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SPATIAL ANALYSIS OF THE EFFECT OF LAND USE CHANGE ON FOREST DEGRADATION IN PERI-URBAN COMMUNITIES SURROUNDING PORT HARCOURT, RIVERS STATE, NIGERIA

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Abstract

The study assessed the effect of land use change on forest degradation in peri-urban communities around Port Harcourt, Rivers state, Nigeria. Primary data acquisition involved downloading imageries of years 1986, 2000 and 2020 for land use change analyses. Peri-urban areas/communities around Port Harcourt were delineated for the study. Map overlay functions in ArcGIS 10.5 was employed for determining the change in spatial extent of identified land use types between 1986 and 2000 and between 2000 and 2020. The classified landuse images were then converted to vector format to calculate the area of landuse which included vegetation in each year in squared kilometers using spatial query module in ArcGIS 10.5. Results showed that spatial extent of vegetal cover reduced significantly, from 276.58 km^2 (51.11%) in 1986 to 208.78 km^2 (38.58%) in year 2020. Significantly, the size of built up area increased from 35.32 km^2 (6.53%) in year 1986 to 94.3 km^2 (17.43%) in year 2020. The trend in percentage change revealed that vegetation cover recorded a negative trend -25.27 between 1986 and 2020 while the built up area recorded a positive trend of +92.6 between 1986 and 2020. Thus, activities promoting built up area have reduced forest cover overtime in the study area – a direct indication of forest degradation. It therefore recommended amongst others that the activities contributing to high forest depletion should be regulated in the study area. This will discourage forest degradation and ensure the preservation of plant diversity in the peri-urban communities studied.

Keywords:Peri-urban areas, Land use Change, Forest degradation, Port Harcourt, Spatial extent

GSJ: Volume 10, Issue 12, December 2022
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Introduction

The high level of degradation of forest resources in developing countries is a factor of uncoordinated land use policy and other forms of unregulated land-use regimes for agriculture, grazing, industrialization, urbanization and water management leading to formation of deserts, bare surfaces and general environmental degradation. In the rainforest region, deforestation has risen to an alarming rate that urgent policy instruments are needed to salvage the forests and reduce its environmental challenges (Aigbe and Oluku, 2012). Forest degradation through deforestation is the biggest threat to forests worldwide. This occurs when forest ecosystems lose their capacity to provide important goods and services to people and nature (IUCN, 2019).Over half of the tropical forests worldwide has been destroyed since the 1960s, and every second, more than one hectare of tropical forests is destroyed or drastically degraded (IUCN, 2019). This intense and devastating pressure on forests is not limited to the tropics – an estimated 3.7 million hectares of Europe's forests are reported to be damaged by livestock, insects, diseases, forest fires, and other human-linked activities (United Nations Organization (UNO), 2018).

Peri-urban communities are communities that are found close to urban centres. As described by Zasada*et al*., (2011) peri-urbanisation relates to those processes of dispersive urban growth that create hybrid landscapes of fragmented urban and rural characteristics. Peri-urban areas (also called outskirts or the hinterland) are defined by the structure resulting from the process of peri-urbanisation. It can be described as the landscape interface between town and country, or also as the rural-urban transition zone where urban and rural uses mix and often clash. It can thus be viewed as a landscape type in its own right, one forged from an interaction of urban and rural land use (Lambert, 2011). The forest resources and plant biodiversity in these areas are threatened due to increasing human activities and their land use systems spilling over into the hinterlands. Forested lands are natural ecosystems that render services, products and functions that contribute to humankind and other living organisms' survival (Li *et al.,* 2012). The ecosystem services from forest resources include food production, hydrology adjustment, climate regulation, biodiversity maintenance, gas regulation, wastes treatment, erosion control, and entertainment (Mendoza *et al*., 2012). The provision of ecosystem services is directly affected by land use (Chen *et al*., 2010 and Mendoza *et al*., 2012).

Land use is important in human existence because a great part of the earth sits on land with vast resources that sustain life and the treatment the land receives affects lives (Aigbe and Oluku, 2012).Consequently, there are different types of land use adopted by different people; this is determined by the location of the people, their culture, geographical location and occupation. Most rural and peri-urban dwellers tend to put their land into agricultural and forestry use, which forms the base for their livelihood and occupation (Melese, 2016). Conversely, different human driving forces mediated by the socio-economic setting and influenced by the existing environmental conditions usually lead to the manipulation of the biophysical conditions of the land. In addition, the use to which a piece of land is put is an important component in

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

understanding the interactions of human activities with the environment and thus it is necessary to monitor and detect changes to maintain a sustainable environment (Turner and Meyer, 1994; Melese, 2016). With rapid urbanization and a finite land area, the available land per individual shrinks drastically; especially since land in urban areas are scarce and costly, people have migrated to the peri-urban areas for several purposes ranging from residential, agricultural, commercial and other socio-economic and developmental activities. These activities create more demands on land thereby increasing the pressure on land thus leading to forest loss and degradation overtime in the hinterlands.

The evolution of Geographic Information System (GIS), the Global Positioning System (GPS), and Remote Sensing (RS) technologies have enabled the collection and analysis of field data which can be used for strategic planning, modeling, monitoring and assessment of forest resources (Sonti, 2015). Following the advances in high resolution Remote Sensing Digital Data and Aerial Photography, mapping of the trends of cover changes have become relevant source of information for understanding changes in land use and land cover pattern overtime (Wunder, 2007).The study by Eludoyin*et al*., (2012) carried out spatio-temporal analysis of shoreline changes in Bonny Island, Nigeria.The studies by Jacob *et al* (2014) and Robert (2015) on land use and land cover change in AkwaIbom State has also provided guidance on the methods of data collection, data processing and analyses that will lead to vegetation assessment in relation to land use. The same method and approach was also adopted by Aniekan and Okon(2016) when evaluating the pattern of land use and land cover change of the AkwaIbom state from 1986 to 2016 using a three time series multi-temporal data.Eludoyin*et al*., (2017) use GIS and remote sensing technique to assess the effects of urbanization changes on land use in Yenagoa Metropolis, Bayelsa state, Nigeria. However, several studies on land use and forest loss and degradation abound in the literature; but little is known concerning the effect of land use change on forest degradation in peri-urban areas of Port Harcourt.

