Urban Growth Dynamics and Land use Change in Port Harcourt Metropolis, Nigeria between 1986 and 2020

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Abstract: - This study evaluated the urban growth dynamics and landuse change in Port Harcourt Metropolis for five epochs, namely: 1986, 1990, 2000, 2010 and 2020, with the application of geo-information techniques. The landuse/land cover (LULC) classification and change detection due to urban growth on a decadal basis was retrieved from multi-temporal Landsat 4 & 5 Thematic (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI), and Thermal Infrared Sensor (TIRS) images at a spatial resolution of 30m. Supervised classification using maximum likelihood algorithm classifiers was used to classify similar spectral signatures into various major classes which included vegetation cover, farmland, water bodies, built-up area and open space/bare soil. The area of each landuse class was computed in ArcGIS 10.5 which was used to compute the landuse change and percentage change in squared kilometres. The findings indicated that the landuse pattern of the city has momentously been dynamic and most of these changes are driven by the progression in the growth of the city. Between the period of 1986 and 2020, waterbodies and built-up area increased by 3.61% and 172.59% respectively; while thick vegetation reduced by 33.06%, riparian/swamp forest and farmlands decreased by 13.02% and 19.96% respectively; signifying spatial expansion of the urban centre to the detriment of other landuses, notably thick vegetation. On the premise of the findings, the study recommends that regulatory authorities should strictly control urban growth and be dogged with the enforcement of planning regulations; landuse planning and mapping should be routine course of action for the authorities and urban growth should be frequently monitored by the governments so as to be able to detect slightest changes in the city's morphology.

Key Words: — ***Decadal, Urban, Growth, Dynamics, Landuse, Change, Metropolis.***

I. INTRODUCTION

The origin of cities can be tied to the civilisation of the river valley of Mesopotamia (contemporary Iraq), Egypt, India, and China, at which time, agriculture and home-grown cattle were the main economic stay of these territories; but in time cities expanded in dimension and would later become centres for merchandise and commercial activities (Centre of Expertise for Urban Programming (CUEP), 2018). Today, the evolution and dynamics of urban growth world over has been noteworthy both in space and time, showing a very reflective relationship with the natural environment with some accompanied feedback, which may be negative or positive. Hence, Torrey (2004) held that the increase in the world's population and its redistribution are possibly going to impact the natural systems of the earth and the relationship between the urban environments and the people.

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From these early periods, the growth of urban areas has been speedy and unprecedented, propelled by population migration in search of better opportunities occasioned by the dawn of industrialisation about 200 years ago and this growth has progressed most rapidly over the past 50 last years (CEUP, 2018). Before the 20th century, the contrast between city and rural regions was very apparent, but the trend would change in the 20th century with the experience of speedy urbanisation to the extent that there has been a gap in the consciousness among the people on the trend and how to cope with it (Gold, 2002). This situation, though analogous to 19th century urbanisation, to some extent expounds the urban crises of the late twentieth century (Gold, 2002). This modern urbanisation has seen cities with imprecise boundaries as against their historical counterparts that were delineated by walls (CEUP, 2018) or seen as self-contained entities with easily recognisable boundaries (Gold, 2002), thus defiling the historical dimensions of cities.

Thus, the size of cities has since the last two centuries metamorphosed from being comparatively enclosed settlements to being a significantly wide space stretching over kilometres of adjoining non-urban districts accommodating all landuse types, contrary to earlier times when people often live far away from their occupational, economic, commercial and social sites. This kind of growth typifies the urban sprawling phenomenon which has speedily and unprecedentedly transformed the urban texture having been instigated and boosted with the dawn of industrialisation and transport systems, and differs with the experience of early cities which were compact habitats established with defence in mind (Martins et al., 2012). This proliferation and subsequent expansion of urban areas is worse in less developed and developing countries such as those in Africa where the experience is much more rapid and unplanned (Emenike and Sampson, 2017) and without control but patterned by sprawling; thus imposing dire ecological, climatic, socio-economic, administrative and human health challenges. Hence, presently, though representing only a meagre 2% of world's total land, urban landuse is increasing speedily with the encroachment of more cities into natural ecosystems and agrarian zones (Trusilova et al., 2007) and has been doing so at a proportion greater than urban population growth rate and is expected to reach 1.5 million km^2 by 2030 rising from 58,000 km^2 from 1970 to 2000 (Seto et al., 2011 in Aina et al., 2017).

