Land Use Dynamics of Urban Change in the Lagos-Ogun Urban Fringe, Southwest Nigeria

[*1]Abiodun, Oludayo Emmanuel&[2]Salami Tosin

Department of Surveying and Geoinformatics, University of Lagos.

Email: *abiodunoludayo@yahoo.com, jsalami@unilag.edu.ng

Abstract

In recent decades, the conversion of various land use types to urban land has occurred at a rapid rate globally, resulting in urban expansion. Lagos can be described as one of the cities most affected by extensive urban expansion in Nigeria. In Lagos State, urban sprawl is most visible in the towns near the Lagos-Ogun boundary. Interestingly, previous studies of urban land use change in the region concentrated on Lagos State or Ogun State with no particular attention to the development at the Lagos-Ogun urban fringe. A study of land use change along the Lagos-Ogun boundary will reveal the dynamics of urban land use, which can assist in identifying urban planning solutions for resilient and sustainable urban development. This study, therefore, investigates land use dynamics of urban change in the local government areas along the Lagos-Ogun boundary at five epochs (1984, 2001, 2013, 2018 and 2020). The maximum likelihood algorithm was adopted in processing acquired lands at images of the study area to six classes of dense urban, moderate urban, vegetation mangrove, waterbody and wetland. Image processing was done using ENVI software, while processed images were imported to ArcGIS for analysis. Total and annual changes in land use types were determined. The six land use classes were later regrouped into three, from where further analyses of land use change were carried out. Results showed that the annual rate of urban change between 1984 and 2020 and 2018 and 2020 was 63.28 km^2 and 317.99 km^2, respectively, much higher than the rate of change in Lagos. Results also showed that urban land use increased by 2278.02 km^2 between 1984 and 2020. A uniform urban planning policy and decentralised planning authorities are recommended to ensure the area's resilient and sustainable urban development.

Keywords: Land use, urban, sustainable, settlement, development

Introduction

Many parts of the world are experiencing transitions from rural settlement to urban life. Settlements are more permanent in nature in recent times as against what is obtainable a few centuries away. Most settlements are temporary and could be displaced by war, pandemic or other physical and natural disasters. There are more cities globally today, resulting in the emergence of cities of more than 10 million population generally referred to as megacities (Anslem, 2019). The only megacities known globally in the 1950s were New York in the United States of America and Tokyo, the capital city of Japan. By 2018, there were 33 megacities, and Lagos was ranked 18th on the list of world megacities (UN, 2018).

Rapid and extensive urbanisation in Lagos is characterised by challenges like heavy traffic, sprawls of uncoordinated suburban growth, poverty, unemployment, and an increased crime rate (Bloch et al., 2015). Despite its drawbacks, Lagos is considered a desirable location, especially for young people with a maximum primary-level education. Furthermore, the nature of expansion in Lagos is today more complicated because it is difficult to isolate or identify a particular area as the centre of development. Many areas are now so developed in terms of commercial activities, job opportunities and other issues that they now serve as expansion hotspots (Salami et al., 2020). Previously, it was a common belief that a place like “Broad Street" (in Lagos Island) with adjoining areas was the only centre of commerce. From the current structure of Lagos, other areas are competing as centres of aggregation for people and businesses.

Lagos is a centre of attraction to every inhabitant from virtually all over the world (Akanle & Adejare. 2017). It has emerged from many small independent farming and fishing settlements of the 18th century to a modern megacity that now spreads beyond Lagos State's boundary to the nearby Ogun State. Urbanisation, especially in Lagos, is overwhelming, such that planning interventions have been virtually reduced to nothing (Mabogunje, 1992). This development has, therefore, triggered various research efforts on Urban Land Use change detection in Lagos State.

