Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 4, No.6, 2014

Residential Development Dynamics in Port Harcourt Metropolis: Implication for Efficient Urban Planning

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Abstract
Since 1980s the rate of expansion of Port Harcourt city has been very rapid with attendant accelerated housing development within the metropolis. This paper examines the residential development dynamics in Port Harcourt metropolis using Geographic Information Systems (GIS) approach. In order to achieve this objective, two Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) multi-seasonal images of 19 December 1986 and 22 December, 1990 and NigeriaSat1 image of April 2004 for the Study area were acquired for this study. The Landsat TM, ETM+ and NigeriaSat1satellite data were processed using ERDAS IMAGINE 9.2 image processing software. The result from the land use changes between 1986 and 2004 shows prominent conversion of agricultural land to residential land uses. This implies that residential area has become one of the most important land use types within the periods under review. The paper recommended the need to invigorate planning machinery and activity in Port Harcourt metropolis to incorporate and integrate new planning paradigm into planning of the city and to introduce measures to manage smart growth.
Keywords: Residential development dynamics; GIS, Efficient urban planning; Metropolis.

Introduction

The urban fabric of Port Harcourt metropolis has undergone dramatic changes during the last decades. From a colonial city clearly delineated in its historic boundaries, Port Harcourt has and continues to grow into the surrounding landscape, swallowing even more villages, coastlines, and previously unspoiled landscape, transforming into an ever increasing urban conglomerate. After 1980s, multi-center development of cities and its catalytic impact on reshaping of the economic landscape in metropolitan areas has drawn much attention (Hackworth, 2005). During the last quarter of the twentieth century, Port Harcourt experienced tremendous structural transformation due to population and economic growth and development of its transportation and communication systems and the impact of globalization (Obinna, Owei and Okwakpam, 2010).

Like many cities in Nigeria, Port Harcourt has recorded rapid growth in population and aerial spread. From an estimated population of 500 in 1915 it grew to 30,200 in 1944. By 1963, its population was 179,563 and by 1973 it has reached 231, 532 persons. The Port Harcourt municipality's population was given as 440,399 by the 1991 national census (Okoye, 1975, Ogionwo, 1979, Alagoa and Derefaka, 2001). The 2006 national census show this population is more than a million (Obinna, Owei and Mark, 2010). In terms of its physical size, the city grew from 15.54 sq. km in 1914, to a metropolis covering an area of 360 sq. kilometers in the 1980s.

Urban development is denser on the corridors determined by geographic thresholds and major transportation connections. Port Harcourt as a result of population increase and economic growth spreads to the periphery as in the other metropolitan cities. However, this decentralization is not realized with an integral and regional planning but with patchwork of partial plans. This causes negative effects on urban environment, forests, fertile agricultural land and cultural values are threatened. This kind of sprawling process creates a settlement pattern that increases the costs of infrastructure. Residential development dynamics of Port Harcourt has been very rapid (Wizor, 2012)

Physically spread has occurred in both a south – easterly direction and a northerly direction. To the south, growth was through marshland colonization in squatter settlements locally called "waterfronts". In the last few years settlements of these waterfronts have been demolished by the Rivers State Government. Growth has also occurred in north – westerly and north – easterly direction through the entrapment of indigenous enclaves of semi – rural and rural communities within the built – up area of the city. The Port Harcourt urban fringe currently stretches to Iriebe, Eleme, Elelewon Rukpoku, Woji, Choba, Rumokwurusi and Onne (Wizor, 2012).

Much of this growth is unplanned and unregulated (Owei, Ede, Obinna and Akarolo, 2008). As part of its efforts to manage the city's growth, the Rivers State Government in 2009 established the Greater Port Harcourt City Development Authority with jurisdiction covering Port Harcourt city and Obio Akpor Local Government Areas (LGA) and parts of eight other local government areas. It covers an area of approximately 1,900 square kilometers (40,000 hectares of land) with a projected population of about two (2) million people (GIBB, 2009).

Rapid urban development and increasing land use changes due to increasing population and economic growth is being witnessed in Port Harcourt and cities in other developing countries. The measurement and monitoring of

these land use changes are crucial to understand urban development dynamics over different spatial and temporal scales. Today, with rapid urbanization, there is increasing pressure on land particularly in the metropolitan cities. The cities are expanding in all directions resulting in large scale urban sprawl and changes in urban land use. The spatial pattern of such changes is clearly noticed on the urban fringes or city peripheral areas, than in the city centre. This has made the fringe area of the city to be the most dynamic landscape (Kirk, 2003). In the modern age of urban expansion, 'fringe' is of much significance. The term 'fringe' suggests a border – line case between the rural and the urban and it actually lies on the periphery of urban areas, surrounding it and distinguishing it from the truly rural countryside.

