Spatio- Temporal Land Use Dynamics of Port Harcourt Metropolis, Rivers State, Nigeria

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Abstract: **Assessing spatio-temporal dynamic of land use of Port Harcourt Metropolis is very important. Such assessment provides basic information for appropriate decision-making. Utilizing quasi-experimental design of satellite images of Port Harcourt Metropolis between 1990 to 2020, the study identified built up area, waterbodies, farmland/sparse vegetation as the land use type. The study revealed that percentage change of waterbodies is 48.62 km^2 (10.61%) and built up area landuses 213.09 km^2 (46.50%); respectively increased in terms of areal extent while thick vegetation 89.13 km^2 (19.45%) ,wetlands size 44.61 km^2 (9.74%) and farm/spares vegetation land uses continued to decrease between 2000 and 2020. The results not only confirmed the applicability and effectiveness of the combined method of remote sensing and metrics, but also revealed notable spatio-temporal features of land use. The study indicates that the increase rate of built up area and other land use types are continuously at opposite direction due to urban expansion or urban sprawl. The study recommended that; adequate and continuous monitoring of landuse should be made by utilizing satellite remote sensing; there should be adequate land use planning and conservation management in the study area.**

***Key Words*: Spatio, Temporal, Land use, dynamics, Port Harcourt**

I. INTRODUCTION

Land use change has emerged as a phenomenon and the most significant anthropogenic activity affecting the urban structure through demographic pressure, changes in technology, state policy, and economic leading to urban stress and ecological imbalance. The extent and effects land use change is occurring without corresponding public policy planning to cope with the very rapid rate of change in most cities such as Port Harcourt is alarming. The current imprint on land use in Port Harcourt Metropolis is obvious and suffers from disproportionate landuse burden because of the unique and sensitive developmental activities, which the inhabitants neither inspire nor desire these developmental processes and experience great difficulty in adapting to the situation and, which often instead of leading to an overall enhancement, in fact in most cases exert adverse impacts on urban environment and considerable socio-economic damage to the inhabitants (Okwakpam & Epelle, 2013).

Land is the most valuable resource that encourages man's existence on earth. Land describes the way and purpose for which human beings exploit the land and its resources. In recent time, the term 'land' has been broadened from vegetation such as forest or grass cover to include other things such as human structure, soil type, *biodiversity*, surface and ground water (Millenium ecosystem assessment, 2005); it could be linked of crop land, forest, wetland, pasture, roads, and urban areas among others (FAO,1989). The transformation of land in the natural landscape, mainly driven by urban growth or an alteration in the way certain area of land is being used or managed by humans requires human intervention, both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used (Turner, Skole, Sanderson, Fischer, Fresco, and Leemans, 1995).

Land use represents a functional relationship between the existing population of areas and available land (Patel et al., 2019); a general term used for the human modification of Earth's terrestrial surface. It reflects the way in which, and the purpose for which, human beings utilize the land and its resources (Meyer 1996); Land use concerns the products and/or benefits obtained from use of the land as well as the land management actions (activities) carried out by humans to produce those products and benefits. It is an outcome of natural and socio-economic factors and their utilization by Man in time and space for different uses legally or illegally. Many of the environmental problems are inevitable results of unplanned urban space (Elfadaly, Wafa, Abouarab, Guida, Spanu, & Lasaponara 2017); usually with emphasis on the functional role of land in economic activities; which are directly related to the land. Land use change is one of the main drivers of environmental changes. In the recent times, studies have shown importance of the use of Landsat data for assessing dynamic change of land use. This is now well established by many authors, for example; the use of the band six of Landsat TM data for getting thermal information (Southworth 2004): Transforming urban space to different land use of residential, commercial, industrial and institutional (Swangjang and Iamaran, 2011); assessing land use changes and its impact on the land surface temperature (LST) (Buyadi et al. 2013): dynamism of land use changes in surface temperature for a particular case study in Kenya (Kayet et. al, 2016); Monitoring landuse land cover change in Northern eastern Latria (Fonji & Taff 2014); Classification of land use in an arid region using multi spectral satellite images (Pande, Moharir, Khadri & Patil, 2018); Assessing the land use and land cover in Kashmir (Alam, Bhat & Maheen, 2020); land use balance determination in South Sulawesi Province, Indonesia (Sange, Djainal & Dem; 2021); Application of satellite imageries and GIS for Land use and Land cover change Mapping in an estuarine Watershed (Yang & Liu, 2007).

