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Forest Cover Dynamics in a Changing Climate: A Case Study of Ibadan, Nigeria

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Abstract

Forest resources are vulnerable to the effect of climate change extremes and human activities. However, the environmental protection potentials and ecological value associated with forest resources in response to climate change and environmental degradation are enormous. Sustainable management and monitoring of forest resources can, therefore, contribute to the resilience of cities to lessen the severity of climate change manifestation. This study quantifies the magnitude of depleted forest land-cover in Akinyele and Egbeda local government areas in Ibadan, Oyo State, Nigeria, using Geographic Information System (GIS) and Remote Sensing (RS) tools. Landsat Imageries for the years 1986 and 2019 were subjected to a supervised classification on ArcMap 10.3. Besides, a structured questionnaire was used to collect information on the socio-economic characteristics of respondents, knowledge of respondents about environmental benefits associated with forest resources in response to climate change, as well as the causes of forest depletion. The GIS results revealed an overall decline in the forest area. Also, the majority of the respondents were farmers (34%) with little or no knowledge of the benefits of forest conservation in tackling the challenges posed by climate change. Moreover, agriculture (35%), logging (30%) and urbanization (28%) accounted for the leading causes of forest depletion in the study areas. The study, however, recommends policies to be adopted in response to forest resource depletion and climate change manifestations.

Keywords

Climate Change, Environmental Degradation, Forest, Ibadan, GIS

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1. Introduction

The last two decades have been all about the impact of climate change, resource depletion and environmental degradation. These issues have attracted researchers from diverse disciplines, intending to identify the causes, measure the effects and proffer a lasting solution to these environmental challenges [1]. The risks presented by global warming and climate change cannot be overemphasized; thus demands a multidisciplinary problem-solving approach [2]. Moreover, several studies have shown that urbanization and the ever-increasing human population is harming some of the world's most cherished resources, e.g. water, land, forest [3]. At that, the world's population is expected to increase by 2 billion come 2050 with sub-Saharan Africa, contributing mainly to the numbers [4]. Studies have also shown the importance of trees and forest resources in mitigating several environmental problems, by providing ecosystem services. For example, they can serve as natural purifiers and promotes nutrient cycling, as well as providing raw materials such as fuelwood, poles, medicinal drugs, and edible fruits. The carbon sequestration ability of trees has also been identified as a way of reducing the effect of global warming. It also

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assists in mitigating other extreme climate events such as runoff, strong wind, and high temperature, which is currently increasing in developing countries [5].

According to FAO [6], protected forests account for about 10% of the entire land area in Nigeria, with the majority occupying the southern part of the country, and with over 150 indigenous trees reported to have provided edible products for both man and animal consumption in Nigeria. Notably, agricultural activities have been identified as one of the major contributors to deforestation. At that, the agricultural sector is one of the most vulnerable sectors to the impact of climate change, suffering from the prolonged dry spell, high temperatures, intense and fluctuating rainfall patterns, which affects land suitability and the much-needed water resources for food production [7]. In response, Agroforestry has been suggested as a means of reducing the impact of intensive land use in agriculture while maintaining ecosystem services and conserving associated species such as birds using trees as shelter, and fishes in the watershed, in addition to the protection of riverbanks [8].

Presently, Nigeria is faced with an urgent need for infrastructural growth and development, making it challenging to enact stiffer policies to protect forest resources. Recently, environmentalists have been agitating for tree planting and conservation of our forest resources, which is evident on every World Environmental Day, observed on the 5th of June each year [9]. At that, various environmental impacts of deforestation are more severe in developing countries, where developmental projects put pressure on scarce resources without replacement policies and adequate documentation [10]. Efforts to upheld environmental management in Nigeria resulted in the establishment of the Ministry of Environment, which is saddled with the responsibility of checkmating activities leading to environmental degradation. Nevertheless, little has been achieved so far, due to inadequate involvement and participation of all the major stakeholders involved in the subject matter. Stakeholders in this context refer to local farmers, community heads, forestry and government department, policymakers and logging industries [11].