In time, this modern situations and posture of urban areas would become exacerbated because regions of the world are still urbanising and above half of the world population (55%) are currently urbanites, yet by 2050 68% (6.3 billion) of the world's people will be urban dwellers (United Nations Department of Economic and Social Affairs (UNDESA), Population Division, 2014a, 2014b and 2018) as opposed to minute 2% in 1800 (Torrey, 2004), 10% in 1900 (Grimm et al., 2008 in Ikporukpo, 2018) and 751 million in 1950 (UNDESA, 2014a, 2014b and 2018). These episodes imply that the global urban population is tripling while the world's population is doubling (Torrey, 2004). Yet there are prospects of further increase in the population of the urban with approximately 90% of this anticipated upsurge being concentrated in Asia and Africa between 2018 and 2050 (UNDESA, 2014a and b, 2018), with more than 1/3 of this growth occurring only in China, India, and Nigeria (UNDESA 2018). Suffice to say that irrespective that the desired socio-economic and improved changes are historically congruent to the course of urbanisation and the fact that urbanisation is inherently related to the three pillars of sustainable development (economic development, social development and environmental protection); this speedy, sprawling, unplanned and poorly controlled urban growth impedes the realisation of sustainable development and its goals (SDG) by the cities (UNDESA, 2014b; Aina et al., 2017).

For more than ten thousand years, humans have continued to be a strong environmental force (Wolman, 1993 in Torrey, 2004) and over eight thousand years started to alter the natural landscape with the dawn of agriculture and activities ushered by the industrial revolution (Torrey, 2004). It is arguable that contemporary landuse change is an episode been driven and facilitated by not only the factors of urbanisation but also by man's domineering attitude towards his environment all in the bid to reach self-satisfaction in all spheres. Hence Okwakpam and Mark (2021) noted that landuse change as an urban incidence is the greatest major manmade action engineered by population pressure, shift in technology, government regulations and programmes, and economic pursuit that impact the arrangement and texture of urban areas resulting to urban pressure and environmental unevenness.

Urbanisation expropriates lands and other surfaces of the natural environment and converts same into manmade structures and surfaces such as buildings, roads, parking lots, and other paved surfaces. This replacement of the natural landscape with anthropogenic structures causes change in the landuse and land cover (LULC) types and their services in the natural environment. The consequences of this transformation in turn is varied but not limited such as issues as changing the surface albedo, heat capacity, and thermal conductivity of the surface (Yang, 2015); low connectivity, loss of vegetation and evapotranspiration (Hidalgo et al. 2008 in Aguejdad et al., 2012; Kumi-Boateng et al., 2015); reduction in natural resources and loss of biodiversity (Kim and Pauleit 2007 in Ayanlade, 2016).

National and regional growth and landuse change dynamics of urban areas have been recorded by studies which revealed that in many urban areas world over, the ratio of vegetated areas and municipal open spaces that ought to have been conserved are rapidly depleted when compared to the built-up areas that have replaced them (Rosenzweig et al., 2006; Kim and Pauleit, 2007; Qiao et al., 2013; Kandel et al., 2016 in Ayanlade, 2016). Qiao et al. (2014) reported that in Beijing, China between 1989 and 2010 the urban land increased by a total of 775.82 km^2 at a rate of 184.31%, with individual increase of 469.32 km^2 occurring between 1989 and 2000, and 306.50 km^2 increase was experienced from 2000 to 2010. In

Nanjing, China the city has expanded, as indicated by the percentage of the built-up region increasing from 15.4% to 39.2% while Shenzhen has transmuted from a small town into a metropolis contesting equality with Hong Kong in just 31 years (Li et al., 2015).

Igun (2017) observed that from 2002 to 2013 as the city of Lagos expanded there was resultant decrease in the densely vegetated areas, farmlands, deep water body, and bare surface and shallow water; while the spatial extent of the built-up areas typified by highly dense areas, moderately dense areas and less dense areas increased by 3.35% (2200.77 ha), 27.87% (13681.35 ha), 6.20% (3284.01 ha) respectively. Still in Lagos, Ayanlade (2017) reported that between 2002 and 2014 remarkable change in LULC was experienced to the tune that urban core and urban fringe increased by 15.93% and 94.49% respectively, while forested area and wetland diminished by 5% and 8% respectively. Musa et al. (2012) in their study recorded that in Abuja as at 1986 vegetated area was the largest LULC type covering an area of 3835.62 km^2 which represents 86.22% of the total land area, while habited area was the least LULC type covering an area of 617.315 km^2 which represents 13.78% of the total land area of the city. But from 2002 to 2006, while vegetated areas declined, habited area grew to 932.957 km^2 (20.80%). In all, between1986, 2002 and 2006, built up area has expanded from 17.88% of the total land area of Abuja in 1986 to 27.02% in 2006, while vegetation covers reduced from 47.23% to 37.79% within the period.