Land use dynamics is a process that results from human interaction with the physical environment. The resultant effect of this interaction is a modification in the biophysical attribute of the Earth's surface, leading to a shift into a new land use type (Liping et al., 2018). While this process can hardly be stopped since man will keep interacting with the physical environment, it impacts the environment negatively. Changes in land use type have been identified to influence changes in the global climate, such as a rise in global temperature, reduction or destruction of water bodies and reduction in vegetation stock, all of which undermine stability in the ecosystem (Xue et al., 2021).

In the last few decades, data acquired through satellite remote sensing (RS) has been used as the primary source of information in monitoring and analysing land use changes (Rawart & Kumar, 2015). RS is usually coupled with Geographic Information System (GIS) technique to ensure effective monitoring and analysis of land use change detection. GIS is a veritable tool for acquiring, storing, presenting, evaluating and analysing the required land-use change data (Halefom et al., 2018). One of the applications of remote sensing is using spatio-temporal satellite imagery for land use classification, which aids in identifying earth-based features such as land use at the time of data collection. Classification techniques can either be unsupervised or supervised, with each technique having several algorithms. Supervised classification is preferred for better accuracy, and the maximum likelihood technique of the supervised classification has also been adjudged to give excellent results for land use change analysis (Mohammady et al., 2015).

Observing the state of an object or a phenomenon and quantitatively analysing the observed differences using multitemporal datasets is known as change detection. Therefore, change detection in urban land use allows for the analysis of observed differences in land use at different periods (Afify, 2011). There are several categories of change detection techniques available in the literature. Lu et al. (2004) categorised these techniques into six groups: algebra, transformation, classification, advanced models, GIS approaches and visual analysis. The post-classification comparison technique, which falls under the classification category, is most commonly used for land use change detection because it reduces the effect of atmospheric variations between images of different epochs. In contrast, the comprehensive change information is still preserved (Si Salah., 2020).

Previous studies on urban land use dynamics in Lagos include Wang and Maduako (2018), where the authors investigated the possibility of integrating Multi-Layer Perception and Markov Chain Analysis to accurately map and predict future land use/land cover change scenarios in the Lagos Metropolis. The study results revealed that about 50% of urban land expansion occurred outside the administrative boundary of Lagos State between 2000 and 2015. This work is, however, limited to the Lagos metropolis and data analysis was limited to a period between 2000 and 2015. In another study, Faisal-Kokoet al. (2021) analysed urbanisation and land cover change in Lagos, Nigeria, using multiple image datasets from 1990 to 2020 at ten-year intervals. Results showed a substantial increase in the city's built-up area from 496 km^2 in 1990 to 1256 km^2 in 2020. The study concluded that observed changes must have been a significant contribution to incessant urban flooding as well as an increase in other natural and humanly induced disasters in Lagos. This study also focused on Lagos, which implies that even though there is continuing urban expansion along the Lagos-Ogun boundary, it was overlooked.

In a separate study, Onilude and Vaz (2021) analysed the pattern of change in land use and land cover. The Cellular Automata was used to predict future urban development in Lagos. The study revealed a rapid increase in artificial surfaces and a decline in agricultural land, grassland, shrubland, wetlands, and waterbodies. During the study period, observed urban development expanded beyond the administrative boundaries of Lagos to neighbouring towns and settlements in Ogun State. The study predicted that the growth would be more significant by 2030. However, the extent of urban expansion into Ogun State was not quantified. Abiodun et al. (2017) conducted a study to develop a multivariate model for urban expansion in

Greater Lagos. The results predicted an increase of 56% in urban expansion in the year 2030. The authors concluded that the results should serve as a basis for policy reform in Lagos. The study, however, did not quantify the influence of urban growth at the Lagos-Ogun urban fringe on the overall growth reported. Previous studies on urban land use change in Ogun State available for review extend over only a section of Ogun State, such as the Abeokuta metropolis (Adebayo et al., 2019; Adeleke & Orimmogunje, 2016), lower Ogun River basin (Awoniran et al., 2013), Obafemi Owode Local Government (Oladehinde et al., 2021) and Odeda Peri-Urban of Ogun State (Tobore et al., 2021) with none of them touching specifically on the Lagos-Ogun urban fringe.