Assessment of land use is increasingly becoming important in building urban structure; helping in curbing the problems of haphazard, uncontrolled development. It serves as important instrument for monitoring the dynamics of land use land cover arising from the demands of an increasing population pressure in urban area (Pande, 2014). Land use land cover change is an important measurement for assessing spatial temporal change in an urban environment. In urban environment there is the need for articulate techniques and strategies for using geo-spatial data as ancillary information to improve the result of the land-cover classification Since land use is not an event but a process, it can be understood and forecasted quite well before time. Understanding land use and land cover helps in preserving urban natural resources.

One of the important factors in building urban structure is having data on existing land use and assessing the rate of changes in land use through time. In the present study, an effort is made to identify the land use change in the study area with the help of remote sensing and Geographical Information System (GIS) based approach. Since remote sensing is a powerful tool for obtaining spatial and temporal information within a small period, this method proved itself one of the best methods for change detection. Thus the need to put in place short and long term preparedness and environmental management strategies which require geospatial data and information gives credence to this study. This is very necessary in view of the fact that knowledge of the present distribution and area of urban lands as well as information on their changing proportions is needed by legislators, planners, and local government official to determine better land use policy, to identify future development pressure points and areas, and to implement effective plans for urban development. In view of the above, the study will focus on the spatial-temporal land use change of Port Harcourt metropolis from 1990 to 2020. The result of the study will enhance spatial planning and policy making for sustainable land use in the study area.

II. STUDY AREA

Geographical coordinate of Port Harcourt is $4^{0}49'27'$N and $7^{0}21'$E. The climate of Port Harcourt metropolis falls within the sub equatorial belt. Temperature and humidity are high throughout the years. This soil is organic in nature, mangrove swamp alluvial soil is found in the north to the coastal sediments zone and they are brownish on the surface. Port Harcourt metropolis is the hub of the petroleum industry of Nigeria. Aside the petroleum industry, there are companies in the manufacturing sector and the maritime sector making the study area a nodal point for trade. The high influx of people, influenced by urbanization or urban sprawl; continuous demand for housing, modern urban amenities, medical and educational facilities, as well as services resulted in unplanned land use of the Metropolis (Okwakpam, 2021). Poor land use planning is a contributing factor to uncontrolled expansion of the Port Harcourt and humans are increasingly being recognized as a dominant force in land use change.

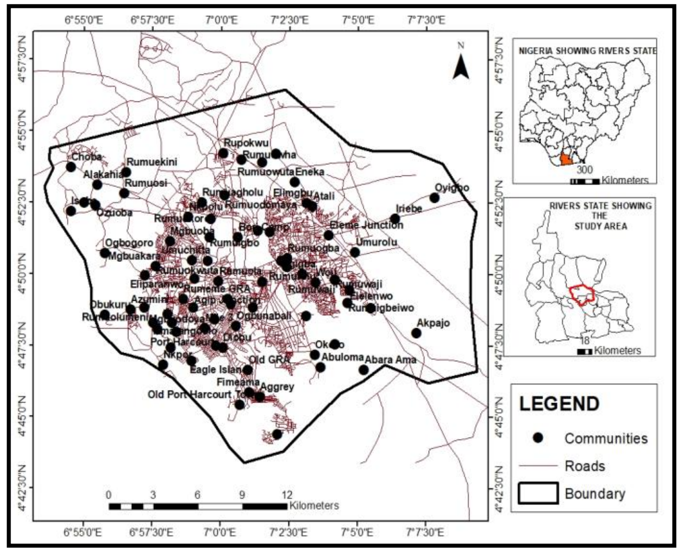

Figure 1.1: Study area ofPort Harcourt Metropolis

source: Nigeria Local Government Administrative Map (2021)