In Sokoto, Ogunjobi et al. (2018) reported that the LULC in the order of magnitude as at 1986 was bare soil (circa 71%), farmland (13%), vegetation (12.3%), built-up (1.8%) and water body (1.6%). But by 2016 (30 years after), the area covered by bare land had dropped to 56.5%, though remained the major LULC in Sokoto; farmland increased slightly to 13.2%; built-up increased tremendously to 7.4%; vegetation also increased to 19.7% and water body decreased to 1%. This trend shows that the three predominant LULC ranking higher than the urban built up are bare land, farmland and vegetation and is quite opposite to popular views and expectations such as the observation of Musa et al. (2012) in Abuja and Igun (2017) in Lagos where built-up land use gulped more space than any other. The reason for this trend in Sokoto may not be unconnected with the fact that it has vast land mass, its people are majorly agrarian and it is desert prone. The findings of Srivanit et al. (2012) revealed that the unplanned, sprawling and uncontrollable urbanisation and subsequent rapid expansion of urban landuse in Bangkok has led to depreciation or loss of agricultural landuse adjacent the city. In this city, the urban/built-up area nearly tripled from 1994 to 2009, as it rose from 15% in 1994 to 42% in 2009; while vegetated area on the other hand decreased from 72% in 1994 to 40% in 2009 (Srivanit et al., 2012).

The experience of LULC in Delhi show that in the past decade agricultural land use reduce by 17% around the urban fringes while greatly dense residential area increased by 122% due to encroachment and colonisation of peripheral zones by urbanisation (Rhaman et al., 2009). Similarly, in the Sekondi-Takoradi Metropolis (SKM) of Ghana, Kumi-Boateng et al. (2015) reported that urban areas have increased by 83.04% while non-urban areas have decrease by 36.72%, occasioned by the transformation of substantial vegetative areas and other natural land covers into diverse urban uses. Recently, Okwakpam and Mark (2021) in their spatio-temporal assessment of landuse dynamic of Port Harcourt Metropolis between 1990, 2000 and 2020 found that between 1990 and 2020, waterbodies increased by 20.37 km^2 (72.11%), thick vegetation decreased by 30.39 km^2 (25.45%), wetlands decreased by 78.62 km2 (63.80%) while built up area/open lands increased by 127.95 km^2 (150.28%), indicating that waterbodies and built up area landuses increased in terms of areal extent while thick vegetation and wetlands continued to decrease between 2000 and 2020.

Similar results as that of Okwakpam and Mark (2021) were earlier obtained by Wali et al. (2019) in their study on landuse and land cover changes in the wetland ecosystem of Port Harcourt Metropolis for 4 epochs (1984, 1999, 2003 and 2013) and Wizor and Eludoyin (2020) in their study on landuse/land cover changes in the University of Port Harcourt host communities (Choba, Aluu and Alakahia) between 2005-2010 and 2010-2015, in that built-up areas tremendously increased in all the periods investigated due to urban growth; while vegetated area, farmland and wetlands decreased.

Granted from the foregoing that studies have been carried out in the domain of urbanisation dynamics and landuse change, and it is evident from these studies that urbanisation and its continuous progression has a corresponding effect on landuse and land cover in a negative direction to the natural environment irrespective of region and natural features such as arid land, forested land, agricultural land or wetland. Nevertheless, in the case of the Niger Delta and particularly Port Harcourt, such studies are spatio-temporarily clearly limited in scope both in terms of quantity and epochal dimension, unlike this study which considered five epochs. Therefore, the study focused on the evaluation of the landuse change pattern and the decadal urban growth dynamics in Port Harcourt Metropolis between 1986 and 2020.

II. MATERIALS AND METHODS

Port Harcourt Metropolis is located between latitudes 4o 44’ 58.8’’N and 4o 56’ 4.6’’N and longitudes 6o 52’ 7.2’’E and 7o 7’ 37.7’’E. The climate of the city is tropical humid with prolonged and heavy rainy seasons and very wee dry seasons. Amount of sunshine in Port Harcourt city is very copious with average temperatures of between 25°C-28°C (Ogbonna et al., 2007). The existence of numerous surface water and heavy rainfall of between 2000mm and 2400mm leaves Port Harcourt with poor drainage (Mmom and Fred-Nwagwu, 2013). The city has an elevation less than 15.24m and is largely webbed by low lying coastal plains, which structurally is representative of the sedimentary formation of the contemporary Niger Delta (Oyegun and Adeyemo, 1999; Chiadikobi et al., 2011).

