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Spatio-Temporal Analysis of Land Use Land Cover Dynamics, a Case Study of Iwo Local Government, Nigeria

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Abstract. The application of land use land cover change analysis in assessment and monitoring of ecosystem resources ensures informed decision regarding environmental and biodiversity protection. This study investigates the Iwo Local Government land use land cover to detect and ascertain the extent of the change for environmental management and policy, and to discern an understanding to relationship between population growth and the land use change. Landsat data was collected from United States Geological Survey (USGS) data repository website and processed using ArcGIS 10.7 software. For further analysis, excel analytical tool was also used to reveal pattern of change in the data. The results showed that there has been significant increase in the built-up area at the expense of loss of vegetation and water body land cover. The study highlights rapid urban growth and human activities, leading to ecosystem changes and potential impacts on biodiversity, carbon emissions, and local climate. It is concluded that the rapid changes in land use land cover of Iwo Local Government needs to be urgently addressed. The study recommends urban forest initiatives and enforcement of environmental laws as urgent actions to address the disappearance of vegetation and water bodies.

Keyword:

Environmental Management, GIS, Iwo LG, Land Cover, Land Use, Remote Sensing

1. Introduction

Land use land cover (LULC) change analysis is central to the recent and modern way of managing and monitoring natural resources and environmental changes. LULC change is an interconnected phenomenon that is highly associated with natural factor, i.e. biophysical, and anthropogenic factor, i.e. socio-economic [1]. These factors bring about climatic change, changes in vegetation cover, alteration in landscape structures, and an increase in CO_2 emission [1,2]. Land cover refers to the natural cover of the earth's surface, which includes water, vegetation, rocks, soil, and the man-made structures [3]. Land use refers to the man's modification of natural land cover, which is greatly influenced by man's basic

needs [2]. The land use and land cover changes are dynamic and well pronounced on the local, regional, and global scales [4]. A 2012 survey in Iwo Local Government (Iwo LG) revealed that residential buildings account for the largest land use in Iwo LG [5]. The global urban residents' growth is the function of increased human activities, which, in turn, changes ecosystem LULC patterns, with significant climatic consequences at all scales [6]. In recent years, increasing population and urban growth have been a major concern that drive research about the natural aesthetic and the built environment [7]. Water bodies have been affected by large-scale land reclamation for urban development [8]. Natural vegetation is being cleared for housing, creating impervious surfaces [8]. Population increase, either through natural growth, i.e. birth rate higher than the death rate or through migration, i.e. immigration higher than the emigration, is well associated with the urban expansion [9]. Urban expansion and other factors related to LULC are significant to ecosystem change. Biodiversity change, animal migration, air quality change, urban heat, and industrialization are strongly connected to urbanization [2,10–12]. Natural land cover and previous land use are replaced with other land use due to urban growth. Urban growth could call for the need to open forest for agriculture or for housing and administrative buildings, or for land conservation for aesthetic reasons and recreational use. Deforestation has been one of the major factors for land cover change and has been the most concerning in Sub-Saharan Africa due to its serious climate change implications [13,14]. Natural resource demand has stressed the natural environment, resulting in deforestation and extended agricultural practices, which are the most significant factors in LULC Change for decades [15]. In Sub-Saharan Africa, population increase as a result of an increase in natural growth rate and rural-urban migration has been a notable phenomenon [9,16]. The United Nations 2024 report shows that Africa's urban population will be doubled in two decades to come [9]. This will lead to an increase in resource utilization and expansion of cities towards their peripherals.

In Nigeria, over the last five decades, notable urban growth and expansion have been observed. Many Nigerian cities have experienced expansion in recent times. In Ebonyi State, a well-pronounced LULC was detected between 1996 and 2018, occasioned by physical expansion and robust transportation development [17]. In Lagos State, LULC was detected between the years 2000 and 2020 as a result of increased urbanization and population growth of Lagos City [18]. In Nguru Wetland, the LULC was detected between 2001 and 2021 with major changes in vegetation cover and loss of biodiversity [19]. There was a notable change in Kwara and Benue State LULC between 1990 and 2020; the results showed that water body, agricultural land, and vegetation land areas had been transformed or converted to built-up and barren land cover [20]. In Niger State, unlike Kwara and Benue, forest land cover is being converted to agricultural land use and built-up areas [20]. In Ila-Orangun, between the period of 1986 and 2018, about 26.36% of forest/vegetation land cover was lost to built-up areas [21]. The built-up area land cover increased by 103.85% at an annual rate of 3.25%, which, in turn, increased agricultural activities by 365.7% [21]. Forest land cover continues to experience decline throughout the study period. In Ado-Odo LG, LULC was observed between 2015 and 2023 with considerable loss of water body and vegetation to the built-up area as a result of urbanization [22]. Iwo LG land cover includes vegetation, built-up area, water bodies, and bare or barren land [23]. The vegetation land cover includes forest, woodland, and teak plantation [23]. The bare or barren land cover includes agricultural land, open land, scanty grasses, exposed rocks, sandy areas, and transitional areas [23]. The water body land cover comprises the surface