III. METHODOLOGY

The study adopted quasi experimental research to comprehensively sample a detachment or unit from a population with similar characterization that subsequently explain the values of these changes and their percentage change per year under consideration at the particular time of the study (Nwankwoala, 2012). Global Positioning System (GPS) was used to determine the Landsat images of Port Harcourt metropolis of 1990, 2000 and 2020 with 30m by 30m spatial resolution as found in Table 3.1. Geographical information System (GIS) allows quantification of changes using remote sensing data, expressed spatially and temporally, to dynamically visualize spatial pattern and land use and land cover change composition (Claudia, Viana, Jorge, 2019). Five classes were identified in this study namely built up area, wetland, water bodies, farmland/sparse vegetation and thick vegetation; and the description of each of the classes is shown in Table 3.2.

The spatial extent of landuse in each year was calculated and simple arithmetic was done by subtracting the area of land use in initial year from the final year. The difference gave the landuse change in terms of spatial coverage. The percentage change of landuse was then computed to determine the percentage increase or decrease of landuse in Port Harcourt Metropolis using the formula in Equ. 1

LU Initial – LU Final/LU Initial x 100 ………………………………… Equ. 1

Table 3.1: Details of Landsat Satellite Images

Year	Date Acquired	Sensor	Cloud Cover (%)	Path	Row	Resolution
1990	13/12/1990	Landsat 5 MSS	0	188	57	30m x 30m
2000	17/12/2000	Landsat 7 ETM	0	188	57	30m x 30m
2020	09/01/2020	Landsat 7 ETM	0	188	57	30m x 30m

Source: US Geological Survey, 2020

Table 3.2: Landuse/Landcover Classification Scheme

S/N	Landuse Types	Description
1	Thick vegetation	Thick forest, Derived forest, mixed forest lands, palms, conifer, schrubs, herbs and others
2	Built Up Area	Residential, commercial and services, industrial, transportation, roads
3	Wetlands	Permanent and seasonal wetlands, low-lying areas, marshy land, rills and gully, swamps
4	Water bodies	Rivers, permanent open water, lakes, ponds, reservoirs, etc
5	Farmland/Sparse vegetation	agricultural area, crop fields, fallow lands and vegetable lands

Source: Researcher's Analysis, 2020

IV. DISCUSSIONS OF FINDINGS

4.1: Spatial distribution of landuse

The major landuse types identified in the study area from 1990 to 2020 include built up area, waterbodies, farmland/sparse vegetation and thick vegetation. As shown in Table 4.1, in 1990 the thick vegetation recorded 119.52 km^2 (26.08%) while built up area recorded 85.14 km^2 (18.58%), wetland occupied a spatial extent of 123.23 km^2 (26.89), water bodies occupied 28.25 km^2 (6.17%) and 102.08 km^2 (22.28%) for farmland/sparse vegetation. The year 2000 showed that the thick vegetation had decreased to 103.92 km^2 (22.68%), built up area had increased to 167.53 km^2 (36.56%) wetland size decreased to 76.41 km^2 (16.68%); waterbodies also decreased to 19.96 km^2 (4.36%); while farmland/sparse vegetation decreased to 90.40 km^2. Consequently, in year 2020, changes were also observed as thick vegetation further decreased to 89.13 km^2 (19.45%) built up area increased to 213.09 km^2 (46.50%); wetland size reduced to 44.61 km^2 (9.74%); waterbodies recorded 48.62 km^2 (10.61%) and farmland/sparse vegetation recorded 62.77km^2.