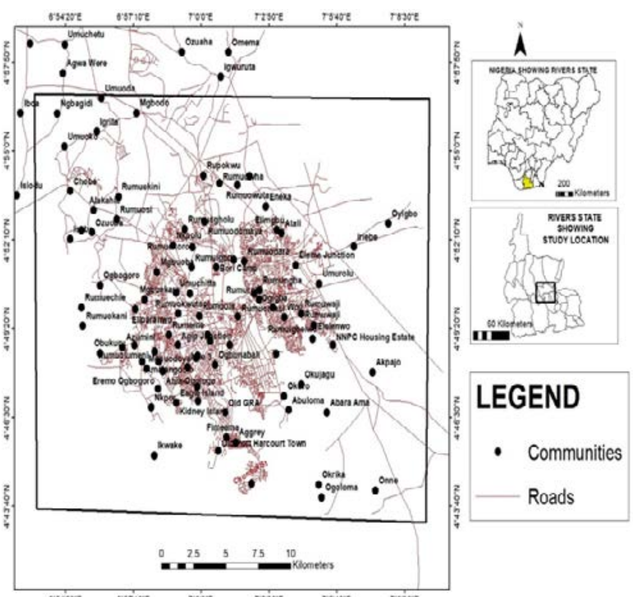

Figure 2.1: Port Harcourt Metropolis showing communities

Landsat satellite imageries were used to evaluate the landuse changes due to urban growth. The landuse/land cover (LULC) classification and change detection arising from urban growth from 1986 to 2020 on a decadal basis was retrieved from multi-temporal Landsat 4 & 5 Thematic (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI), and Thermal Infrared Sensor (TIRS) images at a spatial resolution of 30m (Kumi-Boateng et al., 2015; Tu et al., 2016; Ogunjobi et al., 2018).

Landsat images were used because of their ability to have valuable and continuous records of the earth’s surface for identifying and monitoring changes in man-made and physical environments (El Bastawesy, 2014). The images were enhanced by combining image bands. A false colour composite band sequence 5, 4, 2, RGB was used for classifying the land cover. The combination of channel 5 (red), channel 4 (green) and channel 2 (blue) is effective in discriminating different vegetal cover types (Enaruvbe and Atafo, 2014). Information from each land cover classes were collected from extensive field survey before the classification of satellite imageries (Balogun *et al.*, 2011). The field survey was performed throughout the study area with the use of global positioning system (GPS) to track the coordinates of the sample points in each landuse/land cover. The sample points helped to delineate the training sites which were be clearly mapped in the image in order to denote the various land use/land cover types by various classes.

Thereafter, supervised classification using maximum likelihood algorithm classifiers (Lillesand and Kiefer, 1994; Tu *et al*., 2016) was used to classify similar spectral signatures into various major classes which included vegetation cover, farmland, water bodies, built-up area and open space/bare soil. Maximum likelihood classifier was chosen because it is the most widely adopted parametric classification algorithm (Manandhar *et al*., 2009). The area of each landuse class was computed in ArcGIS 10.5 which was used to compute the landuse change and percentage change in squared kilometres. The percentage change was computed using equation (1) as given in Enaruvbe and Atedhor (2015).

$$\frac{\left(\frac{d}{t1}\right) * 100}{y2-y1} \qquad \text{Eqn. 1}$$

Where,

d is the difference in the value of area covered by a land cover category at the initial time point and final time point

t_1 is the value of the area covered by a land cover category in the initial time point

y1 and y2 are base year and final year respectively.

Table.1. Characteristics of Imagery for Port Harcourt Metropolis

Year	Path	Row	Sensor	Date of Acquisition	Resolution	Source
1986	188	057	Landsat 5 TM	1986-12-19	30m	United States Geological Survey
1990	188	057	Landsat 4 TM	1990-01-07	30m	United States Geological Survey
2000	188	057	Landsat 7 ETM	2000-12-17	30m	United States Geological Survey
2010	188	057	Landsat 7 ETM	2010-12-21	30m	United States Geological Survey
2020	188	057	Landsat 8 OLI/TIRS	2020-01-31	30m	United States Geological Survey