In the South-western part of Nigeria, forest resources in Ibadan, Oyo State have been on the decline since 1960 [12]. Locations of some of the forest destroyed in Ibadan metropolis includes; Scout Camp Fuelwood Plantations; Shepherd Hills Fuelwood (Ogunpa dam) plantations; Bodija Wetlands; Eleyele Fuelwood Plantations and Jericho Forest Reserve. These forests were replaced by other infrastructural projects, which have led to different cases of flooding, and pollution in the state [13]. Thus, this study adopts Geographic Information System (GIS) and Remote Sensing (RS) tools in calculating forest landcover change between 1986 and 2019 in the selected peri-urban Local Government Areas (LGAs) in Ibadan, Oyo State, Nigeria. In addition, it identifies the drivers of forest depletion and highlights the importance of land banking in curbing the increasing and wide-spread degradation and deforestation in the study area.

2. Materials and Methods

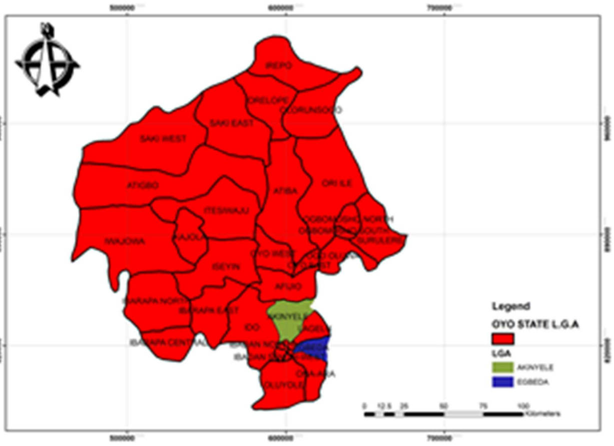
2.1. Research Locale

Eleven LGAs make up Ibadan, where six of the LGAs have been identified to consist of either peri-urban or rural settlements, while the remaining five LGAs are urban areas [14]. In Nigeria, Ibadan ranks third in terms of population size after Lagos and Kano with an estimated population of 2,550,593 [15]. Similarly, it is one of the largest cities in Africa in terms of spatial extent. Two LGAs (Figure 2) out of the six LGAs that constitute Ibadan peri-urban area were randomly selected for this study, namely: Akinyele LGA and Egbeda LGA. Figure 1 shows the study area in its national and regional settings.

The spatial extent of Akinyele LGA is about 478.1566 sq.km. It is one of the LGAs that constitute Ibadan peri-urban area, bounded to the South by Ibadan North LGA, to the West by Ido LGA, to the East by Lagelu LGA and Afijio LGA to the North. It is situated on latitude 7.7°N and longitude 3.8°E of the equator. The International Institute for Tropical Agriculture (IITA) is located in the LGA. Farming is the primary occupation of its residents. However, transport business, petty trading, local engineering, civil service, amongst others were also identified as the occupation of some of its residents. Mostly, the area is dominated by the Yoruba tribe of Nigeria, although, some other Nigerian tribes, migrants from neighboring African countries such as Togo and Benin Republic are also residing in LGA [16].

Source: Ministry of Surveys, Abuja (Digitized in ArcMap, 2018 by Authors).

Figure 1. Study area in its National Settings.



Source: Ministry of Surveys, Abuja (Digitized in ArcMap, 2018 by Authors).

Figure 2. Study area in its Regional Settings.

Just as Akinyele LGA, Egbeda LGA is one of the six LGAs that makeup Ibadan peri-urban area. It shares a common boundary with Lagelu LGA, Irewole LGA (in Osun State), Ona-Ara LGA and Ibadan North LGA to the North, East, South, and West respectively. As at the last population census conducted in Nigeria, the LGA has a population of 281,573 inhabitants [17]. It is situated between latitudes 7°21'N, 8°00'N, and longitude 4°02'E and 4°28'E [18] with a land coverage area of about 188.3435 sq.km.

2.2. Methods

In order to determine the forest cover dynamics within the study area between 1986 and 2019, Landsat satellite images were downloaded from the United States Geological Survey's Earth Explorer website [18]. These images are cost-effective choice for non-for-profit organizations and academics because they are free and open source data [19]. The images for both years have a spatial resolution of 30m each. However, the Landsat imageries acquired for the year 2019 were pansharpened on ArcMap 10.3 for better visualization.

