Dynamics of Land Use and Land Cover Along Drainage Channels in Port Harcourt Metropolis, Rivers State, Nigeria

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Abstract- The increasing rate of urban growth and expansion has adverse effects on the landscape features of urban areas, which significantly impacting on land use and land changes along drainage channels. This study examined the dynamics of Land Use and Land Cover along Drainage Channels in Port Harcourt Metropolis, Rivers State, Nigeria. The adopted the longitudinal research design employing the use of geographic information system (GIS) in collecting geospatial data using multispectral and geospatial technologies for inputting data sets obtained from the United State Geologic Survey on the Land Sat Imagery of Port Harcourt drainage system. The data were analysed using geospatial technologies. Findings of the study revealed that farm land and built-up areas increased greatly while water bodies, riparian or swamp forest and thick forest reduced in spatial extent along the drainage channels within the buffer of 200m, 400, and 600m from 1990 to 2022. The study recommend for the preservation and conservation of natural vegetation which include the thick vegetation and riparian/swamp forest in the flood plain buffer along the stream channels to slow and prevent rapid generation of runoff and flood occurrence.

Indexed Terms- Land Use, Land Cover, Dynamics, Drainage Channel, Port Harcourt Metropolis

I. INTRODUCTION

The growing rate of urbanisation and urban expansion as well as the associated progressive demographic change as well as economic, social or political process is a dynamic and complex process that often has adverse effect on the landscape features of every urban area (Ogarekpe *et al.*, 2021, Elenwo & Efe, 2014). This phenomenon also has significant effect on the land use and land cover changes of the urban environment (Sapena & Ruiz, 2019, *Wiatkowska et al.*, 2021). These changes, determined by ongoing process of urban sprawl, are some of the most important and very often irreversible types of environmental changes, which in turn affect the transformation of natural vegetation cover and the functioning of the urban ecosystems (Grimm *et al.*, 2008, Hahs, *et al.*, 2009, Ramachandra *et al.*, 2012). Urban sprawl contributes to an increase in impervious surfaces, such as buildings, roads, parking lots, technical infrastructure etc., which are the indicators of the degree of urbanization, reflecting the environmental quality of urban areas (Yu *et al.*, 2018).

The increased spatial expansion of the urban built-up areas in most urban centres around the world is due mainly to increase in urban population, which results to rapid and dynamic urbanization especially in the developing countries (Yu *et al.*, 2018; UNDESA, 2021). Urbanization processes are not uniform worldwide, and significant population growth due to natural increase, migration towards urban areas and the transformation of rural areas into urban centres, are driving forces of urban land use and land cover changes (Omodu *et al.*, 2023, Ugwu *et al.*, 2022, Elenwo & Ugwu, 2018, Melchiorri *et al.*, 2018). This make urbanization processes in developing countries more dynamic, which is unfavourable and worrying for sustainable urban development (Hegazy & Katop, 2015). This situation has posed serious challenge to urban planners and the likes in the urban areas especially in the African continents.

Land use and land cover changes resulting from increased urban population and urban expansion have significantly affected the environmental, socioeconomic as well as ecological aspects of the urban areas at local, regional and global level (Yu *et al.,* 2018). This has intense implications for loss of biodiversity, distresses in hydrological cycles, increase in soil erosion, sediment loads and flooding (Lambin & Geist, 2006). These have severe impacts on the livelihoods of the local societies. Changes in land use and land cover bring about changes in the characteristics of the river catchment (Tali, 2011). This also has significant influence of flood regime of any drainage channel and catchments (Tali, 2011).
Sequel to this urban growth and the development of technical and critical infrastructures for the sustainability of the urban environment, is the growth of built-up areas, which affect among other things, the formation of urban heat Islands, increased urban pollution, water management issue, the defective structure and functioning of a city as well as the encroachment and blockage of drainage channels leading to high rate of storm water generation, low rate of runoff-stream or river channels flow and the resultant flooding of the urban landmass (Kielkowska *et al.,* 2018). Thus, land cover types and the spatial configuration of their structures affect the functioning and quality of human life in the urban areas (Ramachandra *et al.,* 2012). In view of the above, this study examined the dynamics of Land Use and Land Cover along Drainage Channels in Port Harcourt Metropolis, Rivers State, Nigeria.