Source: US Geological Survey, 2020

III. RESULTS AND DISCUSSIONS

3.1 Landuse Pattern of Port Harcourt Metropolis between 1986 and 2020

The landuse pattern of Port Harcourt Metropolis between 1986 and 2020 is shown in Table 2. The analysis reveals that in 1986 Waterbodies covered a total area of 53.71 km^2 (7.19%), riparian/swamp forest covered 95.91 km^2 (12.84%), thick vegetation covered 336.65 km^2 (45.06%), farmlands covered 170.5 km^2 (22.82%), while built-up area covered 90.31 km^2 (12.09%). In 1990, waterbodies had a spatial coverage of 53.83 km^2 (7.21%), riparian/swamp forest had 83.56 km^2 (11.18%), thick vegetation had 364.87 km^2 (48.84%), farmlands had 142.75 km^2 (19.11%) while built up area had 102.07 km^2 (13.66%). In 2000, waterbodies had a spatial coverage of 53.88 km^2 (7.21%), riparian/swamp forest had 94.86 km^2 (12.7%), thick vegetation had 304.74 km^2 (40.79%), farmlands had 143.62 km^2 (19.22%) while built-up area had 149.98 km^2 (20.08%). The analysis further showed that in 2010, waterbodies represented 57.3 km^2 (7.67%) areal, riparian/swamp forest represented 93.93 km^2 (12.57%), thick vegetation represented 3313.15 km^2 (41.92%), farmlands represented 105.31 km^2 (14.10%), while built-up area represented 177.39 km^2 (23.74%). Lastly, in 2020, it is discovered that waterbodies covered 55.65 km^2 (7.45%), riparian/swamp forest covered 83.42 km^2 (11.17%), thick vegetation covered 225.36 km^2 (30.17%), farmlands covered 136.47 km^2 (18.27%) and built-up area covered 246.18 km^2 (32.95%).

Table.2. Landuse Pattern of Port Harcourt Metropolis between 1986 and 2020

Land use	1986		1990		2000		2010		2020	
	Areal coverage (km^2)	Percentage (%)	Areal coverage (km^2)	Percentage (%)	Areal coverage (km^2)	Percentage (%)	Areal coverage (km^2)	Percentage (%)	Areal coverage (km^2)	Percentage (%)
Water bodies	53.71	7.19	53.83	7.21	53.88	7.21	57.3	7.67	55.65	7.45
Riparian/ Swamp Forest	95.91	12.84	83.56	11.18	94.86	12.7	93.93	12.57	83.42	11.17
Thick Vegetation	336.65	45.06	364.87	48.84	304.74	40.79	313.15	41.92	225.36	30.17
Farmlands	170.5	22.82	142.75	19.11	143.62	19.22	105.31	14.10	136.47	18.27
Built Up Area	90.31	12.09	102.07	13.66	149.98	20.08	177.39	23.74	246.18	32.95
Total	**747.08**	**100**	**747.08**	**100.00**	**747.08**	**100**	**747.08**	**100.00**	**747.08**	**100**

Source: Researcher's Analysis, 2021.

3.2 Magnitude of Landuse change and percentage change between 1986 and 2020 in Port Harcourt Metropolis

The magnitude of landuse change and percentage change in Port Harcourt Metropolis between 1986 and 2020 is presented in Table 3. The analysis revealed that between 1986 and 1990, waterbodies, thick vegetation and built-up area increased by 0.22%, 8.38% and 13.02% respectively; while riparian/swamp forest and farmlands reduced by 12.88% and 16.28% each. Between 1990 and 2000, it is observed that waterbodies, riparian/swamp forest, farmlands, built up area each increased by 0.09%, 13.52%, 0.61% and 46.94%; while thick vegetation decreased by 16.48%. Between 2000 and 2010, waterbodies, thick vegetation and built-up area increased by 6.35%, 2.76% and 18.28% respectively; while riparian/swamp forest and farmlands reduced by 0.98% and 26.67%. The analysis also showed that between 2010 and 2020, farmlands and built-up area increased by 29.59% and 38.78 each; whereas waterbodies, riparian/swamp forest and thick vegetation reduced in space by 2.88%. 11.19% and 28.035 respectively (see figures 3.1, 3.2, 3.3, 3.4 and 3.5). Generally, between the period of 1986 and 2020, whereas waterbodies and built-up area increased by 3.61% and 172.59% each; riparian/swamp forest, thick vegetation and farmlands decreased by 13.02%, 33.06% and 19.96% respectively. This signifies spatial expansion of the urban built-up area to the detriment of other landuses.

A critical look at the results reveals that water bodies gradually increased in space in all the epochs with its maximum size of 57.3 km^2 (7.67%) reached in 2010; while riparian/swamp forest slightly decreased in all the epochs with its least coverage of 83.42 km^2 (11.17%) reached in 2020. Similarly, space covered by farmlands hugely decreased in all the eras from 170.5 km^2 (22.82%) in 1986 to 136.47 km^2 (18.27%) in 2020. Apart from the 1990 when thick vegetation experienced the highest coverage area of 364.87 km^2 (48.84%), in all other epochs it experienced consecutive decrease in its spatial coverage with 225.36 km^2 (30.17%) been the least reached in 2020. Conversely, built-up area geometrically increased in spatial coverage in all the periods beginning with 90.31 km^2 representing 12.09% of the total land space in 1986 to 246.18 km^2 representing 32.95% of the total land area and being the landuse with the highest coverage in 2020.