Land use/land cover supervised classification was used in this study to identify the pattern of deforestation in the study area. This approach has been adopted in similar studies in Nigeria [20, 21]. For this study, the imageries were classified into Six (6) land-use/land-cover (LULC) classes, namely; Rock/Bare soil, Forest, Open Space, Built Up, Grass Land and Water Body.

The LULC map was ground-truthed for verification, and Google Earth Imagery was used to verify LULC of places that could not be accessed during ground-truthing. After generating the classified maps for each year, the area of each class was determined and converted to square kilometers and percentages. Areas with a dense canopy of 60% or more were identified as forest.

Based on the classification, the red colour depicts the built-up areas, dark blue for water body, dark green for the forest; light green signifies grassland, brown for rock/bare soil and yellow for open space. LULC change was carried out over the 33 years of study to determine the difference in the extent of the identified LULC classes.

Additional information that is of interest to this study were collected through a structured questionnaire that was administered to the respondents. Such as; the socio-economic characteristics of the respondents, knowledge of respondents about environmental benefits associated with forest resources in response to climate change, as well as the drivers of forest depletion. A random sampling technique was used in selecting respondents in the study area, where, 75 respondents were selected per LGA. In total, 150 questionnaires were administered to the respondents. The data collected were analyzed using the Statistical Package for Social Science (SPSS), and presented in tables.

3. Results and Discussion

3.1. Questionnaire Results

Socio-Economic Characteristics of the Respondents

In this study, the respondents were predominantly male, with 56.7% of the total population while, 43.3% were female. The study area was dominated by adults (71%) aged 35-64. Meaning that the majority of the respondents belongs to the working group. Table 1 reveals that 44% of the respondents were married. The primary occupation of respondents in the study area was farming (34.0%) followed by trading (27.4%), artisans (21.3%), civil service (13.3%) and students (4.0%). As at the time of collecting this data, 60% of the respondents live beyond the 18,000 Naira minimum wage.

Table 1. Socio-economic Characteristics of the Respondents.

Characteristics	Respondents	Percentage (%)
Sex		
Male	85	56.7
Female	65	43.3
Age		
0-18	25	16.7
19-34	29	19.3
35-64	71	47.3
65 above	25	16.7
Marital Status		
Single	47	31.3
Married	66	44.0
Divorced	6	4.0
Widow/Widower	31	20.7
Occupation		
Farming	51	34.0
Artisan	32	21.3
Civil Service	20	13.3
Trading	41	27.4
Student	6	4.0

Characteristics	Respondents	Percentage (%)
Income		
Above ₦18,000	60	40.0
₦11,000-₦18,000	44	29.3
₦5,000--₦10,000	22	14.7
Below ₦5,000	24	16.0

Source: Authors' Field Data 2019.

Respondents Knowledge about Environmental Benefits of Forest resources towards Climate change

With the increasing depletion of forest resources in the study area, respondents' knowledge about the reduction of forest resources and climate change could reflect their general level of awareness about how human activities contribute to climate change manifestations. Recognizing continuous forest resources depletion as an imminent danger by the people would go a long way in influencing and improving the attitude of the people towards the conservation of forest ecosystems that act as carbon sequesters. However, the result, as shown by Table 2, revealed that 63.3% of the respondents were not aware of the associated environmental benefits of forest resources in reducing the impact of climate change manifestations. With this, it is evident that much effort and passion is needed in raising awareness and educating the public against climate change and forest depletion in order to enhance forest transition, protect existing forest resources and lessen the severity of climate change manifestations.

Table 2. Respondents Knowledge about Environmental Benefits of Forest Resources towards Climate Change.

Respondent's Knowledge	Local Government Areas		No of Respondents	Percentage (%)
	Akinyele	Egbeda		
Yes	30	25	55	36.7
No	45	50	95	63.3
Total	75	75	150	100.0

Source: Authors' Field Data 2019.

Causes of Forest resources Depletion

Table 3 elicits the drivers of forest depletion in the study area. It was revealed that forest depletion in the study area was driven primarily by the conversion of forest to agricultural land (34.7%). This result is in line with the findings of FAO [21] which revealed that conversion of forest land to agricultural land is the primary driver of forest depletion. However, 30.0% of the respondents believed that logging activities were the cause of forest resource depletion. Only 28.0% of the respondents believed that urbanization is the primary driver of forest resource depletion, while 7.3% chose firewood harvesting as the chief cause of forest depletion.