water body, such as rivers (i.e., Osun River, Ori River, Oba River and Aiba River) and an artificial lake (Aiba) [24]. A dam was constructed on the Aiba River in 1957 to provide water for Iwo LG [24]. The built-up land cover includes commercial, industrial, institutional, public, and residential building [5]. In Nigeria as a whole country, the settlement land use was 0.6% in 1995 and rose to 8.9% in 2016 [25]. The estimation for bare surface land cover was 2.9% in 1995, and it increased to 10.5% [25]. There is a notable depletion of Nigeria's forest and water body land cover between 1995 and 2016 [25].

The recent technological advancement has made it possible to monitor ecosystems' changes in real time. Application of remote sensing, which involves data collection from aerial sensors, has made it possible to carry out a spatiotemporal analysis of LULC change [2, 23, 26]. Iwo LG is a rich agricultural area about 45 km from Ibadan and Oshogbo [24]. This makes it a major trading centre for cocoa, colanuts, foodstuff, yams, meat, and timber. Iwo LG is the most populated local government in Osun State, with a total land area of 299 Km^2 [27]. Iwo LG has recently witnessed increasing urbanization which is driven by rapid population growth. Iwo LG had a population of 191,377 in the 2006 population census, with an estimated annual growth rate of 2.4, which would put the population around 250,443 by the year 2016 and 283,237 by 2026 [27]. Pressure has been noticed on Iwo LG water infrastructure due to unabated population growth and physical expansion [27]. This study investigates land use and land cover change between 2013 and 2023 in Iwo LG, Nigeria. Investigating the LULC change is relevant to environmental and resource management and policy. This will offer an insight and understanding regarding the change extent and its implication for the environment.

2. Methodology

The research was carried out using satellite imagery. The imagery was downloaded via USGS Earth Explorer. The image type is Landsat collection 2 level 1, which is coded as Landsat 8-9 OLI/TIRS C2 L1. The study area's Landsat satellite imageries for the duration of 2013 to 2023 were queried using the address/place geocoding method with a cloud cover of 10% and 30-meter resolution. The bundle images dated 18 December 2013, 01 January 2019, and 27 December 2023 were downloaded from the global visualization viewer of the United States Geological Survey (USGS). The satellite imageries, known as raster data, were processed using Geographic Information System' (GIS) software, ArcGIS 10.7.1, to identify land use change. The raster data was processed using supervised classification method. Geoprocessing tools like data management tool, spatial analytic tool, and maximum likelihood classification model were used. In Geoprocessing, the satellite imagery bands were composited using raster data composite through a data management tool. This method allows the combination of all bands into a single band known as a natural colour composite band. Then, the symbology tool is applied to give a false colour composite. The subsequent step is to extract the study area false colour composite band. There are several options to do this.

In this study, a spatial analytical tool was used by placing the study area shapefile on the false colour composite, which was later extracted using extract by mask within the spatial analytic tool. Subsequently, the study area image classification was done using supervised classification. In order to do this, a sample training manager was selected, followed by drawing a polygon on the pixel value or spectral signature on the study area extracted from the false colour image. This process allows the classification of the land

cover into various classes. Each group of training samples represents land use land cover classification. Each group of training samples was saved as a signature file. The signature file was used in a maximum likelihood classification tool for change detection on the study area raster image. The results from ArcGIS were further processed using Excel analytical for the analysis of LULC change. In addition, relevant literature was reviewed for the study background and for the discussion purposes. The study area map was produced from the Nigeria administrative map shapefile using the selection tool on ArcMap which was saved as a vector data feature class polygon. This research covers the entire administrative boundary of Iwo LG located in the southwestern part of Nigeria on the coordinates $7^0$38'N and $4^0$11'E (Figure 1).