The epochal records show that with a spatial coverage of 336.65 km^2 representing 45.06% of the gross land area of the city, thick vegetation was the landuse with the biggest coverage in Port Harcourt in 1986; while waterbodies was the least with a meagre coverage of 53.71 km^2 representing 7.19% of the city's land space. Likewise in 1990, thick vegetation was also the landuse with the largest coverage (364.87 km^2) representing 48.84%, which indicates an increase in its spatial extent; while waterbodies was also the least with a coverage of 53.83 km^2 representing 7.21% of the city's land space also signifying a slight increment in its coverage. In year 2000, though thick vegetation was still the landuse with the largest coverage with 304.74 km^2, the 40.79% of the overall land area it represented is an indication of decrease compared to the two previous eras. In this same 2000, waterbodies was again the landuse with the smallest coverage (53.88 km^2) representing 7.21% of the total land area.

The records for 2010 presents thick vegetation as the landuse with the largest coverage in space (313.15 km^2) representing 41.92% of the gross land area; while waterbodies yet remained the landuse with the least coverage (57.3 km^2) representing 7.67%. Nevertheless, in 2020, thick vegetation lost its first position to built-up area as the landuse with the largest coverage which tremendously gulped 246.18 km^2 of the total land space representing 32.95%, thus making it the major landuse type in Port Harcourt. Waterbodies again maintained its stance as the landuse with the least coverage (55.65 km^2) representing 7.45%, which is indicative of an increment. In general, between the period of 1986 and 2020, whereas waterbodies and built-up area increased by 3.61% and 172.59% each; thick vegetation reduced by 33.06%, riparian/swamp forest and farmlands decreased by 13.02% and 19.96% respectively. This signifies spatial expansion of the urban centre to the detriment of other landuses, notably thick vegetation.

These epochal analyses indicate that the built-up area which covers the urban, residential, commercial, educational, transportation, industrial, administrative, and recreational land use types exemplifying the urban area, has increased in spatial coverage; whereas other landuse covers notably thick vegetation, riparian/ swamp forest and farmlands have decreased in size. Some of these findings are analogous to earlier findings of Wali et al. (2019), Wizor and Eludoyin (2020) and Okwakpam and Mark (2021).

Table.3. Magnitude of Landuse change and percentage change between 1986 and 2020 in Port Harcourt

Landuse	**1986**	**1990**	**Change (km^2)**	**Percentage Change (%)**
Waterbodies	53.71	53.83	0.12	0.22
Riparian/Swamp Forest	95.91	83.56	-12.35	-12.88
Thick Vegetation	336.65	364.87	28.22	8.38
Farmlands	170.50	142.75	-27.75	-16.28
Built Up Area	90.31	102.07	11.76	13.02
Total	**747.08**	**747.08**		

Landuse	**1990**	**2000**	**Change (km^2)**	**Percentage Change (%)**
Waterbodies	53.83	53.88	0.05	0.09
Riparian/Swamp Forest	83.56	94.86	11.30	13.52
Thick Vegetation	364.87	304.74	-60.13	-16.48
Farmlands	142.75	143.62	0.87	0.61
Built Up Area	102.07	149.98	47.91	46.94
Total	**747.08**	**747.08**		
Landuse	**2000**	**2010**	**Change (km^2)**	**Percentage Change (%)**
Waterbodies	53.88	57.30	3.42	6.35
Riparian/Swamp Forest	94.86	93.93	-0.93	-0.98
Thick Vegetation	304.74	313.15	8.41	2.76
Farmlands	143.62	105.31	-38.31	-26.67
Built Up Area	149.98	177.39	27.41	18.28
Total	**747.08**	**747.08**		
Landuse	**2010**	**2020**	**Change (km^2)**	**Percentage Change (%)**
Waterbodies	57.30	55.65	-1.65	-2.88
Riparian/Swamp Forest	93.93	83.42	-10.51	-11.19
Thick Vegetation	313.15	225.36	-87.79	-28.03
Farmlands	105.31	136.47	31.16	29.59
Built Up Area	177.39	246.18	68.79	38.78
Total	**747.08**	**747.08**		
Landuse	**1986**	**2020**	**Change (km^2)**	**Percentage Change (%)**
Waterbodies	53.71	55.65	1.94	3.61
Riparian/Swamp Forest	95.91	83.42	-12.49	-13.02
Thick Vegetation	336.65	225.36	-111.29	-33.06
Farmlands	170.50	136.47	-34.03	-19.96
Built Up Area	90.31	246.18	155.87	172.59
Total	**747.08**	**747.08**		

Source: Researcher's Analysis, 2021.