Table 3. Causes of Forest Depletion.

Causes of Forest Depletion	Local Government Areas		No of Respondents	Percentage (%)
	Akinyele	Egbeda		
Urbanization	22	20	42	28.0
Agricultural Conversion	25	27	52	34.7
Logging	20	25	45	30.0
Firewood harvesting	8	3	11	7.3
Total	75	75	150	100.0

Source: Authors' Field Data 2019.

3.2. GIS Results

3.2.1. Akinyele LGA

i. *Landsat Classification Results (Akinyele LGA)*

Figures 3 and 4 depict the results of the land-cover classifications of the 1986 and 2019 Landsat images. In the 1986 classification (Figure 3), forest land cover class was the largest in terms of land area coverage, covering 79.8984% (382.04 sq.km.) of the total land area. This cover class was predominantly found in the Northern, Eastern, and Western part of the LGA. Grassland land-cover class constitutes the second largest land area, occupying 7.03457% (33.6363 sq.km) area coverage. A more significant percentage of the area coverage was found in the Northern part of the LGA with some patches dispersed all around the LGA. Lager area coverage of open space was found in the Southern part of the LGA. It covers 6.25094% (29.8893 sq.km.) of the total area. The built-up area covers 5.89906% (28.2068 sq.km.) of the total land area. it was situated mainly around the Southern part of the LGA. Rock/Bare soil and Water body constitute the lowest area coverage of all land cover classes with respective percentage coverage of 0.13789% (0.65932 sq.km.) and 0.77911% (3.72535 sq.km.).

In the 2019 classification (Figure 4), it was revealed that, forest which was the largest land-cover class in 1986 was relegated to the fourth largest land-cover class by grassland, built up and rock/bare soil land cover classes which accounted for 51.63876% (246.9141 sq.km.), 23.97347% (114.6307 sq.km.) and 14.23959% (68.08754 sq.km.) of the total area respectively. However, the lowest land-cover classes were water body and open space. The summary statistics of all the land-cover classes are provided in Table 4.

ii. *Land-cover Dynamics Result (Akinyele LGA)*

With respect to the land-cover dynamics over the 33-years study period, the largest changes in the classified maps were observed in the forest land-cover class, with a significant net loss of about

1725.47% (Table 4) which represented 334.63 sq.km. The forest land cover class was taken over by grassland land-cover class with over 634% net gain, followed by the built-up land-cover class with over 306.35% net gain in their respective spatial extents. This is facilitated by the agricultural practice in the LGA and the increase in urbanization radiating from the inner cities towards the peri-urban areas and population increase.

The classified map revealed that deforestation is visible in all parts of the LGA. According to Table 3, agricultural land conversion and urbanization appear to be major drivers of forest degradation.

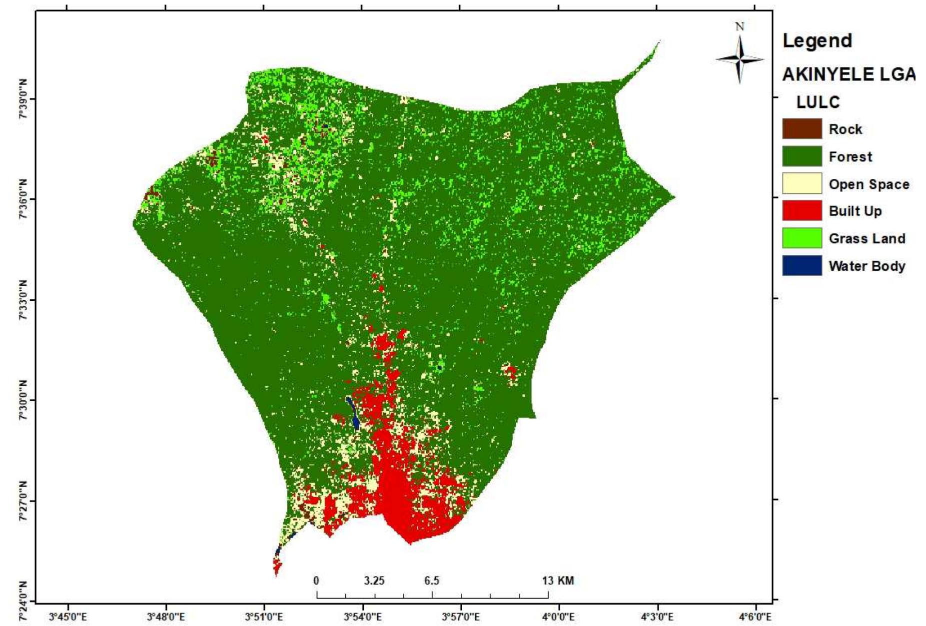


Figure 3. Classified map developed for Akinyele LGA based on Landsat-5 for the year 1986.