Authors of previous literature available for review (e.g., Wang & Maduako,2018; Olaleye et al., 2009) largely agreed that urban land use change in Lagos spread beyond Lagos administrative boundary to Ogun State. Nevertheless, of all previous literature on Lagos and Ogun States' urban land use change, only Abiodun et al. (2017) studied urban change as it spreads from Lagos to four local governments in Ogun State. It is, however, difficult from this study to clearly understand the pattern of land use change in those suburbs. Interestingly, these suburbs, which constitute the Lagos-Ogun urban fringe, have not been accorded much-needed attention by previous researchers. Additionally, the most recent study that touched on these suburbs (Abiodun et al., 2017, even though not explicitly concerned with the Lagos-Ogun peri urban fringe) used information dating as far back as 2013. Therefore, it becomes compelling to isolate and investigate urban change at the Lagos-Ogun urban fringe to understand the dynamics of change within these regions. Understanding these changes will facilitate implementing or re-implementing urban land use planning policy reform in the study area. (Akinmoladun & Oduwaye, 2007).

Therefore, this study seeks to investigate urban land use dynamics at the Lagos-Ogun urban fringe to serve as a basis for urban planning and policy formulations to enhance resilient and sustainable urban development. To achieve this, this study seeks to acquire images of the study area in five epochs (1984, 2001, 2013, 2018 and 2020); process the acquired images into six land use types (dense urban, moderate urban, vegetation, wetland, water body and mangrove); analyse processed images to identify land use changes between the stated epochs; discuss observed changes in relation with possible environmental consequences and make recommendations based on the findings of this study.

Procedures

The Study Area

The study was carried out in parts of Lagos and Ogun State, where Lagos urban growth overlaps the Lagos-Ogun boundary. Lagos, on its own, is the most important commercial city in Nigeria; it was the administrative headquarters of Nigeria until the Nigerian government moved its administrative headquarters to Abuja around the mid-1990s. Geographically, Lagos is situated at Latitudes 6^0 10' and 6^0 15' North of the Equator and Longitude 3^0 10' and 3^0 14' East of the Greenwich Meridian. Lagos State shares a boundary with Ogun State in the East and the North; it is bounded to the West by Benin Republic and to the South by the Atlantic Ocean. On the other hand, Ogun State shares a boundary with Oyo and Osun in the north, Ondo in the east, Benin Republic in the west and Lagos along with the Atlantic Ocean to the south. Ogun State is located within latitudes 6°N and 8°N and longitudes 3°E and 5°E (Solanke, 2015). The local governments within Lagos that share boundaries with Ogun State are Badagry, Ojo, Alimosho, Ifako-Ijaiye, Ikeja, Kosofe, Ikorodu and Epe. On the other hand, the following local governments in Ogun State share boundaries with Lagos: Ipokia, Ado Odo/Ota, Ifo, Obafemi Owode, Shagamu, Odogbolu and Ijebu Ode. These local governments combined constitute the study area, as shown in Figure 1. Figure 1C is the actual study area, while Figures 1A and 1B show their position within Nigeria and Lagos and Ogun States, respectively.

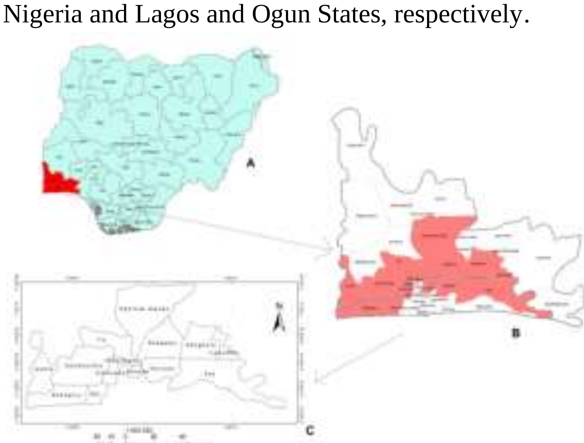

Figure 1: Map of the Study Area

Landsat Images of path 191, row 55 covering the study area, were acquired at six epochs. Administrative maps (electronic copy) of Lagos and Ogun States were acquired from the Office of the Surveyor General of the respective states. Table 1 contains the data acquired and their sources.