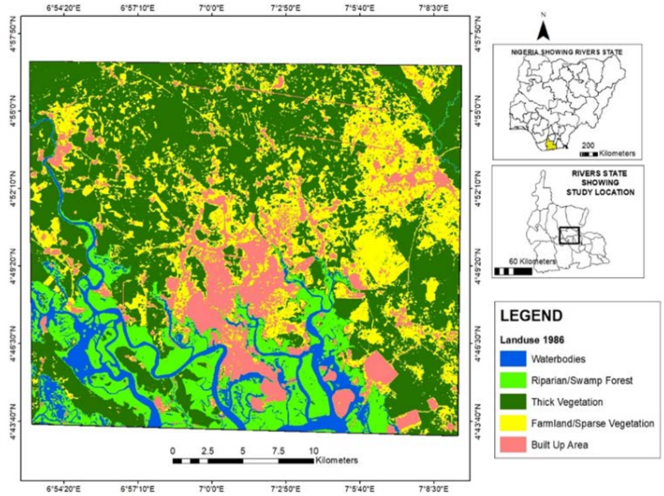

Figure 3.1: Landuse of Port Harcourt City in 1986

Source: Researcher's Analysis, 2021

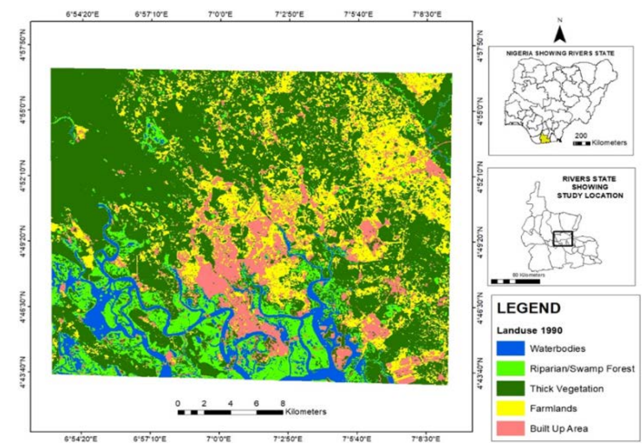

Figure 3.2: Landuse of Port Harcourt City in 1990

Source: Researcher's Analysis, 2021

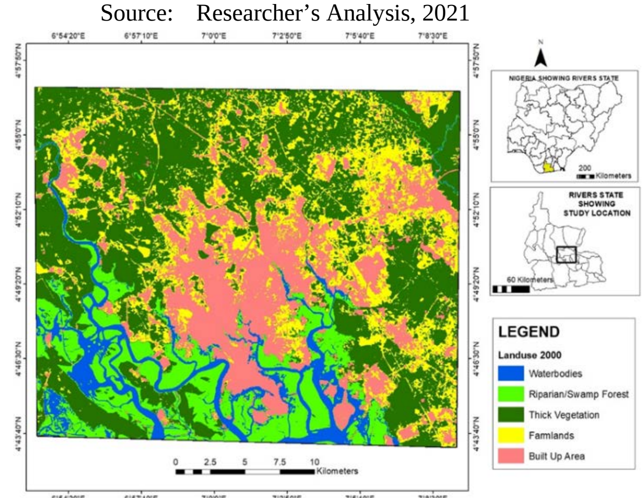

Figure 3.3: Landuse of Port Harcourt City in 2000

Source: Researcher's Analysis, 2021

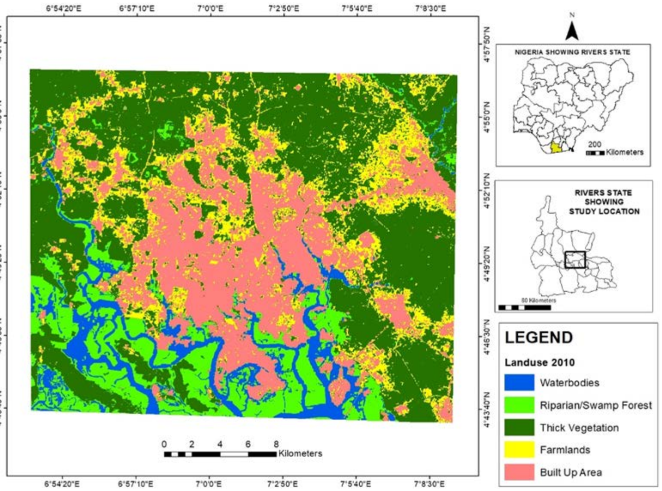

Figure 3.4: Landuse of Port Harcourt City in 2010
Source: Researcher's Analysis, 2021