Table 4.1: Landuse spatial pattern in 1990, 2000, and 2020

Landuse	1990 (km^2)	Percentage (%)	2000 (km^2)	Percentage (%)	2020 (km^2)	Percentage (%)
Thick vegetation	119.52	26.08	103.92	22.68	89.13	19.45
Built Up Area	85.14	18.58	167.53	36.56	213.09	46.50
Wetland	123.23	26.89	76.41	16.68	44.61	9.74
Water bodies	28.25	6.17	19.96	4.36	48.62	10.61
Farmland/Sparse vegetation	102.08	22.28	90.4	19.73	62.77	13.70
Total	458.22	100.00	458.22	100.00	458.22	100.00

Source: Researcher's Analysis, 2021

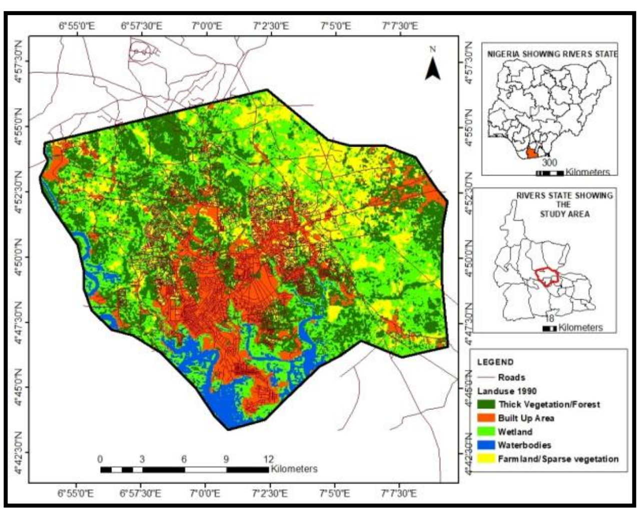

Figure 4.1: Landuse 1990

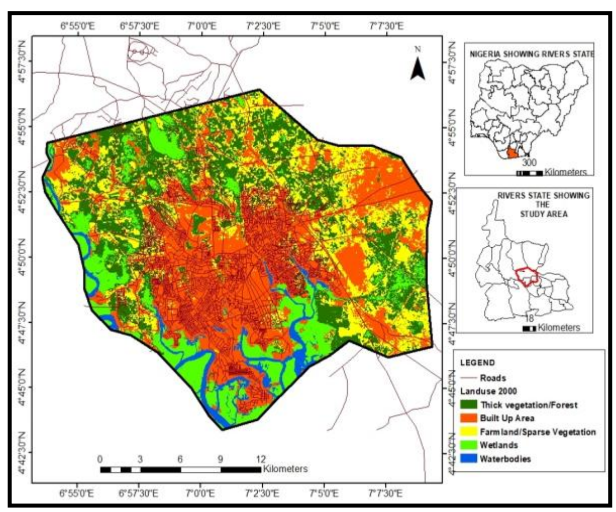

Figure 4.2: Landuse 2000

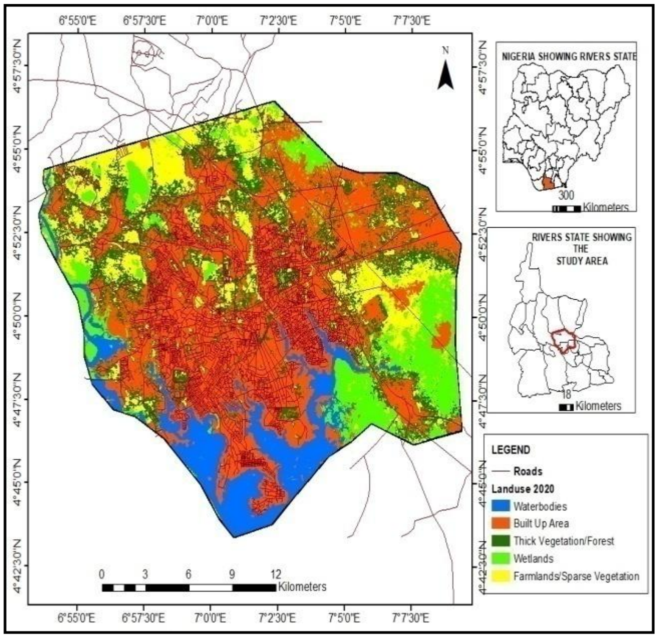

Figure 4.3: Landuse 2020

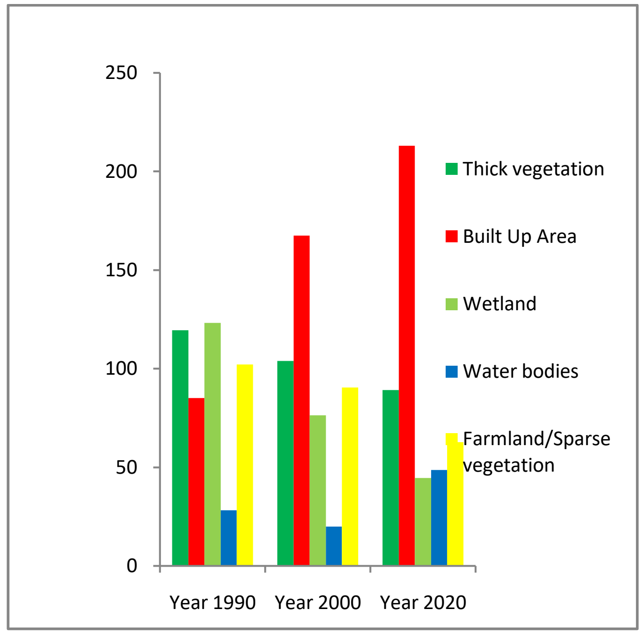

Figure 4.4: Landuse Change in Port Harcourt Metropolis from 1990 to 2020

Table 4.2: Percentage (%) Change in landuse/landcover between 1990 and 2020

Landuse	1990 (km^2)	2000 (km^2)	Change (km^2)	% Change	2010 (km^2)	2020 (km^2)	Change (km^2)	(%) Change	Total Change (1990-2020) (km^2)	Total % Change (1990-2020)
Thick vegetation	119.52	103.92	-15.60	-13.05	103.92	89.13	-14.79	-14.23	119.52	89.13
Built Up Area	85.14	167.53	82.39	96.77	167.53	213.09	45.56	27.20	85.14	213.09
Wetland	123.23	76.41	-46.82	-37.99	76.41	44.61	-31.80	-41.62	123.23	44.61
Water bodies	28.25	19.96	-8.29	-29.35	19.96	48.62	28.66	143.59	28.25	48.62
Farmland/Sparse vegetation	102.08	90.40	-11.68	-11.44	90.40	62.77	-27.63	-30.56	102.08	62.77
Total	458.22	458.22			458.22	458.22				

Source: Researcher's Analysis, 2021

4.2: Rate of Change and Percentage of Changes

The landuse change and percentage change presented in Table 4.2 shows that waterbodies decreased between 1990 and 2010 by 8.29 km^2 (29.35%) while thick vegetation and wetlands also decreased by 15.60 km^2 (13.05%) and 46.82 km^2 (37.99%) respectively during these periods. Generally, 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 km^2 (63.80%) while