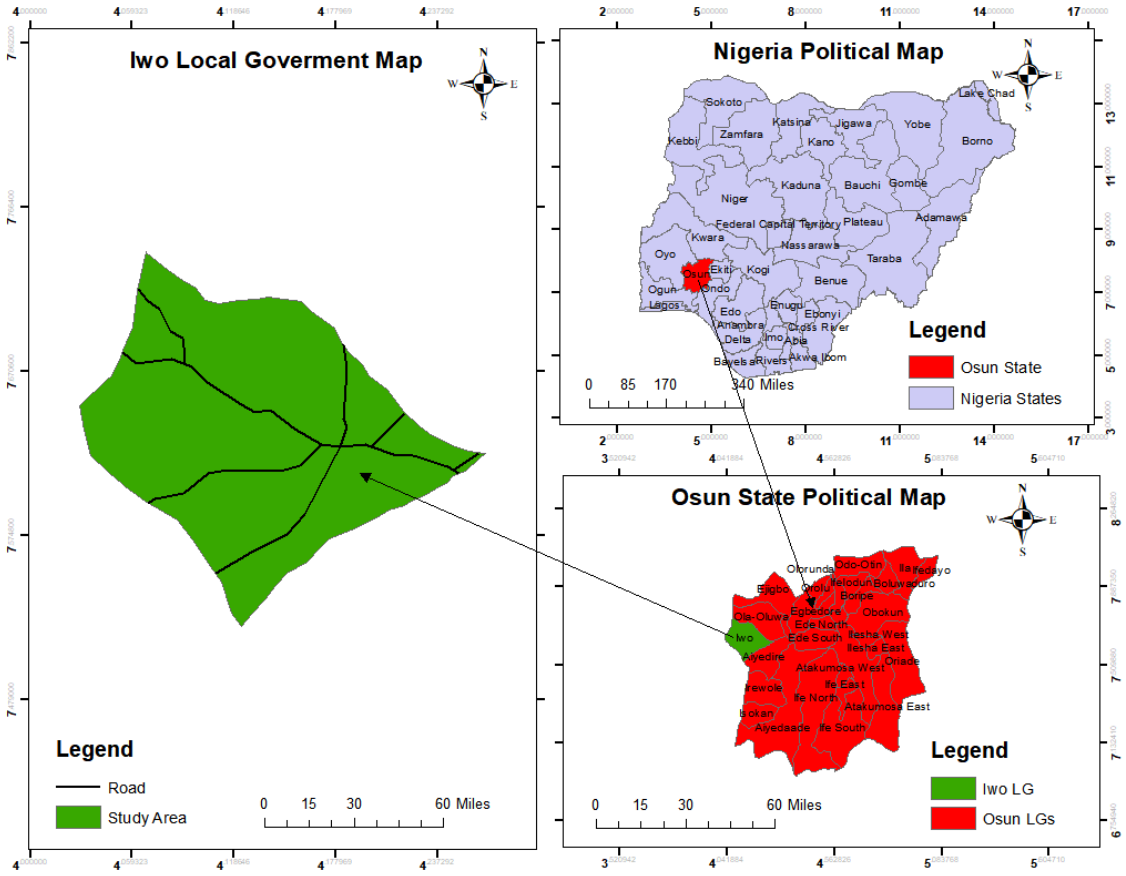

Figure 1. The study area

3. Results and Discussion

The results in Figure 2 below show that there is a significant change in the LULC in Iwo LG between the period of 2013 and 2023. The results show that there has been a rapid disappearance of vegetation, including forestland and woodland. The population increase in Iwo LG supports the significant disappearance of vegetation land cover, which is being overtaken by increased built-Up areas between the period of 2013 and 2023 [27]. Iwo LG has the largest population in the last population census as a result of increased population growth rate and increased migration from surroundings suburbs; consequently, this has reduced the vegetation cover as shown in Figure 2. [27].