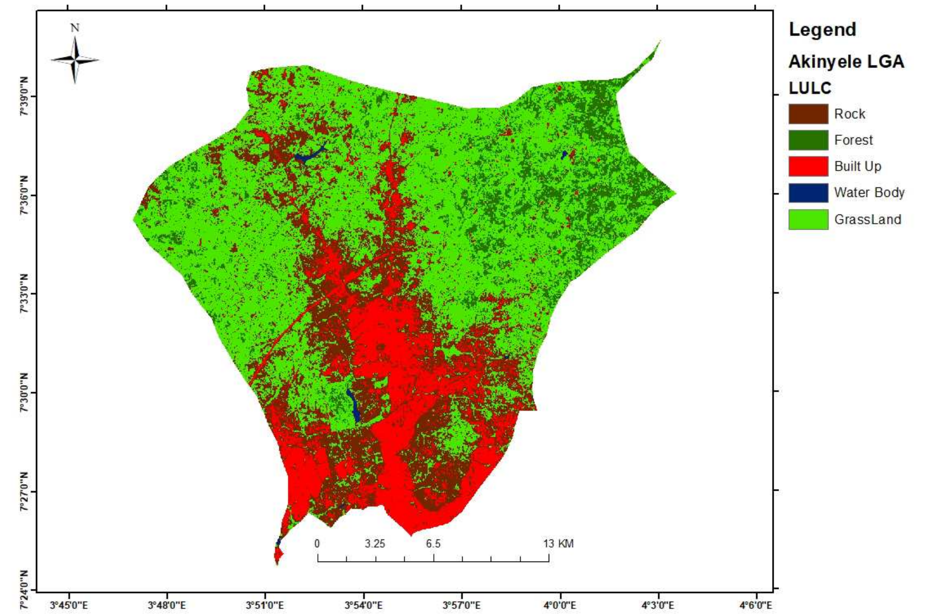


Figure 4. Classified map developed for Akinyele LGA based on Landsat-8 for the year 2019.

Table 4. LULC classes for Akinyele LGA for the year 1986-2019.

LULC Classes	1986		2019		1986-2019	
	Landcover (sq.km)	%	Landcover (sq.km)	%	Net Change (sq.km.)	Net Change (%)
Rock/Bare soil	3.725352	0.779107	68.08754	23.97347	64.36219	13.460483
Forest	382.0396	79.89843	47.40646	9.914423	-334.63314	-69.984007
Open Space	29.88928	6.250942	0	14.23959	-29.88928	-6.250942
Built Up	28.20675	5.899063	114.6307	0.233755	86.42395	18.074407

LULC Classes	1986		2019		1986-2019	
	Landcover (sq.km)	%	Landcover (sq.km)	%	Net Change (sq.km.)	Net Change (%)
Grass Land	33.63625	7.03457	246.9141	51.63876	213.2779	44.60419
Water Body	0.659322	0.137888	1.117714	0	0.458392	0.095867
Total	478.1566	100	478.1566	100		

3.2.2. Egbeda LGA

i. *Landsat Classification Results (Egbeda LGA)*

With the result of Landsat classification (Figure 5), it was identified that in 1986, the spatial extent of forest land cover was the largest in (Table 5) occupying more than 61% (116.4437 sq.km.) of the total land area. In the classified map, forest land-cover was found across the Northern, Southern, Eastern and Western part of the LGA. Open space was identified as the second largest land cover class, covering over 15% (29.95463 sq.km) of the total land area. A larger percentage of its area cover was found predominantly in the Northern and Western part of the LGA with some patches dispersed across the LGA. Over 10% of the total land area (20.31385 sq.km.) was covered with grassland land-cover class. Built-up land-cover class is the next after grassland, and it was found predominantly in the Western part of the LGA with over 7% (13.9396 sq.km.) land coverage area. Rock/Bare soil covered over 3% (6.298448 sq.km.) of the total coverage area of the LGA. In terms of spatial extent, Water constitutes the smallest area coverage, and it was mainly concentrated at Eastern part of the LGA, with over 0.7% (1.393238 sq.km.) of the total land area.