- Theoretical /Conceptual Review

Urban Realm Theory
The urban realm theory was propounded in 1964 by James Vance to improve upon the multiple nuclei model (Harris & Ullman 1945). This theory seeks to explain the nature and pattern of city morphology, growth and expansion. This was consequent upon Vance James observation of the sprawling state and nature of the San Francisco Bay area and its Metropolis. This theory is a model of urban ecology which argues that Metropolises are composed of several separate independent market areas. It challenges the idea that satellite suburbs are simply appendages dependent upon a central city mode; rather, they each are their own strong “urban realm”. The theory emphasized that the element of urban realm are not limited to streets, pedestrians ways, bike ways, bridges, plazas, nodes, squares, transportation hubs, gateways parks, water fronts, natural features, view corridors, landmarks and building interfaces (James, 1964). The theory suggests that every realm exists as a distinctive socio-economic and administrative domain that is connected with other realms to forming a broader city region. It depicts the CBD as losing its dominance (Boyd & Carter, 2015). The realm is the city edge or periphery; and defines the flood plains or drainage channels at the edge of the city, where humans have encroached upon due to urban population and the quest to get land space for housing provision and infrastructural development.

However, this theory is employed in this study because it elucidates how urban expansion has created realms of settlements pattern which has transposed from the CBD into the periphery and fringes and have become urban areas by themselves, encroaching on flood plains, drainage channels and wetlands. The theory best applies to the drainage channels and catchments in Port Harcourt Metropolis because the city just extends from the CBD with rapid growth, unregulated development and show a clear manifestation of urban sprawl and expansion on the drainage channels and flood plains.

Concept of Land Use
The concept of land use entails the human use of a land territory for economic, residential, recreational, conservational, and Governmental purpose, which is closely related with human community development (Nedd *et al.*, 2021). Land use relates to what purpose the land is used for such as agriculture, recreation, industrial, residential, commercial or administrative purpose. It is the management and modification of natural environment or wilderness into built environment such as settlement and semi-natural habitats such as arable fields, pastures, and managed woods (Olatunji *et al.,* 2019). According to Environmental Protection Agency (EPA, 2017), “Land use” is the term used to describe the human use of land. It represents the economic and cultural activities such as agricultural, residential, industrial, mining and recreational uses that are practiced at a given place. Thus, EPA (2017) contends that public and private lands frequently represent very different

uses. For instance, urban development seldom occurs on publicly owned land such as parks and wilderness, while privately owned lands are infrequently protected for wilderness uses. It refers to the land used for producing productive activities, for the habitation of humans, for the sustenance of economic activities and for the overall growth and development of human society.

Concept of Land Cover

The concept of land cover is the physical material at the surface of earth, and includes grasses, asphalt, trees, bare ground, water, vegetation etc., (Cromber *et al.*, 2014). It is the expression used by ecologist Frederick Edward Clements who emphasized that land cover has closet modern equivalent to vegetation. Land cover defined the types of physical covering of the earth's surface by forests, wetlands, impervious surfaces, agriculture, and other land and water types, which include wetland or open water (Cromber *et al.*, 2014). Land cover is commonly defined as the vegetation (natural or planted) or man-made constructions (buildings, etc.), which occur on the earth surface such as water, ice, bare rock, sand and similar surface also count as land cover. It refers to the surface cover on the ground like vegetation, urban infrastructure, water, bare soil etc.

Simply put, land cover has to do with what covers the surface of the earth and include water, snow, grassland, deciduous vegetation and bare soil (Olatunji *et al.*, 2019). Land cover types and classes are aggregated into seven land cover types; such as forest, herbaceous/grassland, shrub land, developed agriculture, wetlands and other including ice/snow, barren areas, and open water.

Land covers are assessed using remote sensing and are critical components of a wider variety of environmental applications. Changes in land cover on a spatial and temporal scale occur due to accuracy, the capacity to develop, flexibility, uncertainty, structure, and the capability to integrate available models (Wang *et al.*, 2020). Land cover is characterized by various combinations of vegetable types, soils, exposed rocks and water bodies as well as anthropogenic elements such as agriculture and built environment (Wang *et al.*, 2020). Land cover is important to the environment as it provides a means to examine landscape patterns and characteristics, which are important in understanding; the extent, availability, and condition of land, etc. Thus, land cover denotes a change in certain continuous characteristics of the land such as vegetation type, soil properties, and so on, whereas land-use change consists of an alteration in the way certain area of land is being used or managed by humans (Patel *et al.*, 2019). Land cover change dynamics are as a result of the interactions between humans and the environment which has resulted into negative impact on ecosystems and human wellbeing, which includes erosion, increased runoff, flooding, loss of water resources, degrading water quality and other negative impacts, which have brought these changes to the attention of the world (Wang *et al.*, 2020). Thus, the timely understanding and monitoring of land use and land cover changes, their intensity, direction, causes, and consequences are critical for sustainable development planning; hence, it is an essential goal in the field of land cover change science (Gondwe *et al.*, 2021, Hussain, 2018).