built up area/open lands increased by 127.95 km^2 (150.28%). It is therefore revealed from the analysis of percentage change 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. The findings assert that urban land use is constantly and rapidly changing due to built up area and this has negative implication on urban land. The number of populations that migrate into the city had taken over to build houses, factories, industries, roads and so on. This confirmed the studies of Eludoyin and Akinola (2015), that dynamic changes in the study area are as a result of sprawl development in a particular land use or land cover changes over time.; anthropogenic factors such as change of landuse activities and urbanisation causes variation in land use (Tijani, Olaleye & Olubanjo 2011).

V. CONCLUSIONS AND POLICY IMPLICATIONS

The study explored the spatio-temporal dynamics of land use change throughout the different time periods in Port Harcourt Metropolis of Rivers State, Nigeria from 1990 to 2020. The study revealed that from the classified imagery of land use virtually all land use in the study area have been converted to other land use or in the verge of being completely lost due to urban expansion or urban sprawl. The study further indicated that the rapid urbanization process has brought about enormous land use changes of Wetland and water bodies to built up areas. This has brought about negative implications on urban land use. If not adequately managed the capacity of the land use will continuously be jeopardized with unregulated, uncontrolled and unsustainable utilization of urban land use (MEA, 2015). Therefore adequate and continuous monitoring of land use change should be encouraged by applying the use of satellite remote sensing in the study area. There should also be land use planning to regulate growth in land use land cover for sustainable urban development.

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