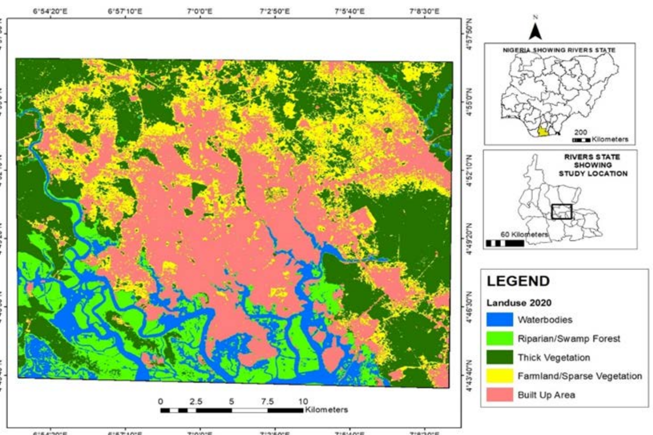

Figure 3.5: Landuse of Port Harcourt City in 2020
Source: Researcher's Analysis, 2021

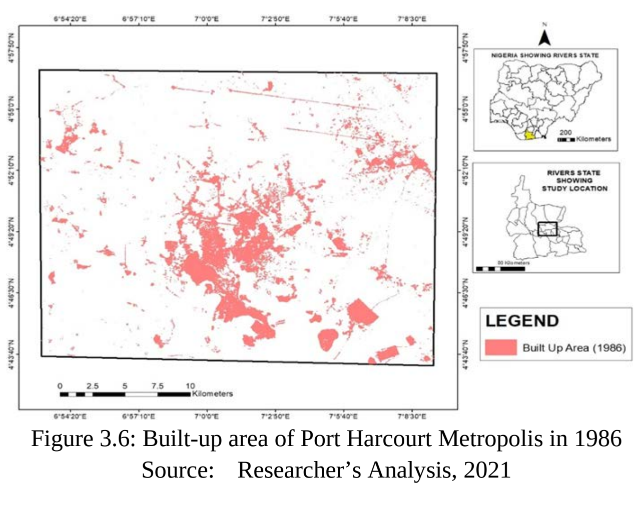

Figure 3.6: Built-up area of Port Harcourt Metropolis in 1986
Source: Researcher's Analysis, 2021

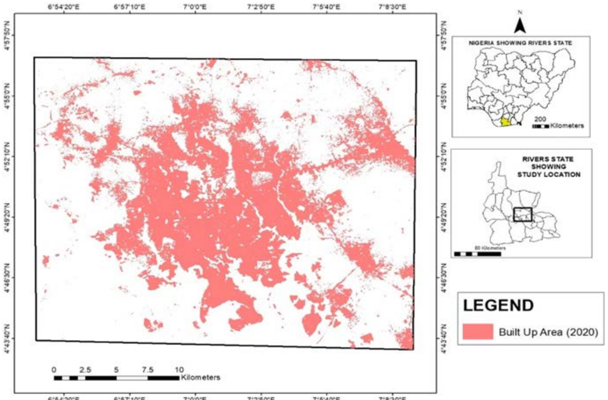

Figure 3.7: Built-up area of Port Harcourt Metropolis in 2020
Source: Researcher's Analysis, 2021

IV. CONCLUSION AND RECOMMENDATIONS

The study assessed the decadal urban growth dynamics and landuse change in Port Harcourt Metropolis for five epochs (1986, 1990, 2000, 2010 and 2020) with the aid of Remote Sensing and GIS techniques. The findings indicate that the landuse pattern of the city has momentously been dynamic over the years and most of these changes are driven by the progression in the growth of the city. Between the period of 1986 and 2020, waterbodies and built-up area increased by 3.61% and 172.59% respectively; while thick vegetation reduced by 33.06%, riparian/swamp forest and farmlands decreased by 13.02% and 19.96% respectively. This signifies spatial expansion of the urban centre to the detriment of other landuses, notably thick vegetation. Hence, the built-up area which covers the urban core, residential, commercial, educational, transportation, industrial, administrative, and recreational land use types exemplifying the urban area, has increased in spatial coverage; whereas other landuse covers notably thick vegetation, riparian/ swamp forest and farmlands have decreased in size.

On the premise of the findings, the study recommends as follows:

- Regulatory authorities should strictly control urban growth and be dogged with the enforcement of planning regulation.
- Landuse planning and mapping should be routine course of action for the authorities which must be updated at regular intervals.
- Urban growth should be frequently monitored by the governments so as to be able to detect slightest changes in the city's morphology.

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