II. METHODOLOGY

STUDY AREA

The study area for this study is Port Harcourt Metropolis, better defined by a broad area contained in the City Master Plan of 2008 referred to as the Greater Port Harcourt City, which comprises of Port Harcourt Local Government and Obio/Akpor Local Government Areas as well as parts of Eleme, Etche, Ikwerre and Emohua Local Government Areas, which spans 1900 km^2 (Ede, 2015 and Government of Rivers State, 2008). It is located 66km^2 from the Atlantic Ocean and is bounded in the North by Ikwerre and Etche Local Government Areas, in the East by Oyigbo and Eleme Local Government Areas, in the west by Emohua Local Government Area and in the South by Degema and Okirika Local Government Areas (Fig. 1). Geographically, it lies between latitude 4^o 5' 11" and 5^o 15' 45" North of the Equator and longitude 6^o 22' 25" and 8^o 5' 12" East of the Greenwich Meridian (Ajie & Dienye, 2014). It has a tropical monsoon climate with temperature ranging from 25^{o}C to 27^{o}C and relative humidity ranging from 77 %to 78%. Annual mean rainfall is between 200mm to 230mm (Efe & Weli, 2015).

Figure 1: Port Harcourt Metropolis Showing the River / Drainage System

Source: GIS Lab, Department of Geography and Environmental Management, University of Port Harcourt, 2015

III. RESEARCH DESIGN

This study adopted the longitudinal research design, employing geo-spatial mapping and time series analysis techniques using the following steps:

(i) The land Viewer App was used to extract Landsat Satellite Images of Port Harcourt drainage channels for 1990, 2000, 2010, and 2022.

(ii) These images were obtained from the United State Geologic Survey (USGS) and Earth Observing System (EOS) land viewer for real-time analysis.

(iii) The entire Port Harcourt drainage channels and catchments were also obtained from Google Earth and Google Earth pro.

(iv) The obtained Landsat bands was imported into ArcMap environment using the composite bands on the Image Analysis Panel, the different bands were merged into a single raster data.

(v) The composite raster image was clipped using Port Harcourt Metropolis boundary.

(vi) Maximum likelihood supervised classification was performed on the clipped images and a land use map classified into Built-up, wetland, water bodies, bare surface etc. The classified raster image was reclassified and then converted to polygon where simple arithmetic was done to determine the percentages and sizes of land use and land cover changes from 1990-2022.

IV. RESULTS

Analysis of the dynamism in land use and land cover pattern along drainage channels in Port Harcourt Metropolis in 1990, 2010 and 2022 from the distant of 200m, 400m and 600m is shown in Tables 1 Figures 2, 3 and 4. The analysis showed that in 1990, within 200m covered 112.04 sqkm in which thick vegetation covers 31.14%, built up areas covers 14.03%, riparian or swamp forest covers 33.76% and farmland covers 18.09%. A radius of 400m covered 104.72sqkm and thick vegetation covers 29.82%, built up area covers 17.66%, riparian or swamp forest covers 32.24% and farmland covers 17.54%. A radius of 600m covered 92.789km in which thick vegetation covers 26.94%, built up covers 19.86, riparian or swamp forest covers 32.74% and farmland covers 17.26%. In 2010, the 200m radius covers 111.8sq km in which thick vegetation covers 24.03%, built up areas cover 40.26%, riparian or swamp forest covers 9.34% and farmland covers 22.58%. The 400m radius covers an area of 104.71sqkm in which thick vegetation covers 23.52%, built up areas covers 40.96%, riparian or swamp forest covers 11.34% and farmland covers 22.71%. The 600mm radius covers an area of 93.175sqkm in which thick vegetation covers 23.45%, built up areas cover 40.17%, riparian or swamp forest covers 11.26% and farmland covers 22.70%. In 2022, the 200m radius covers an area of 112.02sqkm in which thick vegetation covers 20.17%, built up areas cover 44.80%, riparian or swamp forest covers 12.63% and farmlands covers 15.08%. The 400m radius covers an area of 104.65sqkm in which thick vegetation covers 18.62%, built up areas covers 47.67%, riparian or swamp forest cover 13.22%, and farmlands cover 15.05%. the 600m radius has an area coverage of 82.69sqkm in which thick vegetation covers 19.98%, built up areas cover 53.82%, riparian or swamp forest covers 1.23% and farmlands cover 16.98%.