Materials and Methods

Description of the Study Area

The study area comprises of the peri-urban communities surrounding Port Harcourt. The study area is located geographically within latitude 4° 45' 30" N and 4° 55' 00" N and longitude 6° 54' 20" E and 7° 05' 40" E 4° 45' 30" N and 4° 55' 00" N and longitude 6° 54' 20" E and 7° 05' 40" E respectively (Figure 1).Port Harcourt is the capital and largest city in Rivers state. The months of February, March and April records the highest temperature, then gradually slopes down through May, June and more deeply in July and August. Again temperature rises through September, October and November (Ekemini, 2012). The monthly rainfall is almost predictable and a temporal sequence of increase towards July to August before decreasing in the dry season months of November to February. Oguntoyinbo*et al*., (1982) explains the drainage of Port

GSJ: Volume 10, Issue 12, December 2022
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Harcourt as poor, due to a combination of low relief, high water table and high rainfall. The soil of the area belongs to the sandy and sandy loam type, which are underlain by impervious pan constantly leached by the heavy rainfall experienced over the area.

The vegetation of the area is consistently nourished with high rainfall and high temperature, which provide favourable condition for the growth of a varieties of trees like mahogany (*Khayagrandifoliola*), Obeche *(Triplochitonscleroxylon)*,Afara (*Diospyroscelebica)* and abundance of oil palm trees and several other species of economically valuable trees such as raffia palm, shrubs, ferns, and floating grasses, also form of the vegetation (Adeomo, 2013). The transport network can be accessed via series of road network connecting local, regional, national, and international means. Thus, the area has transportation network that can serve inland water ways, road, air, and sea, which aids the movements of goods and services in and out of the city (Akpoghomeh and Obot, 2001). From historical perspective, Ikwerre and Okrika people have been known to occupy the land of Port Harcourt and its surroundings before 1913. However, the Ikwerre occupies the major land area of Obio/Akpor LGA, with three different kingdoms, namely; the Akpor, Obio and Evo Kingdoms respectively. The people in the study area are engaged mainly in fishing and farming (Ekemini, 2012; Adeomo, 2013).