Table 1: Datasets Used in the Study

S/No	DATA	SOURCE
1. 2. 3 4 5	Landsat Image 1984 Landsat Image 2001 Landsat Image 2013 Landsat Image 2018 Landsat Image 2020	United States Geological Survey (USGS) https://gisgeography.com/usgs-earth-explorer-download-free-landsat-imagery/
6	Lagos State administrative map	Surveyor General's office, Lagos State
7	Ogun State Administrative map	Surveyor General's office, Ogun State

The study area was cropped from the shape file of Lagos and Ogun State administrative maps based on the local governments located along the boundary of the two states. The obtained map was used to clip out the study area from the acquired images in each epoch. The images so obtained were after that processed into various land use types.

Image Classification

All remotely sensed images are representations of the real world. The applications of specific processes maximise opportunities for better understanding, interpretation and analysis of these images for the particular purpose under consideration (Brito et al., 2006). Image processing includes all processes involved in correcting, enhancing and classifying images for straightforward interpretation and better analysis (Olaleye et al., 2011). A reconnaissance survey was done to update prior knowledge of the study area. A classification scheme was developed based on information gathered from the reconnaissance with additional information from previous research in the study area (after Anderson, 1976 and Eastman, 2009). Land use types included in the classification schemes are water, dense urban, moderate urban, vegetation, mangrove and wetland. The land use classification scheme used in this study is contained in Table 2. A satisfying and reliable supervised classification approach adopted mainly by many researchers is the Maximum Likelihood classification (Brito et al., 2006; Mohammady et al., 2015) and was used in this study. Image classification was carried out using ENVI software, and processed images were imported into the ArcGIS environment for urban land use change detection and analysis.

Table 2: The Classification Schemes for the Study

S/No	Classes	Description
1	Dense Urban	Residential, commercial and industrial areas, tarred surfaces, settlements and transportation infrastructure
2	Moderate Urban	Open spaces, excavation and construction sites, fallow land and solid waste dumpsites
3	Mangrove	Mangrove forests
4	Vegetation	Different types of forests, trees, palms, orchids, herbs, climbers, gardens and grasslands.
5	Water Body	Open water, rivers, lakes, ponds, canals and reserves.
6	Wetland	Waterlogged and areas prone to flooding

Image Classification Accuracy Assessment

In verifying the accuracy of the processed images, a manual assessment was done by superimposing the processed image on the original image to assess the degree of agreement. Where disparity exists, available maps, experience acquired during reconnaissance and disparity observed were all compared before editing was carried out. After editing, the accuracy of the classification result was checked by comparing the classification result with ground truth information; in this case, ground truths are obtained at the Region of Interest (ROIs). Accuracy assessments of processed images were done using the overall accuracy determined using Equation 1.

$$p_0 = \frac{1}{N}\sum_{i=1}^{m} n_{ii} \quad (1)$$

p_0 = accuracy assessment

n_{ii}= the total number of correctly classified points by class along the diagonal of the error matrix

N = the total number of sampled points (Lo & Yeung, 2007).

Accuracy assessment results show that the overall accuracy for 1984, 2001, 2013, 2018 and 2020 are 62.65%, 86.75%, 81.93%, 53.01% and 73.49%, respectively. According to Landis and Koch (1977) and Eastman (2009), overall processing accuracy between 40% and 60% moderately agrees with actual land use information. It is considered to be acceptable for land use. Since the lowest overall accuracy assessment score was 53%, the accuracy assessment results were accepted to be good enough for urban change analysis in this study.

