). Urban sprawl: *A developing country approach, e-journal ofthe world student community for Sustainable Development, May, 2004 Edition.* www.wscsd.org/ejournal/article=113.

[12] Olayiwole, A.M. and Igbavboa, O.E. (2014). Land Use Dynamics and Expansion of the Built-up Area in Benin City, Nigeria Conference, Asaba, Nigeria. October 18-20, 2005.

[13] Oyinloye, M.A. (2010). Spatial Analysis of Urban Growth in Akure, Nigeria. Unpublished PhD Thesis, Department of Urban and Regional Planning, Federal University of Technology, Akure.

[14] Peters W., ed. (2000). Green Cities-urban Environment solutions, Global Issues-*An electronic journal of the US Department of state.* March 5 (1) 1-39.

[15] Redman, Charles, and Jones, Nancy S (2005). "The Environmental, Social and Health Dimensions of Urban Expansion", *population and Environment, 26(6): 505-520.*

[16] Shishay, Mehari (2006), Mehari (2011). *The Impacts of Urban built-up Area Expansion on the Livelihood of farm Households, in the Peri-Urban Areas of Mekelle City; The capital of Tigray Regional State.* Unpublished Master's Thesis, school of Graduate studies of Addis Ababa University.