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

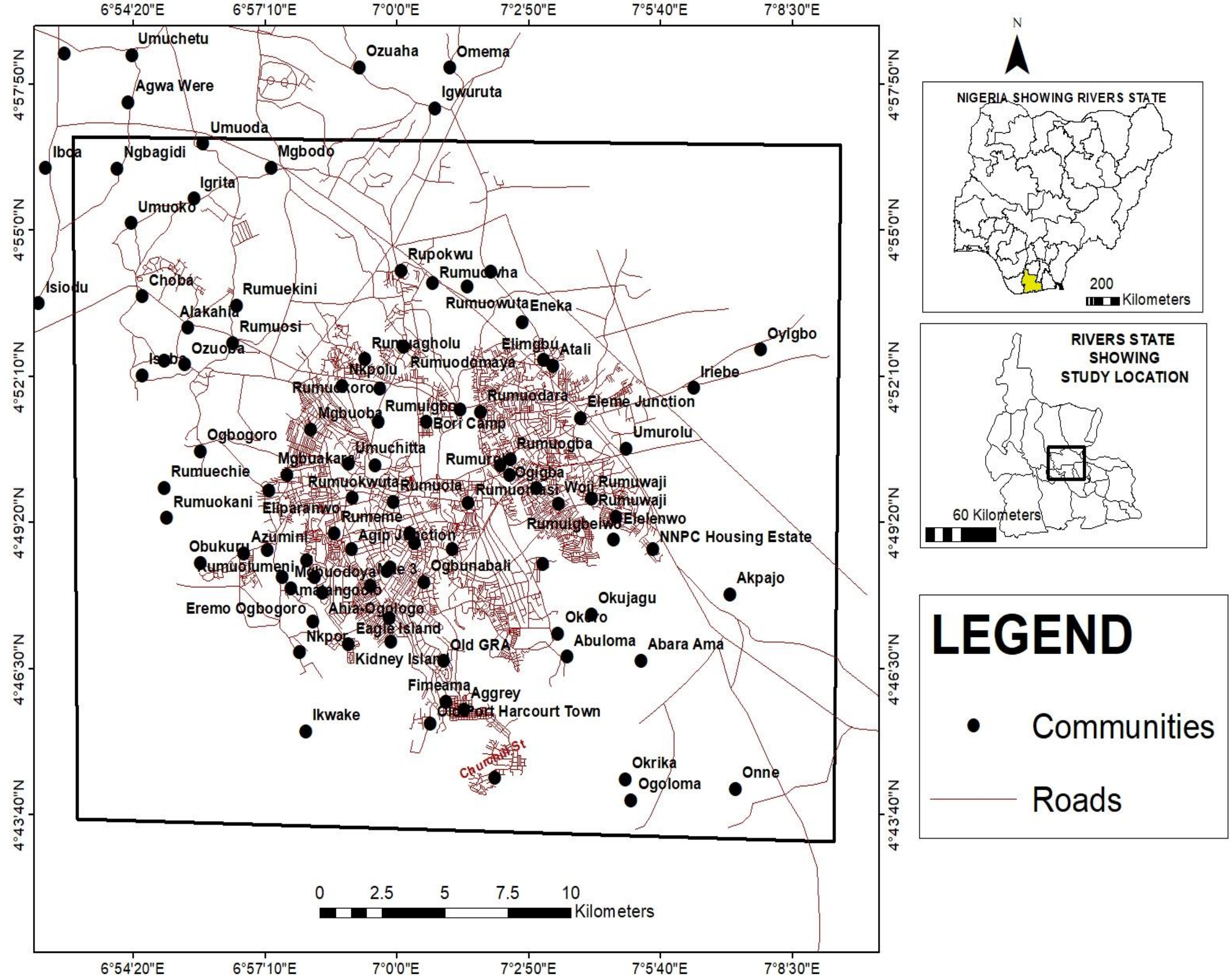

Figure 1: Port Harcourt and its surrounding Peri-urban communities

Data Acquisition

Landsat imageries of years 1986, 2000 and 2020 were downloaded to determine the land use types for the different periods. The imageries were acquired from the official website of the United States Geological Survey, 2020).The best fundamental features of the imageries selected for landuse change analysis with respect to vegetation cover in selected peri-urban communities were Landsat TM, Landsat 7 ETM, and Landsat 8 OLI_TIRS alongside their paths and rows and a usual resolution of 30m x 30m for the geospatial analysis for the study (Table 1). The global positioning systems (GPS) was used to collect data on points of reference for the study which aided the study in groundtruthing the areas tagged as built up, vegetation, farmlands, fallow lands and so on.

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

Table 1: Details of Landsat Satellite Images for Port Harcourt & its Peri-urban Areas

Year	Date Acquired	Sensor	Cloud cover (%)	Path	Row	Resolution
1986	11/12/1986	Landsat TM	0	188	057	30m x 30m
2000	15/12/2000	Landsat 7 ETM	0	188	057	30m x 30m
2020	18/12/2020	Landsat 8 OLI_TIRS	0	188	057	30m x 30m

Source: US Geological Survey, 2020

The dataset of the imageries acquired with associated bounding co-ordinates were imported into the ArcGIS 10.5 environment. With the help of the geo-referencing modules programmed into the software and appropriate application of World Geodetic System (WGS 84), the datum (Mina datum) and the Universal Transverse Mercator (UTM 32) Systems, all the datasets for imageries were effectively geo-referenced using the bounding co-ordinates of the datasets.

Land use Change Detection and Percentage (%) Change

The land use change detection was computed for peri-urban communities surrounding Port Harcourt. The area of land use in each year (1986, 2000 and 2020) was calculated and the use of simple arithmetic was conducted by subtracting the area of land use in initial year from the final year. Thus, the area of each land use types in previous period was subtracted from the area of the same land use in the next period. The difference of this gave the land use change in terms of spatial coverage and direction of changes. The percentage change of each land use was computed to determine the percentage (%) increase or decrease of each land use using the formula below:

$\underline{\text{LU Final – LU Initial}}$ x 100 ………………………………… Equ. 1.

Thus, using map overlay analysis function in ArcGIS 10.5 environment processed imageries was super-imposed on each other. That is, processed map of year 1986 on year 2000 and on the year 2020.

Land use/Land cover classes and Vegetation assessment

Training sites were created on each image whereby, similar spectral reflectances were captured and grouped together to generate signature file for the classification. Maximum likelihood supervised classifications were performed on the landsat images. The per-pixel supervised

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

classificationgroups satellite image pixels with the same or similar spectral reflectance features into the same information categories (Campbell, 2002). The land use/land cover (LU/LC) classes identified in Port Harcourt surrounding peri-urban communities were water bodies, riparian/swamp forest, thick vegetation, farmland/sparse vegetation and the built up area (Table 2). The classified landuse images were then converted to vector format to calculate the area of landuse which included vegetation in each year in squared kilometers using spatial query module in ArcGIS 10.5. The vegetation areas were separated from other landuse to generate a spatial distribution map of vegetation only analysis for Port Harcourt peri-urban areas.

Table 2: Land use/Land cover Classification of Port Harcourt Peri-urban Areas

S/N	Land use Types	Description
1	Water bodies	Rivers, open water which are permanent, lakes, ponds, reservoirs and so on
2	Riparian/swamp forest	Low lying marshy lands, seasonal or permanent wet areas, swamps or gully sites
3	Thick vegetation	Forested areas of all kinds like thick forest, mixed forests lands or derived forest
4	Farmland/sparse vegetation	Agricultural lands that involved all types of farming like crop fields, fallow land etc.
5	Built up area	Residential, commercial and industrial areas, road networks, land development sites etc.

Results of the Analyses

Delineated Land use and Vegetal cover types in Peri-urban Communities

The land use/ land cover types for peri-urban communities are displayed on Figure 2 for year 1986, Figure 3 for year 2000 and Figure 4 for year 2020. The map analysis with respect to its land use types indicated that spatial variations were experienced in land use types and vegetal cover between 1986 and 2020.