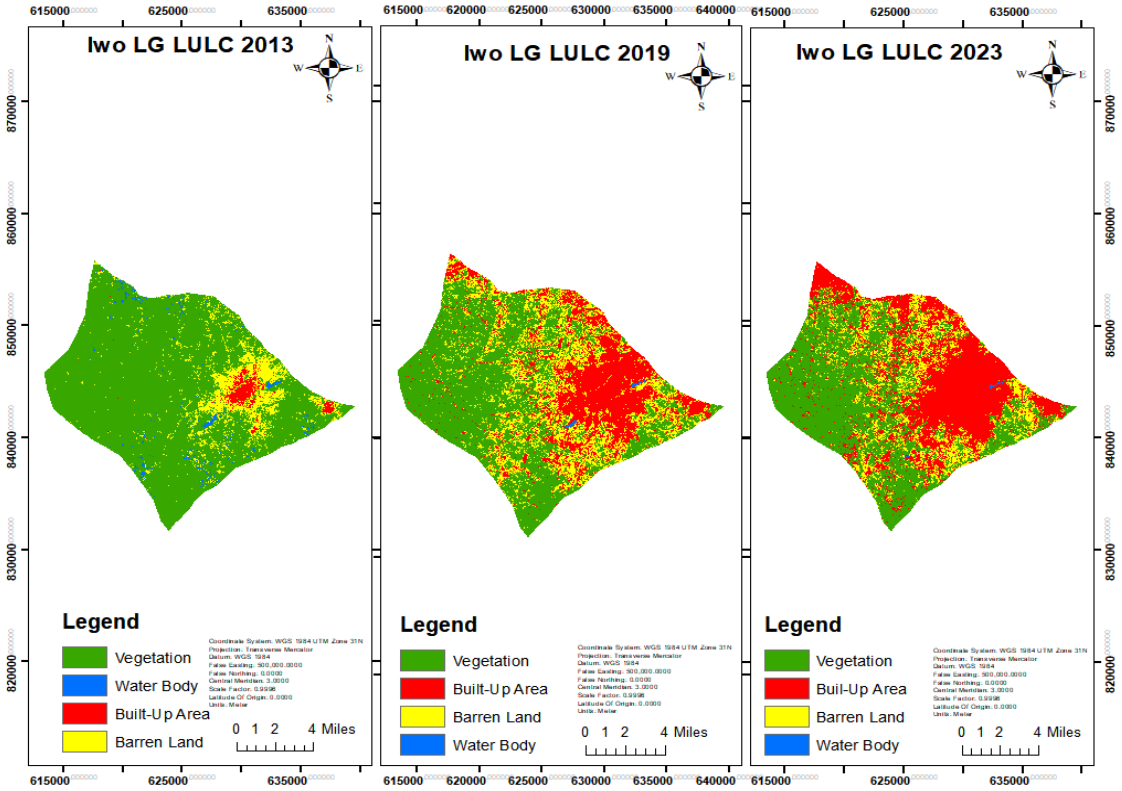

Figure 2. The Iwo LG LULC from 2013 to 2023

This population growth and the resulting economic opportunities reshape urbanization in Iwo LG leading to the disappearance of forestland and woodland [27]. This is similar to Ado-Odo LULC that had a drastic reduction in forest land cover, which is being overtaken by built-up areas between 2015 and 2023 as a result of notable urban expansion and industrialization in the area [22]. Urban expansion in Ado-Odo has been associated with a recent 70% population increase, mostly from nearby towns, as migration due to economic opportunities influences [20]. In Ebonyi State, Lagos State, Nguru Wetland, Kwara State, and Benue State, forest or vegetation land cover has been compensating for the increase in built-up area land cover [17–20]. In the North central the loss of a considerable percentage of thick forest has led to forced migration of farmers with a notable threat to food security [20]. In contrast, increased agricultural land cover was detected in Niger State between 1990 and 2020 [20] and in Ila-Orangun by 365.6% between 1986 and 2018 [21]. In Katsina-Ala, Ila-Orangun, and Niger state, forest land cover compensated for crop land or farming land cover, which differs from Iwo LG, where forest/vegetation compensated for built-up area [17, 19, 28]. The disappearance of forestland has resulted in loss of biodiversity and increased ecological imbalance [10, 12]. The above submissions suggest that the loss of forest ecosystem is largely shaped by the population growth, which could be influenced by both natural growth and migration. Population growth brings about increased economic activities, i.e. forest resources for livelihood, increased demand for shelter, increased energy demand, and increased social cohesion, which exert more pressure on the environmental resources such as forestry. It is noted that both in Niger State and Ila-Orangun, vegetation/forest land cover has been increasingly lost to agricultural land cover. In contrast, the loss of vegetation land cover has been to built-up area land cover in Iwo LG. The scenario in the north central and Iwo LG

pose threat to food security and biodiversity, while the scenario in both Niger State and Ila-Orangun ensure food security but a threat to biodiversity.

The results in Figure 2 also show the disappearance of water bodies such as the Oba River, Aiba River, and Aiba dam between the period of 2013 and 2023. Ogunbode *et al*. [27] opined that unabated population growth is putting undue pressure on water infrastructure in Iwo LG. Therefore, population growth is the function of built-up area and the disappearance of water bodies. There is a strong relationship, on one hand, between population growth and the emergence of built-up areas. On the other hand, between population growth and the disappearance of water bodies land cover. The increase in Iwo LG population has increased built-up areas and subsequently overstressed water body land cover such as the Oba River, Aiba River, and Aiba Dam. The built-up area is not limited to residential buildings but also includes religious buildings and the commercial centres due to the increase in commercial activities in the study area. Iwo LG is known for religious commitment and receives considerable amount of donation from foreign countries for the development of religious houses and centres [29]. In addition, there are notable government development projects in Iwo LG that also change the land use ecosystem in the city. In a similar study, the migration-oriented population expansion in Ado-Odo LG overstressed the water bodies land cover; by 2023 the water bodies land cover had lost 84.3% of its total land cover in 2015 [22]. In Ila-Orangun LG, between 1986 and 2018, water body land cover lost about 50% its size within the study period [21]. In Ebonyi State, the water body land cover remained unchanged between 1996 and 2018 [17]. In Katsina-Ala, water body land cover gained insignificant land cover area, unlike other areas that lost their water body land cover [28]. This suggests an increase in artificial lakes for farming purposes. Increased farming land cover in Katina-Ala brings an understanding to increased water body land cover in the same area. This is due to the fact that farming requires water. Most of these artificial lakes were constructed to harvest water for irrigation farming in a drought-vulnerable area like Katsina Ala. In Lagos city, the water body land cover lost 17.13% of its total size between 2000 and 2020 [18]. It is noted that in both Ebonyi State and Lagos City forest land cover compensated much more for the emergence of built-up areas [17, 18]. In Ebonyi State, water body land cover remained unchanged within the study period. Meanwhile, change is detected in Lagos City water body land cover, with approximately 17.13% lost within the study period. This suggests that development of built-up area in Ebonyi State doesn't stress water land cover, unlike Lagos City, where land reclamation is a well-known practice. Lagos City water body land cover lost a significant amount of its size within the study period. In Iwo LG, the results above show that the change in barren land cover (open land and partly covered scrubland) was so enormous between 2013 and 2019. It suggests that vegetation/forest land cover compensated for this. But, between 2019 and 2023, barren land cover lost about 6% of its land cover while built-up land cover gained more than 6% to its total area cover. This implies that built-up land cover was the cause of the baren land cover loss. In a similar study in Katsina-Ala LG, for a period of 40 years, between 1990 and 2020, bare or barren land cover neither gains nor loses significant cover area [28]. Departing from the various scenarios above regarding bare or barren land cover, if no mitigation measures are taken, the bare land cover will be used for residential, commercial, and religious buildings over time in Lagos City and for farming in Niger State, Katsina Ala, and Ila-Orangun. The bare or barren land cover is not constant in gaining or losing its size. Whichever case depends on several factors such as migration, population increase, agriculture practice, urban growth and development, and economic engagement