Table 1: Land use and Land cover along the Drainage Channels

Year	Land use	Distance					
		200m		400m		600m	
		Spatial Extent (sq km)	Percentage (%)	Spatial Extent (sq km)	Percentage (%)	Spatial Extent (sq km)	Percentage (%)
1990	Thick Vegetation	34.89	31.14	31.23	29.82	24.95	26.91
	Built-Up Area	15.72	14.03	18.49	17.66	18.41	19.86
	Riparian or swamp forest	37.82	33.76	33.76	32.24	30.35	32.74
	Waterbodies	3.34	2.98	2.87	2.74	2.99	3.23
	Farmland	20.27	18.09	18.37	17.54	16	17.26
	Total	112.04	100.00	104.72	100.00	92.7	100.00
2010	Thick Vegetation	26.86	24.03	24.63	23.52	21.85	23.45
	Built-Up Area	45.01	40.26	42.89	40.96	37.43	40.17
	Riparian or swamp forest	10.44	9.34	11.87	11.34	10.49	11.26
	Waterbodies	4.25	3.80	2.61	2.49	2.25	2.41
	Farmland	25.24	22.58	22.71	21.69	21.15	22.70
	Total	111.8	100.00	104.71	100.00	93.17	100.00
2022	Thick Vegetation	22.6	20.17	19.48	18.62	16.52	19.98
	Built-Up Area	50.18	44.80	49.86	47.67	44.5	53.82
	Riparian or swamp forest	14.15	12.63	13.83	13.22	1.02	1.23
	Waterbodies	8.2	7.32	6.38	6.10	6.61	7.99
	Farmland	16.89	15.08	15.05	14.39	14.04	16.98
	Total	112.02	100.00	104.6	100.00	82.69	100.00

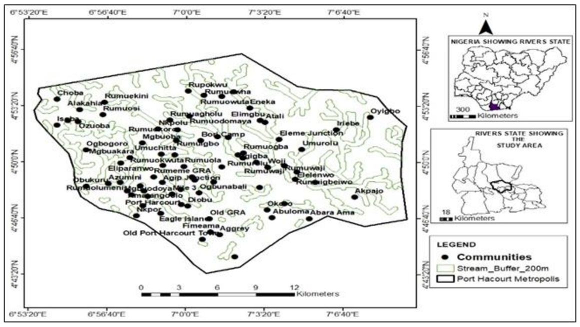

Figure 2: Buffer of 200m of Drainage Network (2024)

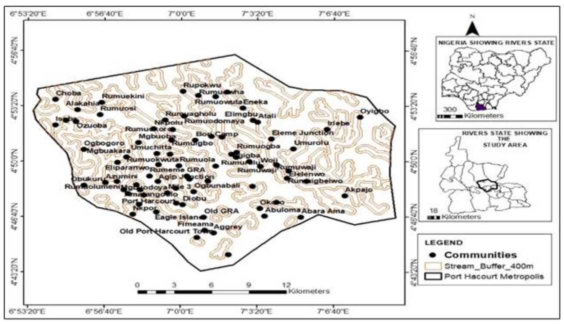

Figure 3: Buffer of 400m of Drainage Network (2024)

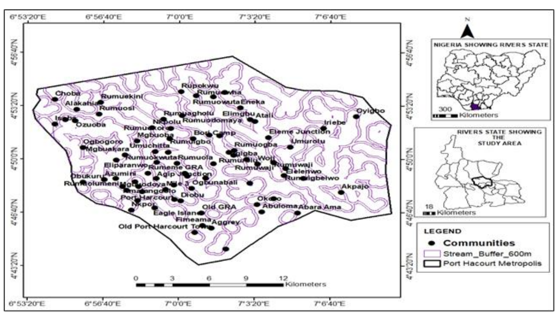

Figure 4: Buffer of 600m of Drainage Network (2024)