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

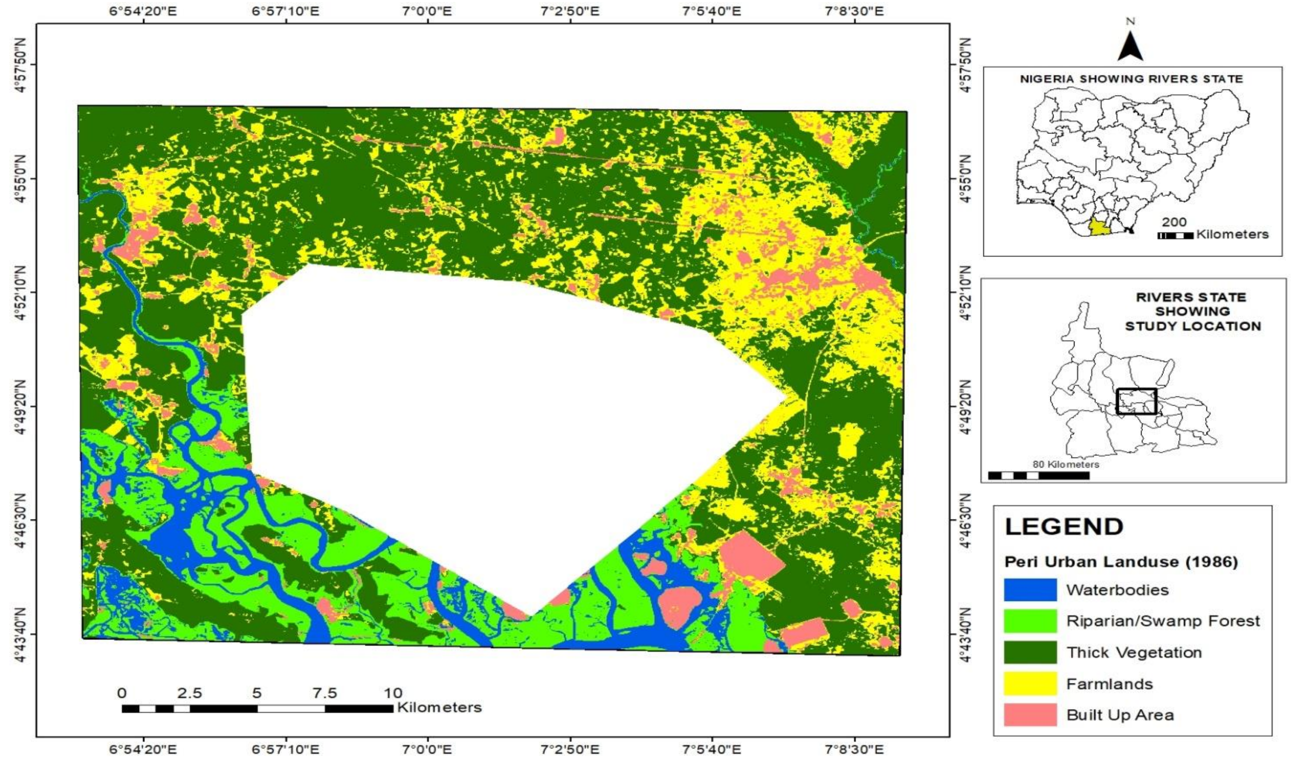

Figure 2: Land use Analysis for Peri-urban Communities around Port Harcourt in year 1986

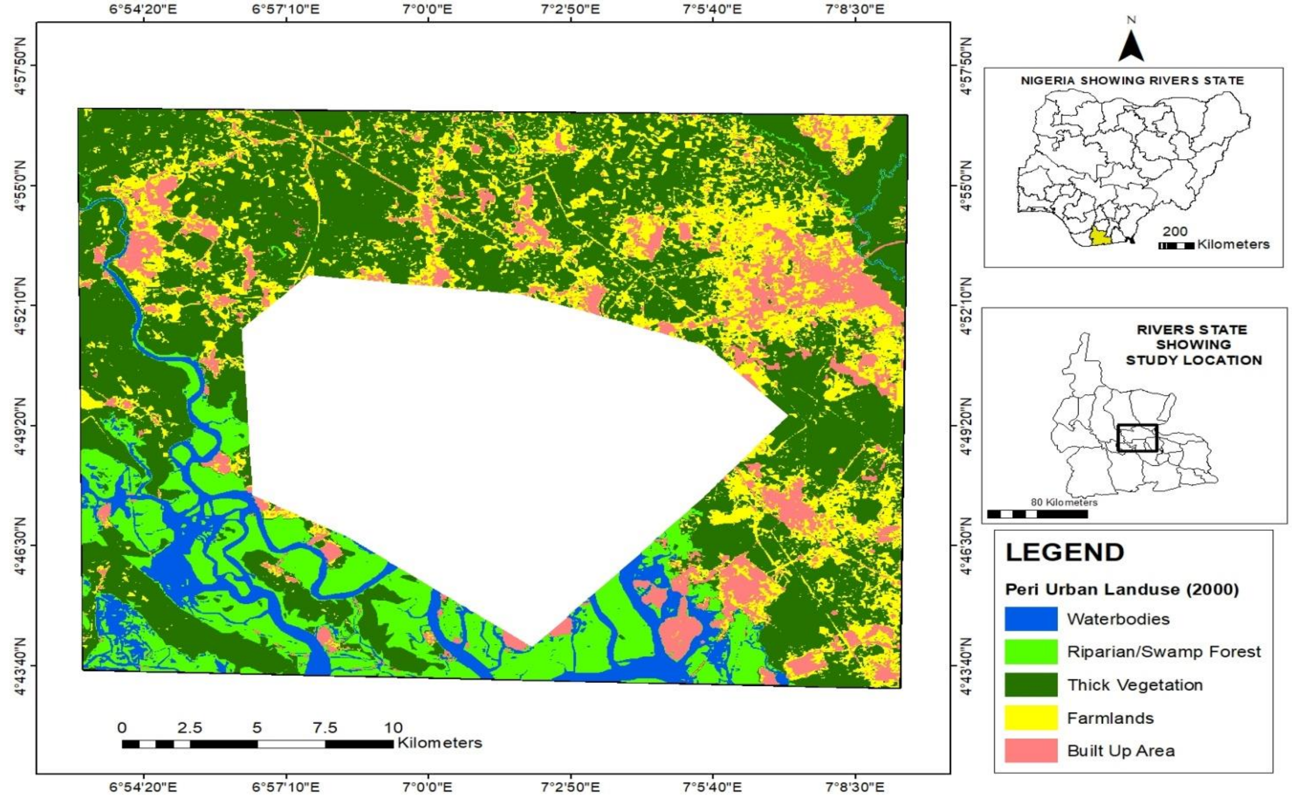

Figure 3: Land use Analysis for Peri-urban Communities around Port Harcourt in year 2000