[7, 17–21]. Population growth is central to other stated factors. Population growth is the function of economic engagement, urban growth, physical expansion, increased agricultural practices, loss of biodiversity, loss of forestry, and urban heat.

Table 1. showing area and percentage of Iwo LG LULC from 2013 to 2023

Land Use Type	2013		2019		2023	
	Area	Percentage	Area	Percentage	Area	Percentage (%)
Barren Land	32.52	10.85	68.76	22.95	51.13	17.06
Built-Up Area	6.26	2.09	74.24	24.78	109.99	36.21
Vegetation	256.23	85.51	156.1	52.1	138.23	46.13
Water Body	4.63	1.55	0.53	0.18	0.28	0.09
Total	**299.65**	**100**	**299.63**	**100**	**299.64**	**100**

In the table 1 above, results show that a total of 118 km^2 of vegetation cover has been lost between 2013 and 2023, with a large portion of vegetation cover disappearing between 2013 and 2019. On the other hand, the built-up area has sharply increased by 103.73 km^2, occupying a total of 36.21% in 2023 as compared to 2.09% in 2013. However, barren land increased between 2013 and 2019 and later decreased between 2019 and 2023. The above results show that 100.13 Km^2 vegetation was lost to the built-up area and the barren land. In the similar studies, loss of vegetation/forest land cover is prevalent without exception [17–20,28]. What differs is the land cover that gains from the loss of vegetation/forest land cover. In some cases, built-up area land cover gains form the loss of vegetation/forest land cover [17–19]. In some other cases, farmland cover gains from the loss of vegetation/forest land cover [20, 21, 28].

The loss of vegetation in Iwo LG suggests that there is rapid development in Iwo LG at the expense of biodiversity loss. The potential vegetation cover that could have absorbed CO_2 has been lost to built-up ecosystems which, in turn, increases the CO_2 emission and prevalence of urban heat within the local climate and beyond. It is essential to state that vegetation cover plays an essential role in maintaining environmental ecological balance. Continuing degradation of vegetation land cover suggests unsustainable use of land resources. In Iwo LG, between 2019 and 2023, a total of 17.64 Km^2 of barren land was lost to built-up area and not to vegetation. This suggests that there has been more rapid economic development than ecosystem restoration programs in Iwo LG. Similarly, in Ado-Odo, 23.73km^2 of bare land was lost or converted to built-up areas between 2015 and 2023, with a huge loss of vegetation land cover within the same period [22]. [22] opines that this could be because of urban expansion and economic growth influenced by migration-induced population growth. In Nguru, it is opined that forest is being cleared for agricultural land, and it is a common thing among rural dwellers [19]. Waterland cover has also been reduced significantly in the last decade in Iwo LG, Nigeria. Between 2013 and 2019, water land cover lost 4.1 Km^2, which, in turn, has great environmental and economic implications. This is surface water body that is very important for ecological systems, plants and animal species habitat, irrigation, pastoralism, recreation, and among others [30]. The significant

water body disappearance in Iwo LG is well associated with the physical expansion of the city. Water body land cover disappearance is being understood to be due to urban growth (commercial and residential), agriculture activities, landfilling and encroachment [31] Similarly, significant water body disappeared in Rajshahi City between 1996 and 2016 due to urban growth. [30]. About -10.70% per year of water body was lost between 2015 and 2023 in Ado-Odo [22]. In Nguru, about 811.20 hectares of water body per year were lost between 2001 and 2021 [19]. There was a significant loss of water body in Lagos City between 2010 and 2020 [18]. In contrary, water body land cover of Katsina-Ala slightly increased between 1990 and 2000 [28].