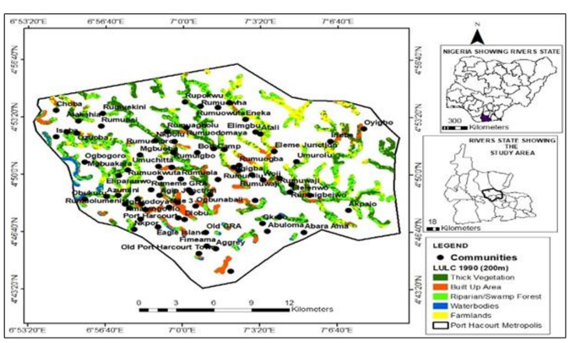

Figure 5: Land Use, Land Cover of Buffer of 200m for 1990

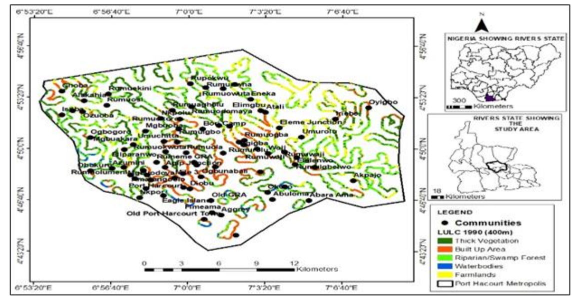

Figure 6: Land Use, Land Cover of Buffer of 400m for 1990

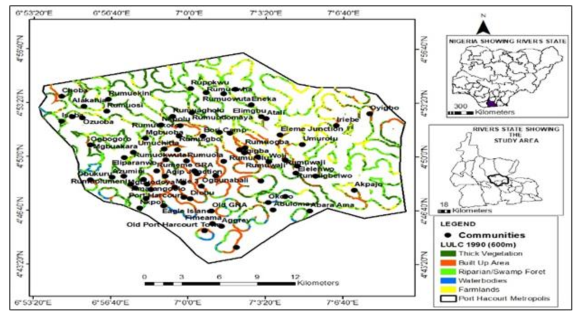

Figure 7: Land Use and Land Cover of Buffer of 600m for 1990

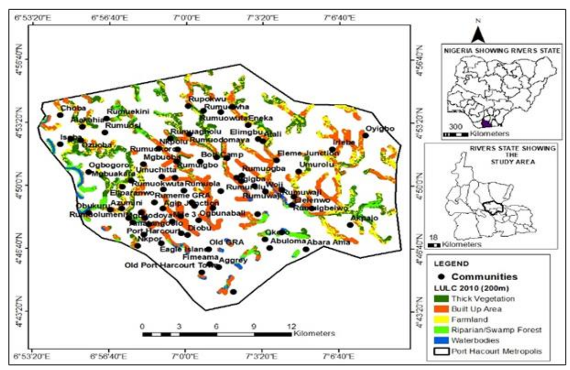

Figure 8: Land Use, Land Cover of Buffer of 200m for 2010

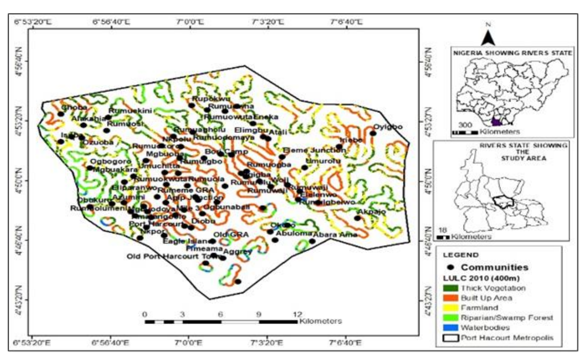

Figure 9: Land Use, Land Cover of Buffer of 400m for 2010

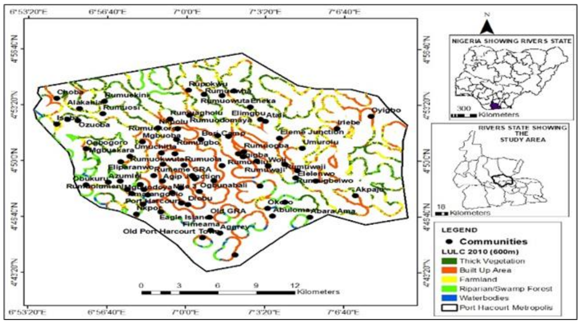

Figure 10: Land Use, Land Cover of Buffer of 600m for 2010

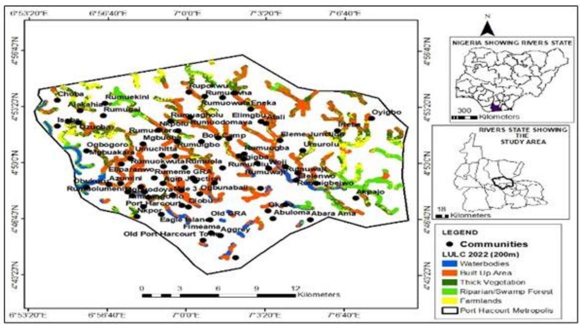

Figure 11: Land Use, Land Cover of Buffer of 200m for 2022

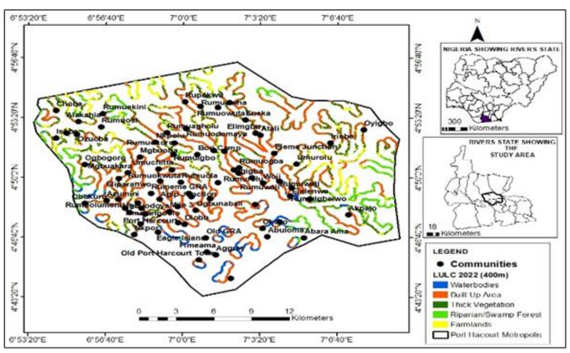

Figure 12: Land Use, Land Cover of Buffer of 400m for 2022

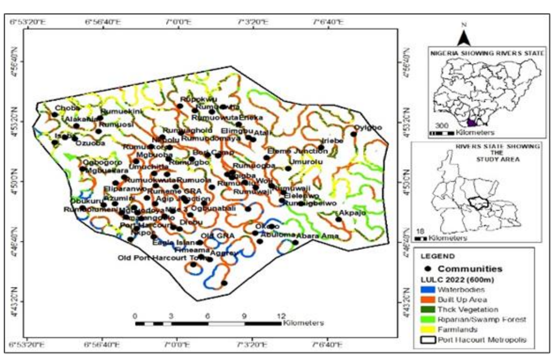

Figure 13: Land Use, Land Cover of Buffer of 600m for 2022

V. FINDINGS AND DISCUSSION

In Table 1 and Figures 2 to 13, it is shown that the land use and land cover change along the drainage channels from 1990 to 2022 indicates that the thick vegetation and farmlands reduced with increasing distance from the drainage channels (34.89 – 19.98), while the built-up area increased with increasing distance from the drainage channels (15.72-53.82). The increase in the built-up area was accompanied by a decline in thick vegetation which decreased during the same period of study. Thus, vegetation reduction has been considered a triggering factor for several environmental-related issues, including soil erosion, decreased air quality, and reduced biodiversity (Gilbert & Shi, 2023). Similarly, it can be deduced that what was lost in vegetation was gained by built-up and that urbanization and industrialization are major factors of loss of green vegetation (Agbaogun & Akintunde-Alo, 2020).