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

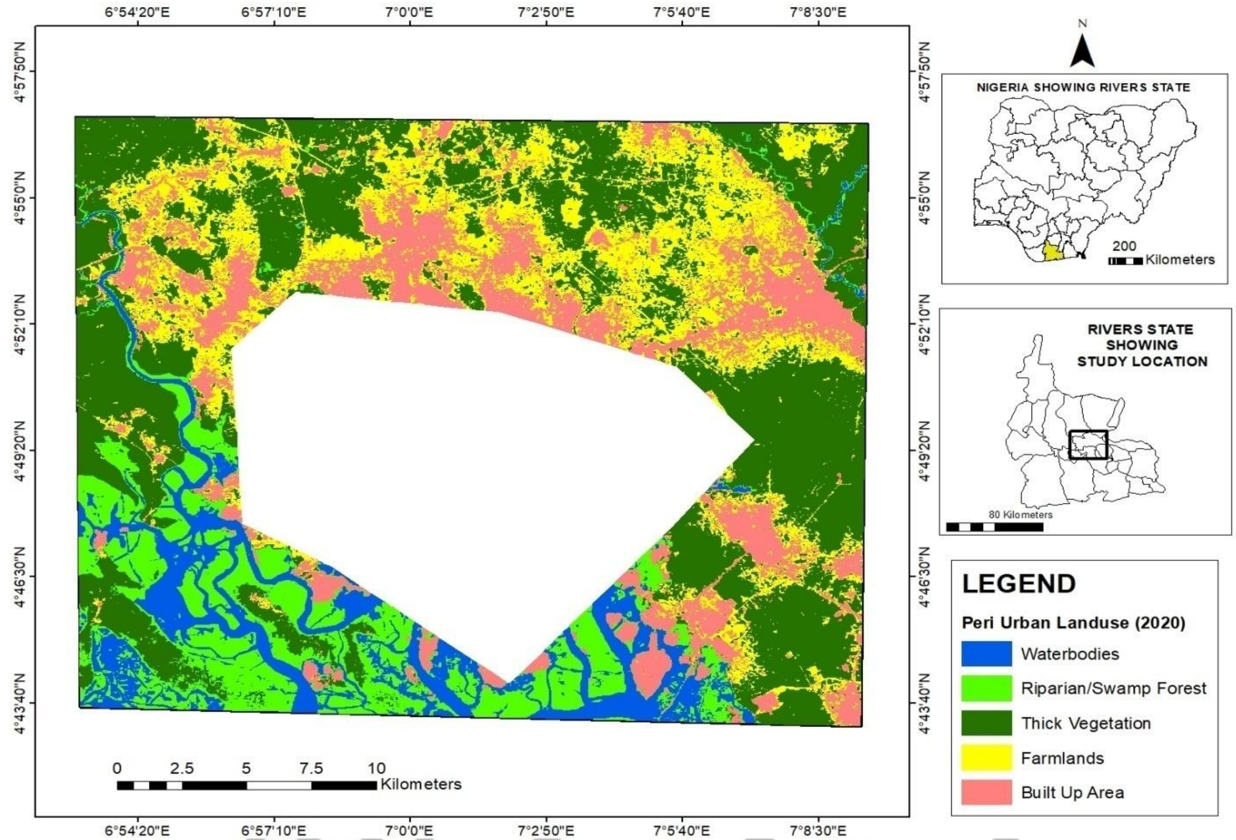

Figure 4: Land use Analysis for Peri-urban Communities around Port Harcourt in year 2020

Periodic Changes of Identified Land use and Vegetal cover between 1986 and 2020

The information for the periodic changes in land use pattern of peri-urban communities surrounding Port Harcourt between 1986 and 2020 is displayed on Table 3. It was revealed that in 1986 the spatial extent of water bodies was 43.07 km^2 which accounted for 7.96% from the total land use area of 541.1 km^2. The riparian/swamp forest in 1986 occupied 13.46% from the total land use area which was about 72.85 km^2 in relation to total size of 541.1 km^2. The spatial extent of thick vegetation was 276.58 km^2 from total land use area coverage of 541.1 km^2 which was 51.11% and this indicated half the size of the total land use coverage of 541.1 km^2. The area coverage of farmlands/sparse vegetation was 113.28 km^2 (20.94%). The size of built-up area was 35.32 km^2 which means that built up area only occupied 6.53% of the total land use/land cover area in 1986.

The land use analysis for peri-urban communities surrounding Port Harcourt analysis indicated that the spatial coverage of thick vegetation was half of the size of the total surface area of peri-urban communities surrounding Port Harcourt in the year 1986. In the year 2000, the spatial coverage of water bodies which decreased from 7.96% to 7.70% that is from 43.07 km^2 in year 1986 to 41.65 km^2 in year 2000. The size of riparian/swamp forest increased slightly from 72.85

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

km^2 in 1986 to 74.62 km^2 in 2000 which was from 13.46% to 13.79%. The size of thick vegetation reduced from 276.58 km^2 (51.11%) in 1986 to 266.98 (49.34%) in 2000. The spatial distribution of farmland/sparse vegetation also reduced from 113.28 km^2 (20.94%) in 1986 to 103.53 km^2 (19.13%) in 2000. The spatial extent of built up area of 35.32 km^2 (6.53%) in the year 1986 increased to 54.32 km^2 (10.04%) in the year 2000.

Thus, the year 2000 showed that the spatial coverage of riparian/swamp forest and built up area increased from their initial size while the spatial extent of water bodies, thick vegetation and farmlands/sparse vegetation reduced between year 1986 and year 2000. In the year 2020, the spatial coverage of water bodies increased to 54.39 km^2(10.05%) while the spatial coverage of riparian/swamp forest reduced to 71.7 km^2 (13.25%), thick vegetation also further reduced to 208.78 km^2 (38.58%). The spatial coverage of farmlands/sparse vegetation which reduced in year 2000 increased to 113.93 km^2 (20.69%) in the year 2020. The area coverage of the spatial distribution of built up area further increased to 94.3 km^2 (17.43%) in the year 2020.