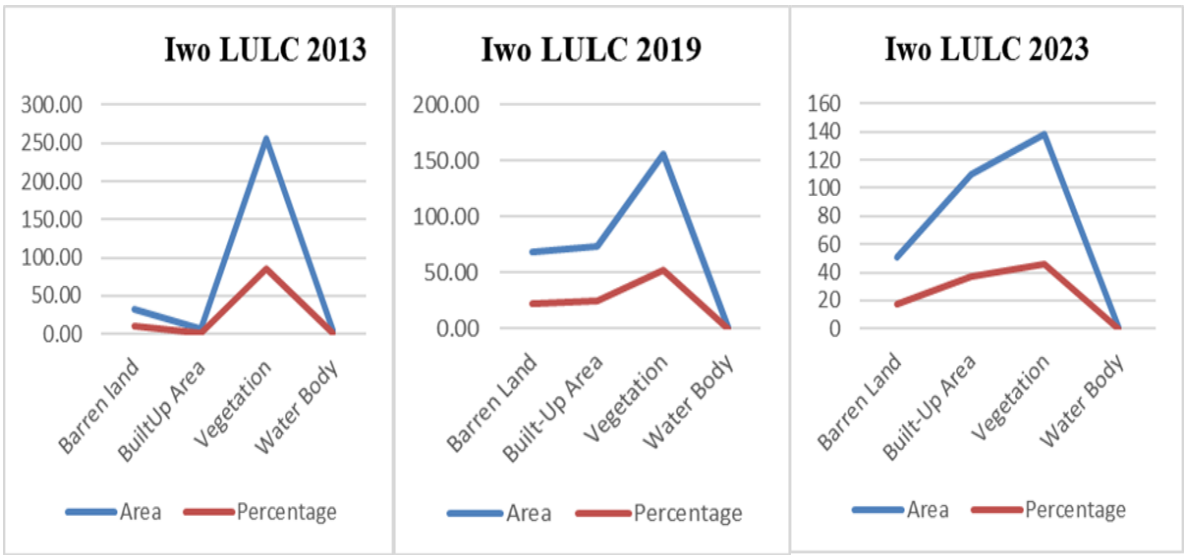

Figure 3. Iwo LG LULC in 2013, 2019 and 2023

Between 2013 and 2023, there was a notable change and dynamic in Iwo LG land use land cover, as shown in Figure 3 above. Within this period, barren or bare land cover gained an average of 1.86 km^2 and 0.62% per year. Built-up area increased by an average of 10.37 km^2 and 3.41% per year. Vegetation, which includes green forest, lost an average of 11.80 km^2 and 3.94% per year. Lastly, the water body land cover lost an average of 0.41 km^2 and 0.15% of its size per year within the study period. There has been significant loss of vegetation cover in Iwo LG, as shown in Figure 3. This suggests that vegetation cover has been excessively cleared to pave the way for the development of the city hence endangering the livelihoods of the Iwo LG residents while exposing the city to the likelihood of drought, flooding, and other environmental challenges. This is similar to a submission by [13, 14] on the consequences of deforestation practices, where they found out that infrastructure development, agricultural practices, and resources extraction, among others, leads to deforestation which in turn causes ecosystem disruption, biodiversity loss, soil erosion, climate change, and other environmental consequences. The percentage of barren land dropped from 22.95% to 17.06%, indicating 5.89% drop between year 2019 and 2023. It is important to mention that this gain has nothing to do with any intervention to restore the lost vegetation. Rather, both vegetation land cover and barren land cover have compensated for an increased built-up area land cover within Iwo LG. This suggests that during the period, physical expansion is notable and significant due to population growth and unsustainable urban growth.