The 2019 classified map of Egbeda LGA (Figure 6) revealed that grassland land-cover class significantly covers over 43% (82.56913 sq.km.) of the total land area. The larger percentage of its area coverage was found in the Eastern part of the LGA. The built-up land area comes second after grassland (Table 5) with over 25% (47.77091 sq.km.) area coverage of the total land area. The depleting forest land-cover within the LGA can be attributed to the increase in the spatial extent of the built-up land-cover class, radiating from the Western part of the LGA, towards the Northern, Sothern, and Eastern region. Rock/bare soil land cover class spatial extent was estimated to be more than 23% (44.93544 sq.km.) of the LGA's total land area. Forest constitutes over 6% of the LGA while water land cover class constitutes over 0.7% of the total land area in the LGA. Just as Akinyele LGA, water land cover class has been consumed totally.

ii. *Land-cover Dynamics Result (Egbeda LGA)*

Between 1986-2019 in Egbeda, a net increase of over 306.55% (62.26 sq.km.), 613.33% (38.64 sq.km.) and 242.68% (33.83 sq.km.) were recorded for grassland, rock/bare soil and built up land cover classes respectively. The increase in the spatial extent of rock/bare soil land-cover class within the LGA was attributed to the rise in built-up lands in the study areas. This was as a result of humans' attempt to open up more areas for development. Furthermore, the most notable net loss was observed in areas covered by the forest with an 89.94% decline. In 1986, forest land-cover class accounted for 116.44 sq.km. However, by 2019, it has declined to 11.72 sq.km.

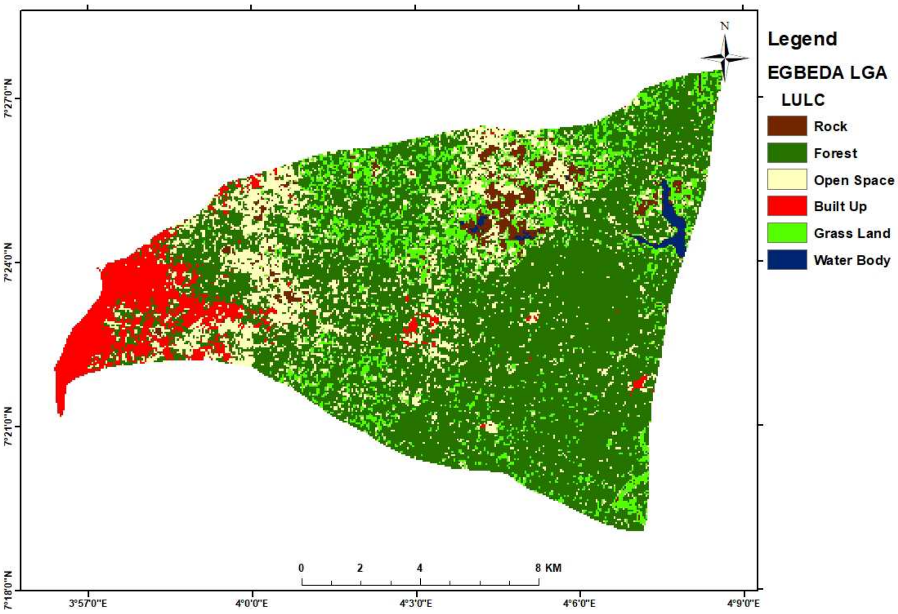


Figure 5. Classified map developed for Egbeda LGA based on Landsat-5 for the year 1986.