This means that spatial coverage for thick vegetation decreased considerably between the year 1986 and the year 2020. That is, the spatial coverage of thick vegetation which was initially 276.58 km^2 (51.11%) in the year 1986 decreased considerably to 208.78.36 km^2 (38.58%) in the year 2020. The map analysis showing the spatial distribution for only vegetation depicted on Figure 5 for year 1986, Figure 6 for year 2000 and Figure 7 for year 2020 shows significant reductions in the spatial distribution of vegetal cover which now affected its overall size (spatial extent) between 1986 and 2020**.**

Table 3: Periodic Changes in Port Harcourt Peri-urban areas between 1986 and 2020

Land use	1986		2000		2020	
	Spatial extent (km^2)	Percentage (%)	Spatial extent (km^2)	Percentage (%)	Spatial extent (km^2)	Percentage (%)
Waterbodies	43.07	7.96	41.65	7.70	54.39	10.05
Riparian/Swamp Forest	72.85	13.46	74.62	13.79	71.7	13.25
Thick Vegetation	276.58	51.11	266.98	49.34	208.78	38.58
Farmlands/Sparse Vegetation	113.28	20.94	103.53	19.13	111.93	20.69
Built Up Area	35.32	6.53	54.32	10.04	94.3	17.43
Total	541.1	100.00	541.1	100.00	541.1	100.00

GSJ: Volume 10, Issue 12, December 2022
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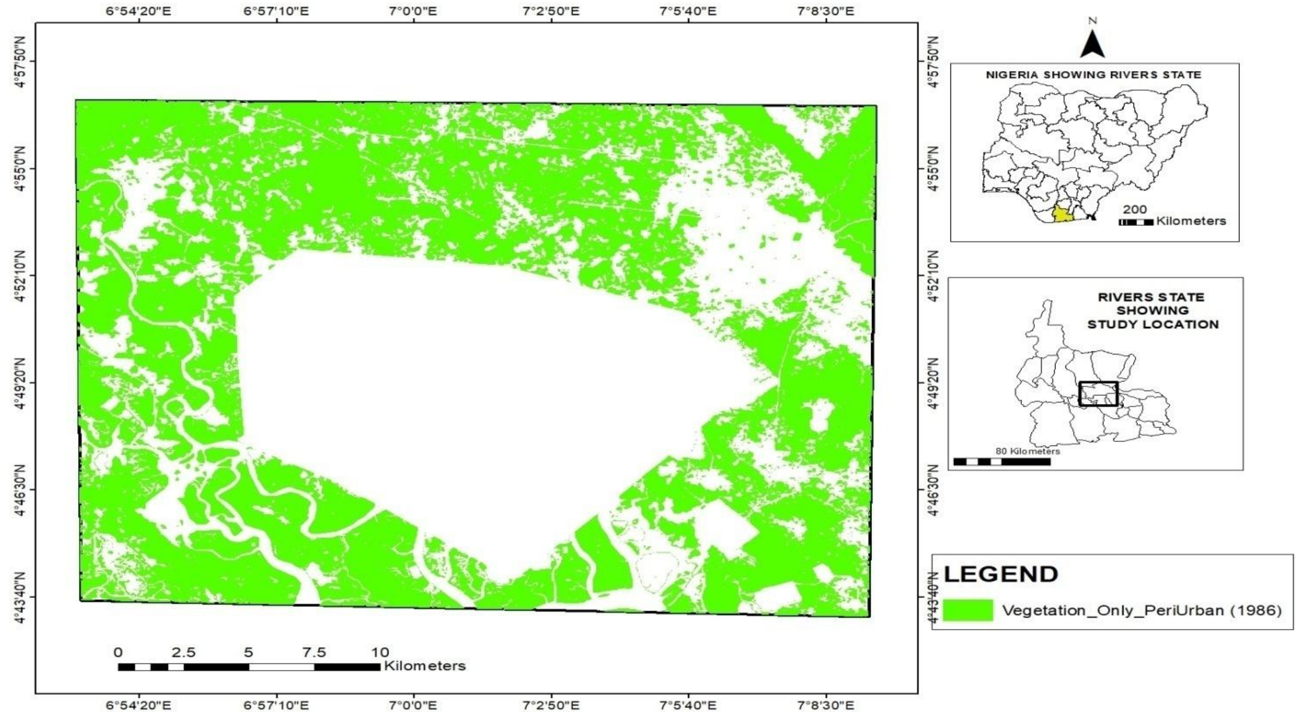

Figure 5: Spatial Coverage of Vegetation only in Peri-urban communities surrounding Port Harcourt in year 1986