In analysing the data in this study, both moderate and dense urban classes were treated as urban development. However, the distinction between them gives information about those areas that are densely developed at each epoch. Changes in urban development were determined from one epoch to the next epoch; changes were also determined between each of the epochs to 2020. Total urban change in the urban expansion (C) between earlier epoch "*a"* and a later epoch "*b"* was determined by Equation 1, while the annual rate of change (Ĉ) was determined by Equation 2.

$$C = A_{ib} - A_{ia} \quad (2)$$

$$\hat{C} = \frac{A_{ib} - A_{ia}}{b - a} \quad (4)$$

Results and Discussions

The results of images processed for 1984, 2001, 2013, 2018 and 2020 are presented in Figures 2 to 6. From the Figures, the growth of urban development is evident from an earlier epoch to a later one. It must be noted that due to the unavailability of cloud-free and precise image data, it was impossible to carry out the analysis at regular intervals, which should have permitted a better analysis and comparison of urban developments at regular intervals. It must also be observed that though 1984 and 2018 images were relatively more affected by cloud cover, the results of processed images at the two epochs still convey enough information to represent the changes observed at each epoch. From Figure 2, the outcome of image processing revealed that urban development is predominantly in the local governments within Lagos administrative boundaries. The South-Western part was seriously affected by cloud cover. Nevertheless, the region covered by the cloud is basically covered by vegetation. From Figure 3, the output of the 2001 processed image shows that urban development has moved further north, especially in the Ifo Local Government area of Ogun State. Although these two local governments are within Lagos State, a noticeable increase in urban development can be found in the Kosofe and Ikorodu areas.

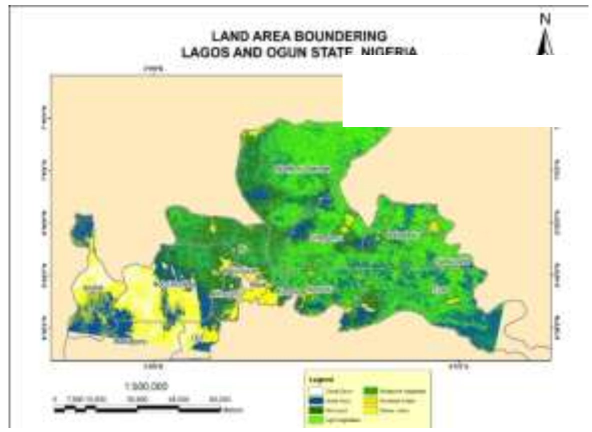

Figure 2: 1984 Land use map of the study area (Source: Authors' Analysis)

Figure 3: 2001 Land use map of the study area
(Source: Authors' Analysis)

According to Figure 4, it was clear that by 2013, urban development crossed the Lagos boundary to Ogun State in Shagamu Local government (north of Ikorodu), Ifo and Ado/Odo Ota local governments (north of Ifako-Ijaye and Alimosho). Moderate urban development is equally noticeable towards the north of Badagry and Ojo into Ado/Odo Ota local government. It can also be observed that urban development leap-frog along the Lagos Ibadan Expressway from Isheri to Arepo, thereby leaving spots of undeveloped land that separate new development from existing built-up areas. The undeveloped portion is the flood Plain of the Oyan River, which is usually flooded during the rainy season.

Figure 4: 2001 Land use map of the study area (Source: Authors' Analysis)

Urban development in the study area, as shown in Figure 5, revealed that most areas covered with moderate development in 2013 became densely developed in 2018. Similarly, a significant portion of areas covered by vegetation in 2013 were converted to urban development in 2018. This development is particularly evident in the local governments of Ikorodu, Obafemi Owode, Shagamu, Ifo, Alimosho and Ado Odo-Ota. The flood plain between Isheri and Arepo (along the Lagos-Ibadan Expressway) in Obafemi Owode local government, which was largely undeveloped in 2013, was moderately developed by 2018. Although the Western part of the 2018 image was seriously affected by the cloud, spots of urban development can still be seen in many parts of the Ado/Odo Ota and Ipokia Local Government areas. These areas were predominantly covered by vegetation in 2013.