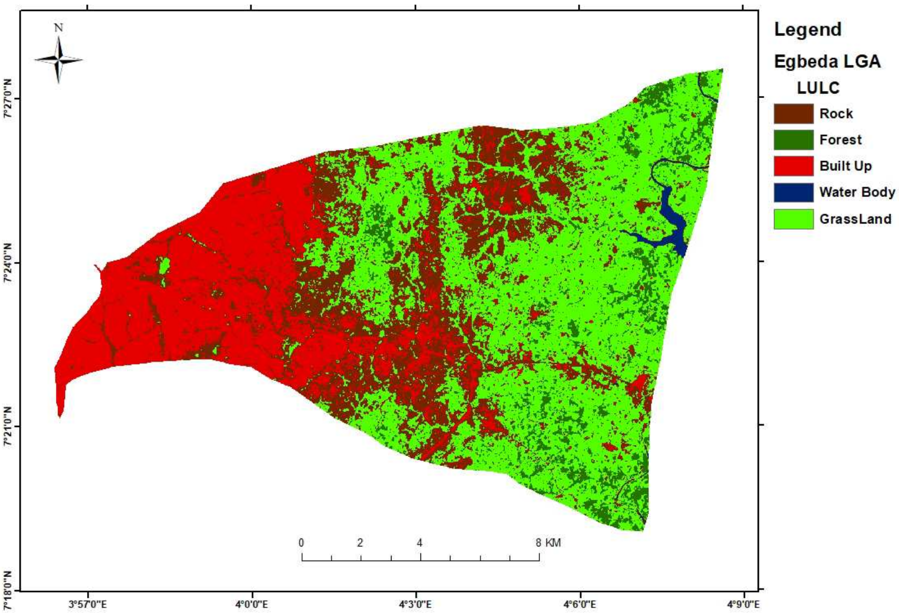


Figure 6. Classified map developed for Egbeda LGA based on Landsat-8 for the year 2019.

Table 5. LULC classes for Egbeda LGA for the year 1986-2019.

LULC Classes	1986		2019		1986-20019	
	Landcover (sq.km.)	%	Landcover (sq.km.)	%	Net Change (sq.km.)	Net Change (%)
Rock/Bare soil	6.30	3.34	44.94	23.86	38.64	613.33
Forest	116.44	61.83	11.72	6.22	-104.73	-89.94
Open Space	29.95	15.90	0	0	-29.95	-100.00
Built Up	13.94	7.40	47.77	25.36	33.83	242.68
Grass Land	20.31	10.79	82.57	43.84	62.26	306.55
Water Body	1.39	0.74	1.35	0.72	-0.04	-2.88
Total	188.34	100	188.34	100		

4. Discussion

Our findings coincide with the results of Bishaw [22], Kiange et al. [23] and Guzha et al. [24] who indicated a steady decline of forests in their respective study areas. The two major contributors to forest decline in Egbeda were agricultural land conversion and logging (Table 3). Besides these, urban sprawl is another driver for the change. Similar findings were also documented by Yahya et al. [25]. The study further indicates that in about 3 years, the forest land cover in the study areas would be totally consumed if depletion of forest resources continues at this rate.

The current state of forest cover dynamics in the study area may intensify the magnitude of climate change impact as forests provide hosts of opportunities with respect to fighting climate change such as carbon sequestration and regulation of water flows [26]. In this light, Bastin et al. [27] noted that tree restoration ranks high among the potent means for climate change mitigation. They further stated that a 25% increase in forest land is capable of reversing the effect of about 50% of all the carbon emitted since 1960. This implies that forest restoration would enhance climate change mitigation efforts and sustainable management of natural resources.

5. Conclusion

The increasing competition for land in the cities coupled with limited available land for infrastructural development facilitates the movement of the people towards the peri-urban areas for developmental purposes and economic benefits. Thereby, encouraging sporadic growth of cities and forest land conversion at the expense carbon sequestration service provided by the forest. Therefore, the issue of climate change and extreme weather events are likely to become more complicated. The Nigerian Government is advised to take advantage of the environmental benefits associated with forest resources in response to climate change manifestations by implementing forest conservation policies and organizing awareness programmes.

The Nigeria Government should adopt the concept of land banking in order to control anticipated sporadic, unbridled and haphazard growth of cities. The associated benefits of land banking can be extended to climate change mitigation and immunization of forest resources against depletion.

Geographic Information System (GIS) and Remote Sensing (RS) tools are advocated to be explored by concerned agencies in overcoming the challenges associated with monitoring and management of forest biodiversity.

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