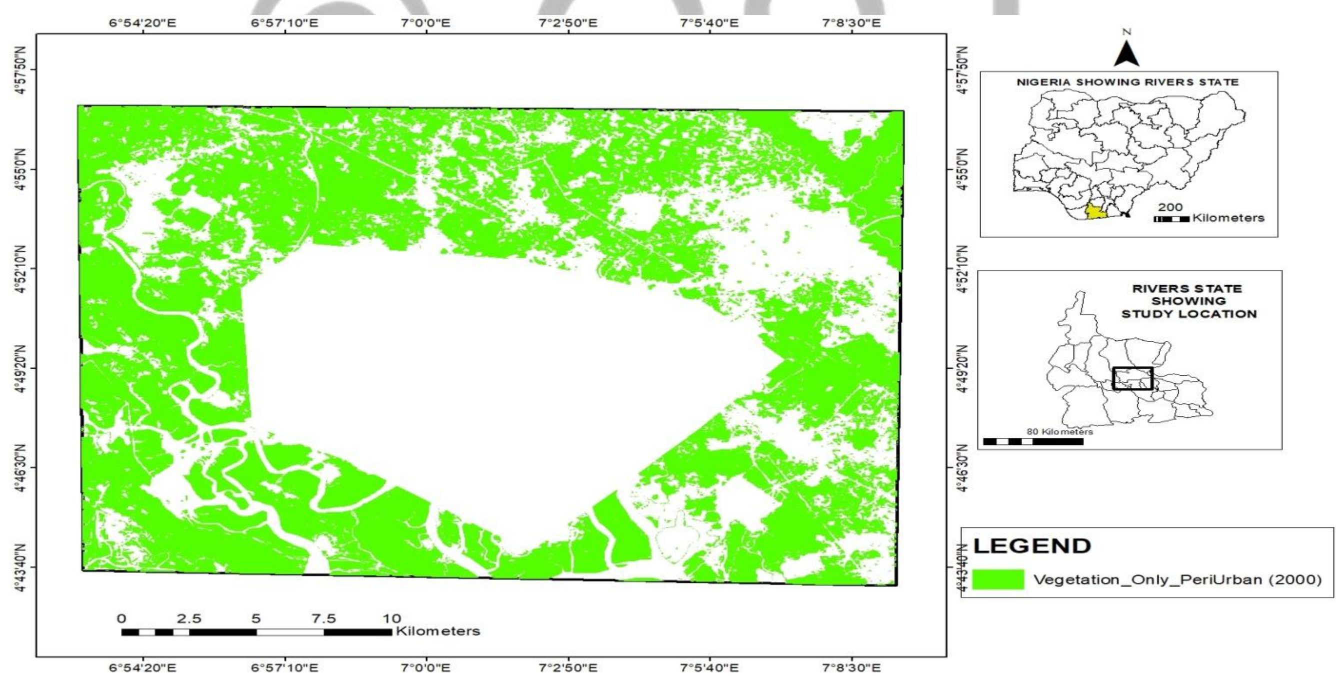

Figure 6: Spatial Coverage of Vegetation only in Peri-urban communities surrounding Port Harcourt in year 2000

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

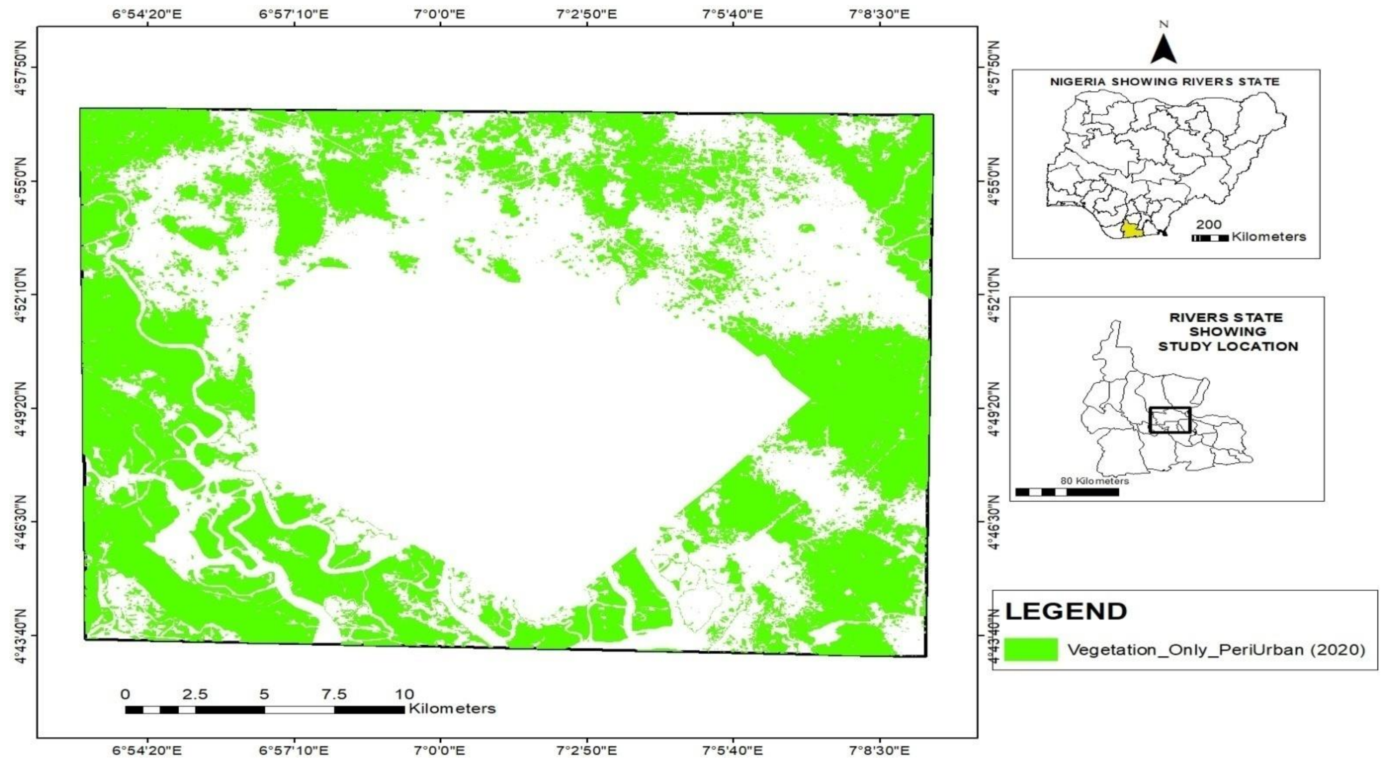

Figure 7: Spatial Coverage of Vegetation only in Peri-urban communities surrounding Port Harcourt in year 2020

Percentage Change in Land use Pattern between 1986 and 2020

The information for the change and percentage (%) change (trend) in land use pattern of identified land use types and vegetal cover for peri-urban communities surrounding Port Harcourt is displayed on Table 4. The results showed that between year 1986 and year 2000 the change and percentage change for water bodies was -1.42 km^2 and -3.30%; riparian/swamp forest recorded a change of 1.77 km^2 and a percentage change of +2.43%; the thick vegetation cover land use recorded a change of -9.6 km^2 and a percentage change of -3.47%; for farmlands/sparse vegetation the change was -9.75 km^2 and a percentage change of -8.61%; while the built up area land use recorded a change of 19 km^2 and a percentage change of +53.79%. The change and percentage change for land use types in Port Harcourt between 1986 and 2000 therefore indicated that the riparian/swamp forest, thick vegetation cover and farmland/sparse vegetation that recorded a reduction in trend of change in size (km^2) between year 1986 and year 2000 while water bodies and built up area recorded an increase in trend between 1986 and 2020.