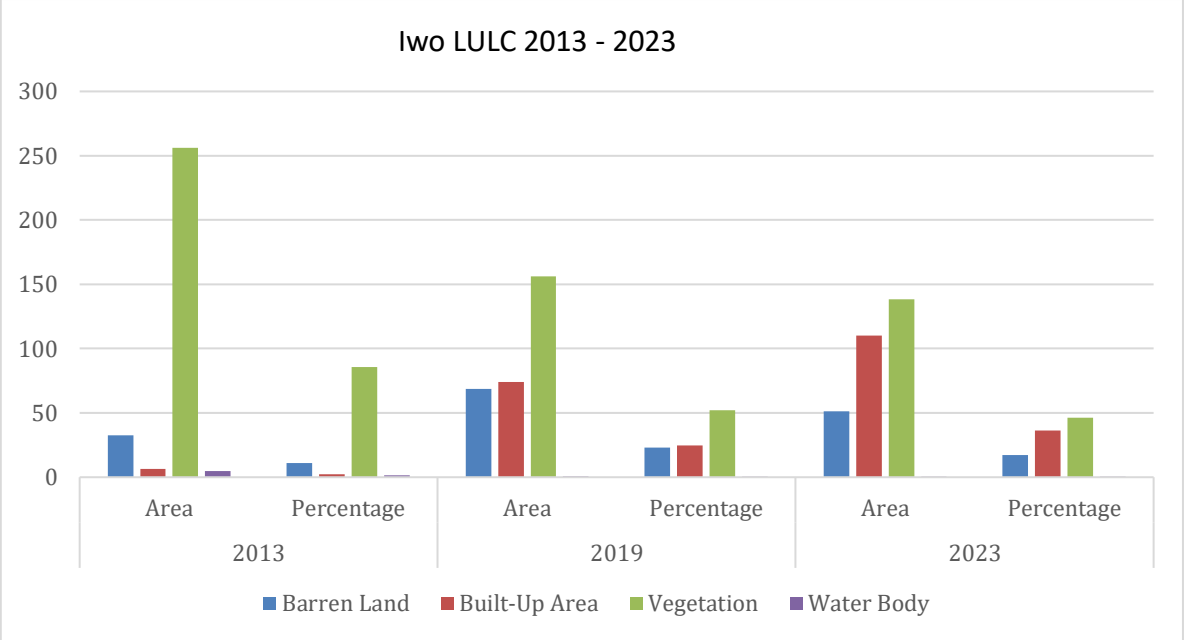

Figure 4. The dynamics of LULC of Iwo LG in a decade in area and percentage.

Figure 4 above shows the area and percentage of land use and land cover change for a period of 10 years in Iwo LG, Nigeria. It shows that more than 100 km^2 of vegetation cover was lost to built-up land use between 2013 and 2019. In the literature stated above, the vegetation/forest land cover shows a significant negative change in Nigeria [17–22, 28]. But the factors responsible for the change differ over time and space. In the urban areas it is mostly caused by population growth and the need for physical expansion, as in the case of Iwo LG [17, 18]. In the rural areas, the change to vegetation land cover is being associated with the need for land for agriculture [20, 21]. In any case, there is a significant implication for flooding, erosion, livelihood loss, biodiversity, climate change, and urban heat [6, 13, 14]. In Figure 4 above, it is clearly shown that water body land cover has been lost to a greater extent, with implication for spreading diseases, food insecurity, livelihood loss, and increased poverty [24, 27]. It is essential to state that, from the economic perspective, the urban expansion could mean more income for the state and a source of livelihood for individuals. But, urban expansion, from the context of the environment, degrade the environment to a large extent.

4. Conclusion

LULC change is a crucial aspect of managing natural resources and environmental changes. It is linked to biophysical and socio-economic factors, causing climate change, vegetation changes, and increased CO_2 emissions. This study investigated land use and land cover change in Iwo LG, Nigeria, between 2013 and 2023, providing insights for environmental and resource management and policy. The study found that urban growth and human activities have led to changes in ecosystems, including the growth of built-up areas and the loss of vegetation and water areas in Iwo LG. It should be noted that the change has been rapid and significant over a period of just ten years. The changes could then lead to urban heat, water scarcity, livelihood lost, food scarcity, and, among others. Iwo LG LULC change needs a holistic approach to slow down or reduce its effect on the natural ecosystem. This suggests that, if unchecked, the results would be devastating in

decades to come, especially for biodiversity, carbon emission, and local climatic behavior. The rapid disappearance of vegetation and water bodies in Iwo LG needs to be urgently addressed because of their importance to the ecological system and biodiversity. The study recommends that urban forest initiatives should be activated. The residents and various stakeholders should be encouraged to plant trees in the city, and effort should be focused on the conversion of open barren land to vegetation land. It is noted from the literature that Nigeria is losing her forest resource to urban development on one hand and to increased agricultural practices on the other hand. Therefore, the study further recommends that the Government of Nigeria needs to live up to her responsibilities by enacting laws that will protect the environment. The enforcement of the law must be ensured.

References

1. Arsanjani JJ. Dynamic Land Use/Cover Change Simulation: Geosimulation and Multiagent-Based Modelling. Springer; 2012.

2. Pouliot D, Latifovic R, Olthof I, Fraser R. Supervised classification approaches for the development of land-cover time series. Remote Sensing of Land Use and Land Cover: Principles and Applications. CRC Press; 2016:177-190.

3. Mölders N. Land-Use and Land-Cover Changes: Impact on Climate and Air Quality. Springer Netherlands; 2012:44.

4. Rahman A, Kumar S, Fazal S, Siddiqui MA. Assessment of Land use/land cover Change in the North-West District of Delhi Using Remote Sensing and GIS Techniques. Journal of the Indian Society of Remote Sensing. 2012 Jan;40:689-697.

5. Structure Plan for Iwo and Environs (2014-2033) State of Osun Structure Plans Project.

6. Nwakaire CM, Onn CC, Yap SP, Yuen CW, Onodagu PD. Urban Heat Island Studies with emphasis on urban pavements: A review. Sustainable Cities and Society. 2020 Dec; 63:1-20.