Similarly, moderate urban development in the 2018 image processing output (Figure 5) has displaced the vegetation cover of 2013 (Figure 4) in a westward direction from Ojo to Badagry Local Government areas of Lagos State. Another significant observation is that spots of urban development located within Shagamu Local Government of Ogun State in the 2013 processed image (Figure 4) could be seen to be spreading towards the Ikorodu Local Government area in Lagos in the 2018 image processing output (Figure 5). Figure 6 shows that urban development has gone beyond the boundary of Ifo and extended to Ewekoro Local Government. It is, however, difficult to establish how much of Ewekoro Local Government has been converted to urban development since the local government is not part of this study.

Figure 5: 2018 Land use map of the study area (Source: Authors' Analysis)

Figure 6: 2020 Land use map of the study area (Source: Authors' Analysis)

The results, as presented in Figures 2 to 6, allow for understanding the location and direction of urban growth in the study area. From this understanding, a conjecture about the direction of future development could be made almost correctly. Quantitative results of area coverage of each land use type at each epoch are presented in Table 3. It must be noted that, generally, the calculated total land area of this study was not the same from one epoch to the other. Notably, there was a significant increase in total land area from 2001 to 2013. This could be attributed to sand-filling activities in the coastal area, which generally increase the total land area under investigation. According to the statistics presented in Table 3, urban development increased steadily from 1984 to 2020. Moderate urban experienced a percentage growth from 1.36% in 1984 to 15.79% in 2020. Similarly, dense urban grew from 3.26% in 1984 to 22.39% in 2020. On the contrary, water bodies and vegetation reduced between 1984 and 2020. While vegetation reduced from 40.40% in 1984 to 21.76% in 2020, Water bodies reduced from 10.24% in 1984 to 5% in 2020.

Table 3: Area and Percentage Coverage of Land Use Types at each Epoch.

SN	Land Use Type	Coverage Area and Percentage Coverage area in each epoch (km^2)									
		1984	%	2001	%	2013	%	2018	%	2020	%
1	Waterbody	672.10	10.24	610.96	9.21	332.29	4.94	338.14	5.00	338.16	5.00
2	Wetland	1412.91	21.53	1375.75	20.75	1178.46	17.50	1169.38	17.30	1164.90	17.23
3	Vegetation	2651.03	40.40	2572.10	38.79	2529.72	37.58	1789.98	26.48	1470.91	21.76
4	Mangrove	1214.36	18.51	1212.19	18.28	1205.97	17.92	1002.86	14.83	997.93	14.76
5	Moderate Urban	89.56	1.36	234.90	3.54	618.27	9.19	905.98	13.41	1067.18	15.79
6	Dense Urban	213.13	3.26	515.13	7.77	886.12	12.87	1039.22	15.38	1514.00	22.39
7	Cloud	308.68	4.70	110.09	1.66	0	0	512.98	7.60	207.56	3.07
	Total	**6561.77**	**100**	**6631.12**	**100**	**6730.83**	**100**	**6758.54**	**100**	**6760.64**	**100**

Based on the results obtained, there appears to be some interplay between some of these land use types. For instance, the water body increased slightly from 4.94% in 2013 to 5% in 2018. This increase in the area may have been gained from areas previously occupied by wetlands or mangroves. Wetlands could serve as a transition stage between water and other land use types, while mangroves could serve as a transition stage for vegetation. Similarly, it could be argued that moderate urban is a transition stage for dense urban. Figure 7 depicts the outcomes of merging transition land use categories with the primary types, as well as water body and wetland, mangrove and vegetation, and moderate urban and dense urban.