Consequently, the trend in land use change and percentage change between 2000 and 2020 indicated that the water bodies land use recorded a change of 12.74 km^2 and a percentage change of +30.59%; the riparian/swamp forest experienced a change of -2.92 km^2 and a percentage change of -3.91% between 2000 and 2020. It was observed that a change of -21.80 km^2 and a

GSJ: Volume 10, Issue 12, December 2022
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percentage change of -67.8% were recorded for the thick vegetation land cover between year 2000 and year 2020. However, farmlands land use type experienced a positive trend of 8.4 km^2 and a percentage change of +8.11%; while the built up area land use showed a change of 39.98km^2 and percentage change of +73.60% between year 2000 and year 2020.

The overall total (change km^2 and % change) change for all identified land use types in peri-urban communities around Port Harcourt between the year 1986 and year 2020 are: water bodies (11.32 km^2 and +27.29%); riparian/swamp forest (-1.15 km^2 and -1.48%); vegetation cover recorded total change and total percentage change of -67.8 km^2 and -25.27%; farmlands showed a total change of -1.35 km^2 and total percentage change of -0.5%); while built up area recorded a total change of 58.98 km^2 and a total percentage change of +92.6%.

The study noted that only the water bodies and built up area land use types recorded increase in their percentage change overtime while the other land use types recorded a negative trend. Thus, activities in peri-urban land use areas are promoting more developed lands (built up areas) which may be as a result of the overlapping effects of infrastructural developments from the urban area which is Port Harcourt. For instance, activities like the Greater Port Harcourt have several land use change on peri-urban communities since the focus is to extend developments into the outskirts of the city. It is concluded here that urban sprawl and change in governmental policies (urban planning policies) for Port Harcourt urban center are one of the major contributors to forest depletion and vegetation loss in peri-urban communities surrounding Port Harcourt.

Table 4: Change and Percentage (%) Change in Land use Pattern of Peri-urban Communities surrounding Port Harcourt between 1986 and 2020

Land use Types	1986 (km^2)	2000 (km^2)	Change (km^2)	% change	2000 (km^2)	2020 (km^2)	Change (km^2)	% change	Total change (km^2)	Total % change (1986-2020)
Water bodies	43.07	41.65	-1.42	-3.30	41.65	54.39	12.74	+30.59	11.32	+27.29
Riparian/Swamp Forest	72.85	74.62	1.77	+2.43	74.62	71.7	-2.92	-3.91	-1.15	-1.48
Thick Vegetation	276.58	266.98	-9.6	-3.47	266.98	208.78	-58.2	-21.80	-67.8	-25.27
Farmland/Sparse Vegetation	113.28	103.53	-9.75	-8.61	103.53	111.93	8.4	+8.11	-1.35	-0.5
Built up Area	35.32	54.32	19	+53.79	54.32	94.3	39.98	+73.60	58.98	92.6

% Change = - Negative sign means reduction; + Positive sign mean increase

GSJ: Volume 10, Issue 12, December 2022
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Discussion

The spatial extent of vegetal cover has reduced overtime in the study area indicating forest degradation. The forested lands in peri-urban areas surrounding Port Harcourt have suffered much encroachments especially as the built up area land use has been increasing steadily between year 1986 and year 2020. The peri-urban communities are gradually being absorbed into the urban centre as indicated by increase in land coverage of built up area with its effect evident from all ramifications. Results showed that between 1986 and year 2020 the forest cover was converted to other land use types such as farming and mostly built up areas. Therefore, the decreasing vegetation cover is an indication that forested lands are being encroached upon resulting in forest degradation and loss in biodiversity overtime. This finding aligns with other findings that the practices associated with forests encroachment are on the increase and these activities especially construction projects causedecrease in the spatial extent of forest cover (Pellika*et al*., 2004; Eludoyin*et al*., 2011 and Eludoyin*et al*., 2017). For instance, it was noted that the results of encroachment activities are usually serious environmental degradation. These pressures emanate from activities like intensified agriculture and intensified developmental construction projects leading to decreasing amount of forested land, biodiversity and intensified land degradation.

Similarly, Audu (2013) noted that in Nigeria, over 60% of the population is engaged in agriculture with 70% of the population located in the rural areas and this provided over 80% of the food needs of the country. Thus, the increase in the spatial coverage of farmland was an indication of the fact that more lands needed to be cleared for farming purposes but unfortunately the evident effects were on the forested lands in the study area. The percentage change in land use and size of vegetation cover revealed that thick vegetation land use recorded a negative trend in the percentage change between 1986 and 2020; while the farmland and built up area land use recorded positive trend in percentage change due to gaining more land coverage between 1986 and 2020. This indicates that the built up area land use has increased because of the several expansion projects that have taken their collective toll on the thick vegetation land use. This finding corroborates Obiefuna*et al*. (2013) report which revealed that the obvious consequences of population expansion on natural resources are evident whenever need arises for socio-economic development. The urban encroachments experienced in peri-urban communities are indication that rapid urbanization generates negative impacts on the environment including changes in landscape patterns, ecosystem functions and the capacity to perform functions in support of human populations (UN-Habitat, 2010).

Conclusion and Recommendation

Findings of the study revealed that the size of forest cover (thick vegetation) reduced greatly between year 1986 and year 2020 indicating high forest loss leading to forest degradation. The study also revealed that the developmental changes arising from urban sprawl have a spill-over effects on the peri-urban land use areas.There were significant variations in land use and size of

GSJ: Volume 10, Issue 12, December 2022
ISSN 2320-9186

forest cover between the year 1986 and the year 2020 in the peri-urban areas of Port Harcourt. Furthermore, the study exposed the fact that increase in human activities for socio-economic reasons have exerted pressure on land use, thereby causing loss in forest resources overtime in the study area. It is therefore recommended that the activities contributing to high forest depletion should be regulated in the study area to discourage forest degradation and ensure the preservation of plant diversity because of its importance and the values and services it promotes among peri-urban communities. In addition, the campaign against deforestation should be taking seriously as this will inform people on the need to desist from illegal activities reshaping land use and changing land use to other land use types in the study area.

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