The reduction in the riparian or swamp forest (37.82-1.23) is an indication of wetland loss in Port Harcourt Metropolis which can really increase the flood vulnerability and flood risk around the drainage channels. Wetlands, as defined by the Ramsar Convention, include all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peat lands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans. They can also support livelihoods and basic needs for food, water, shelter and fuel before, during and after disasters, thus strengthening resilience against disasters and climate change (United Nations, 2017).

CONCLUSION AND RECOMMENDATIONS

This study examined the dynamics of Land Use and Land Cover along Drainage Channels in Port Harcourt Metropolis, Rivers State, Nigeria. It is observed that in 1990, the analysis that thick vegetation, and farmlands continued to decrease from the drainage channels while the built-up area continued to increase with increasing distance from the drainage channels. In 2010, the analysis has revealed that the spatial extent of thick vegetation was decreasing with increase in the distance away from the drainage channels while other land use and land cover did not have any regular pattern. Despite the irregular pattern, it is shown that at every distance (200m, 400m, and 600m), the spatial coverage of the built-up area was found to be the highest, and followed by thick vegetation, farmland and riparian or swamp forest. This is unavoidably saying that riparian or swamp forest was seriously depleted over time from 1990 to 2010. In 2020, the analysis thus suggested that built-up area continued to increase with increasing distance away from the drainage channels and this is invariably saying that people tend to avoid settling down close to the drainage channels, although sand filling activity is the order of the day to acquire the areas initially mostly by the riparian/swamp forest and also the thick vegetation. The study recommend for the preservation and conservation of natural vegetation which include the thick vegetation and riparian/swamp forest in the flood plain buffer along the stream channels to slow and prevent rapid generation of runoff and flood occurrence.

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