7. Fashae OA, Adagbasa EG, Olusola AO, Obateru RO. Land use/land cover change and land surface temperature of Ibadan and environs, Nigeria. Environmental Monitoring and Assessment. 2020 Jan; 192(2):109

8. Numbere AO. The Impact of Landscape Reclamation on Mangrove Forest and Coastal Areas in the Niger Delta, Nigeria. In: Loures L, ed. Landscape Reclamation - Rising from What's Left. IntechOpen; 2020 Jan:1-18.

9. United Nations. World Population Prospects 2024: Summary of Results.

10. Mcdonald RI, Kareiva P, Forman RTT. The implications of current and future urbanization for global protected areas and biodiversity conservation. Biological Conservation. 2008 June;141(6):1695-1703.

11. Howard E, Davis AK. The fall migration flyways of monarch butterflies in eastern North America revealed by citizen scientists. Journal of Insect Conservation. 2009;13(3):279-286.

12. Alberti M. Maintaining ecological integrity and sustaining ecosystem function in urban areas. Current Opinion in Environmental Sustainability. 2010 Aug;2(3):178-184.

13. Bodo T, Gimah BG, Seomoni KJ. Deforestation and Habitat Loss: Human Causes, Consequences and Possible Solutions. Journal of Geographical Research. 2021 April;4(2):22-30.

14. Allen JC, Barnes DF. The Causes of Deforestation in Developing Countries. Annals of the Association of American Geographers. 1985 June;75(2):163-184.

15. Obiahu OH, Elias E. Effect of land use land cover changes on the rate of soil erosion in the Upper Eyiohia river catchment of Afikpo North Area, Nigeria. Environmental Challenges. 2020 Dec;1:100002.

16. Satterthwaite D. A new urban agenda? Environment and Urbanization. 2016 March;28(1):3-12.

17. Obiahu OH, Yan Z, Uchenna UB. Spatiotemporal analysis of land use land cover changes and built-up expansion projection in predominantly dystric nitosol of Ebonyi state, Southeastern, Nigeria. Environmental Challenges. 2021 Aug;4:1-10.

18. Gilbert KM, Shi Y. Land Use/Land Cover Changes Detection in Lagos City of Nigeria Using Remote Sensing and GIS. Advances in Remote Sensing. 2023 Dec;12(4):145-165.

19. Hassan G, Syakir MI. Spatio-temporal analysis of land use and land cover changes in Nguru Wetland, Yobe State, Nigeria. IOP Conference Series: Earth Environmental Science. 2023;1167:1-11.

20. Okeleye SO, Okhimamhe AA, Sanfo S, Fürst C. Impacts of Land Use and Land Cover Changes on Migration and Food Security of North Central Region, Nigeria. Land. 2023 May;12(5):1-23.

21. Olayungbo A. Land Use and Land Cover Change Detection Using Remote Geospatial Techniques: A Case Study of an Urban City in Southwestern, Nigeria. Problems of World Agriculture. 2021;21(2):4-14.

22. Ologunde OH, Kelani MO, Biru MK, Olayemi AB, Nunes MR. Land Use and Land Cover Changes: A Case Study in Nigeria. Land. 2025 Feb;14(2):1-16.

23. Bukoye JA, Oluwajuwon TV, Alo AA, Offiah C, Israel R, Ogunmodede ME. Land Use Land Cover Dynamics of Oba Hills Forest Reserve, Nigeria, Employing Multispectral Imagery and GIS. Advances in Remote Sensing. 2023 Dec;12(4):123-144.

24. Ogunbode TO, Paul II. Urban Growth and the Challenge of Water Security: A Case Study of Iwo, Osun State, Nigeria. Research & Reviews: Journal of Ecology and Environmental Sciences. 2022 July;10(5):13-25.

25. Land Use/Land Cover and Forest Cover Mapping in Nigeria. FAO; 2020.

26. Read JM, Chambers C, Torrado M. Remote Sensing. International Encyclopedia of Human Geography. 2009:335-346.

27. Ogunbode, TO, Ifabiyi, P. Determinants of domestic water consumption in a growing urban centre in Osun State, Nigeria. African Journal of Environmental Science and Technology. 2014 Dec;8(4):247-255.

28. Hundu WT, Anule PT, Kwanga GM, Dam DP. Assessment of Land Use and Land Cover Change Using GIS And Remote Sensing Techniques in Katsina-Ala Local Government Area of Benue State. Nigeria Journal of Research in Forestry. 2021;13(4):195-204.

29. Oyeweso S, Balogun AS. Kurani IO, Ilu AAFA. Evolution, Growth and Expansion of Islam in Iwoland. Islam and Society in Osun State. MegaPress Limited; 2012:19-50.

30. Kafy AA, Abdullah-Al-Faisal, Raikwar V, Rakib AA, Kona MA, Ferdousi J. Geospatial approach for developing an integrated water resource management plan in Rajshahi, Bangladesh. Environmental Challenges. 2021 Aug;4:1-17.

31. Serageldin I. Toward Sustainable Management of Water Resources. Published online 1995.