Figure 7 shows that the combination of water and wetland declined consistently, as does the combination of mangroves and vegetation. However, urban development has been steadily increasing over the study period.

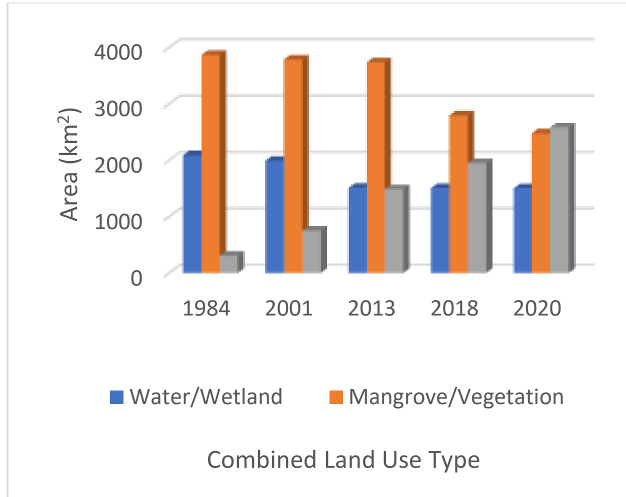

Figure 7: Chart showing merged land use types and area (Source: Authors' Analysis)

Annual change in land use was determined using Equation 3, and the equation was applied to the combined land use types. Hence, results are presented for three land use types (Wetland/Waterbody, Mangrove/Vegetation and Dense/Moderate Urban). Annual change from a preceding year to the following year was determined, as well as annual change for the entire period under consideration (1984 to 2020). Results of total change as well as annual change are presented in Table 4.

Table 4: Total and Annual Change in Combined Land Use Types.

S/N	Period	Urban Change (km^2)		Vegetation/Mangrove Change (km^2)		Waterbody/Wetland Change (km^2)	
		Total	Annual	Total	Annual	Total	Annual
1	1984-2001	446.88	26.29	-81.09	-4.77	-98.30	-5.78
2	2001-2013	734.36	61.20	-48.60	-4.05	-475.96	-39.66
3	2013-2018	460.81	92.16	-942.85	-188.57	-3.24	-0.65
4	2018-2020	635.98	317.99	-323.99	-161.99	-4.46	-2.23
5	1984-2020	2278.02	63.28	-1396.50	-38.79	-581.95	-16.17

Based on the results presented above, it is clear that the area occupied by the water bodies reduced between 1984 and 2020. Since the volume of water is always constant, it can only be that the area left for water is deeper in 2020 than in 1984. Otherwise, part of the water must have moved to other locations due to urban development. When the latter is the case, water must have been pushed to another location with relatively low land. This finding implies that areas (likely not within the study area) that did not experience flooding in 1984 may do so in 2020. This is consistent with the views of Faisal-Koko et al. (2021), who suggested that urban expansion could lead to flooding in low-lying, densely populated areas without adequate amenities. If there had been adequate planning, then provision would have been made to channel displaced water appropriately so as not to result in flooding.

This study also shows that wetlands reduced consistently from 21.53% in 1984 to 17.23% in 2020. According to Wahied and Sachdeep (2021), wetland serves the purposes of flood protection, water quality control in some situations, shoreline erosion control, preservation of some specific type of animals that have wetland as their habitat as well as housing some gases that could be harmful or dangerous to man and the environment. With these advantages, the depletion of wetlands has a negative impact on man. Depletion of wetlands, as witnessed in the study area, can lead to flooding. Other long-term implications, which may have significant detrimental effects on man and the environment, are also possible due to climate change (Obiefuna et al., 2021). Adequate urban planning policy and implementation could minimise the depletion of wetlands in the study area.
Therefore, urban planning within the study area will be needed to protect wetlands from further depletion.

The percentage of land covered by vegetation fell from 40.40% in 1984 to 21.76% in 2020. As a result, by 2020, dense urban areas had displaced vegetation as the land use type with the most extensive coverage. This study supports the findings of Salami et al. (2020), who reported that the rapid rate of urban expansion in Lagos, particularly on the outskirts, is resulting in an unprecedented loss of agricultural land to a built-up environment. Loss of agricultural land at such a rapid rate, as seen in the study area, may have long-term consequences for food security in the study area and its immediate settlements. Apart from food security, vegetation preservation will stem the tide of the rise in global temperature (Orie, 2016). Although it is difficult to permanently halt vegetation conversion to urban land, the rate can be controlled with adequate land use planning and implementation.

Furthermore, according to the findings of this study, mangroves decreased from 18.51% in 1984 to 14.76% in 2020. The study area's coastal sections have mangrove forests. Mangroves provide a suitable habitat for various animals and contribute to the ecology. Besides, West Africa has been designated as one of the global locations with a substantial stock of mangroves (Aye, 2022). A planning policy to safeguard mangrove forests is essential to prevent mangrove depletion along the Lagos coast.

The two land use types that grew steadily throughout the period of study are moderate urban and dense urban. According to Figure 7, moderate and urban land use combined rose from 303.16 km^2 in 1984 to 2581.18 km^2 in 2020. Figure 7 shows that when transition and primary land use types are merged, moderate/dense urban combination had the lowest area coverage (4.84%) in 1984. Interestingly, it had grown to occupy the largest percentage of the total land of the study area in 2020 (39.39%). This study also revealed that the annual growth rate in the study area between 1984 and 2020 was 63.28 km^2. This is far higher than the growth rate of 37.84 km^2 reported to Lagos State from 2000 to 2015 by Salami et al. (2020). The growth rate in the study area is higher than that of Lagos State starting from 2001, based on the results of this study. This is an indication of the mass relocation of residents in Lagos to the Lagos-Ogun urban fringe. This mass relocation calls for urgent attention from stakeholders. Since the study area is around the boundary of Lagos and Ogun States, enforcing existing urban planning policies may be difficult because it could be challenging to ascertain the actual boundary between the two states.

Conclusion

This study investigated changes in urban land use in the study area covering the local governments at the Lagos/Ogun administrative boundary using processed images at five epochs (1984, 2001, 2013, 2018 and 2020). Results showed that moderate and dense urban development is rapidly increasing. It was observed that urban development, which was 446.88 km^2 in 1984, became 2278.02 km^2 in 2020, with an annual rate of change of 63.28 km^2 over the same period. These results, compared with previous studies (e.g., Salami et al., 2020), confirm that the rate of urban development at the Lagos-Ogun urban fringe is much higher than the rate within the Lagos metropolis. Results also showed that a combination of Wetland/Waterbody and Mangrove/Vegetation experienced a steady reduction in the study area within the same period. Suppose the observed rate of increase in urban development remains as high as experienced between 2018 and 2020. In that case, other major towns in Ogun State (e.g., Abeokuta and Shagamu) may merge with Lagos in no distant future.

This study, therefore, recommends the following:

i. Further studies on urban development covering Lagos and Ogun States should be conducted. These research efforts will help identify what development pattern is expected and how this can be managed for sustainable development.
ii. Development of a land use plan or a revision of an existing one and strict enforcement of land use plan to guide urban development such that agricultural land, wetlands and mangroves are protected from urban development. This will promote food security as well as the ecosystem, which, in turn, will promote a friendlier environment.
iii. The study area requires a uniform urban planning policy to achieve a more resilient and sustainable urban development. A situation where the same community is governed by different planning rules resulting from an imaginary separating line can promote haphazard policy implementation, leading to less desirable urban development.
iv. More local government should be created, especially in the Ogun State section of the study area. This will ensure the presence of more urban planning officials who will be closer to the residents and have better oversight of all activities taking place in the area.

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