The fringe of an urban complex forms a pattern depending upon the physiographic and transportation facilities of the area. Around major urban centres the physical expansion of built up areas beyond their municipal boundaries has been very conspicuous. As one moves out of a major city along the roads, one observes new residential colonies and a considerable amount of vacant land with partially developed residential land use. An important problem in the urban fringe area is the problem of land use. The pattern of land use in the area is dynamic and changes from rural land use to urban land use over short periods of time and distance.

This paper attempts to justify the obvious residential development dynamics of the metropolis with the aid of Geographic Information Systems (GIS) to ensure that the desire for efficient urban planning is achieved.

Geo Spatial Data Processing and Analysis

In order to examine residential development dynamics in Port Metropolis, two Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) multi-seasonal images of 19 December 1986 and 22 December, 1990 and NigeriaSat1 image of April 2004 for the Study area which include Obio/Akpo, Eleme and Port Harcourt Local Government Areas were acquired for this study. The Landsat TM, ETM+ and NigeriaSat1satellite data were processed using ERDAS IMAGINE 9.2 image processing software. The images were imported into ERDAS using ERDAS native file format GEOTIFF. Since the images were in single bands, they were stacked together using ERDAS layer stack module to form a floating scene and to group the bands together.

The 1986 image was co-registered with the NigeriaSat1 image and later geo-linked to allow for the subset of the three images to the study area. This was followed by performing further Geometric corrections of the 1990 and 2004 images to remove few scattered clouds in the image. The three images were projected to the Universal Traverse Mercator (UTM) coordinates zone 32. The spheroid and datum was also referenced to WSG84. Enhancement of the images using histogram equalization techniques was later performed on all the images and subset to the study area. The images were later displayed as false-color composites with band combination of red as band 4, green as band 3, and blue as band 2. All the images were later categorized using supervised classification technique to identify land cover features within the study area.

Finally the areas of the different land uses were computed from the attribute tables of the different classified land use images. This was done using the compute area tool in the viewer window of ERDAS IMAGINE 9.2 software. The areas were computed in hectares for all the different land use classes for the different datasets. The land use map layout was done in ArcGIS 9.2 environment. The classified land use maps were imported from ERDAS to ArcGIS environment and were put in layout form and then produced **(See Figures 1, 2 and 3 below)**

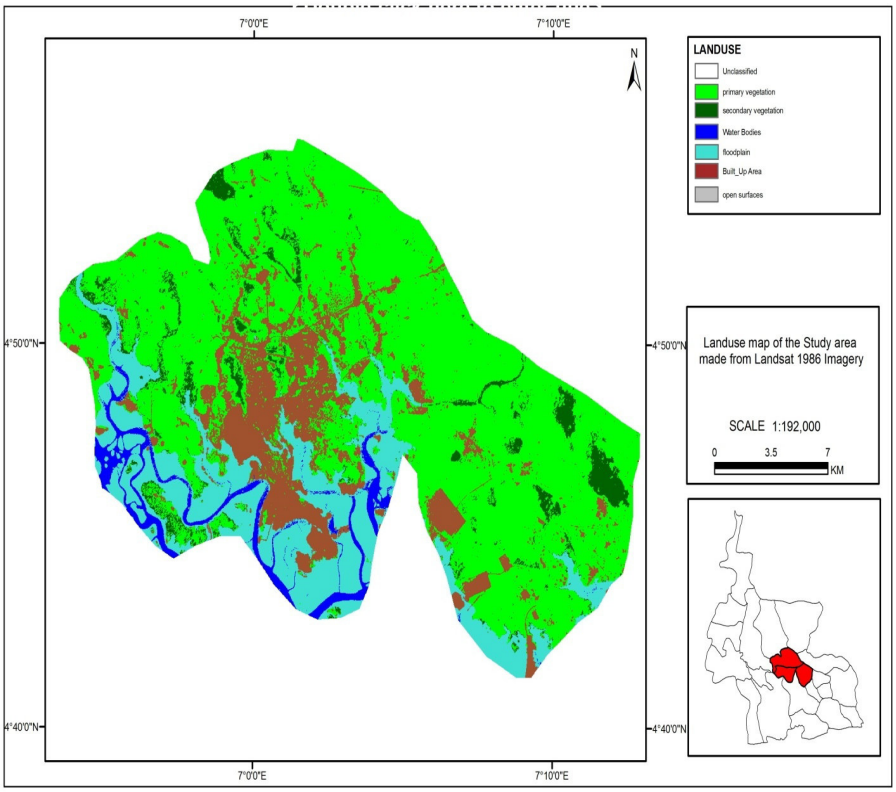

Figure 1. Land Use Map of Port Harcourt Metropolis (Adapted from LandSat 1986 Imagery)

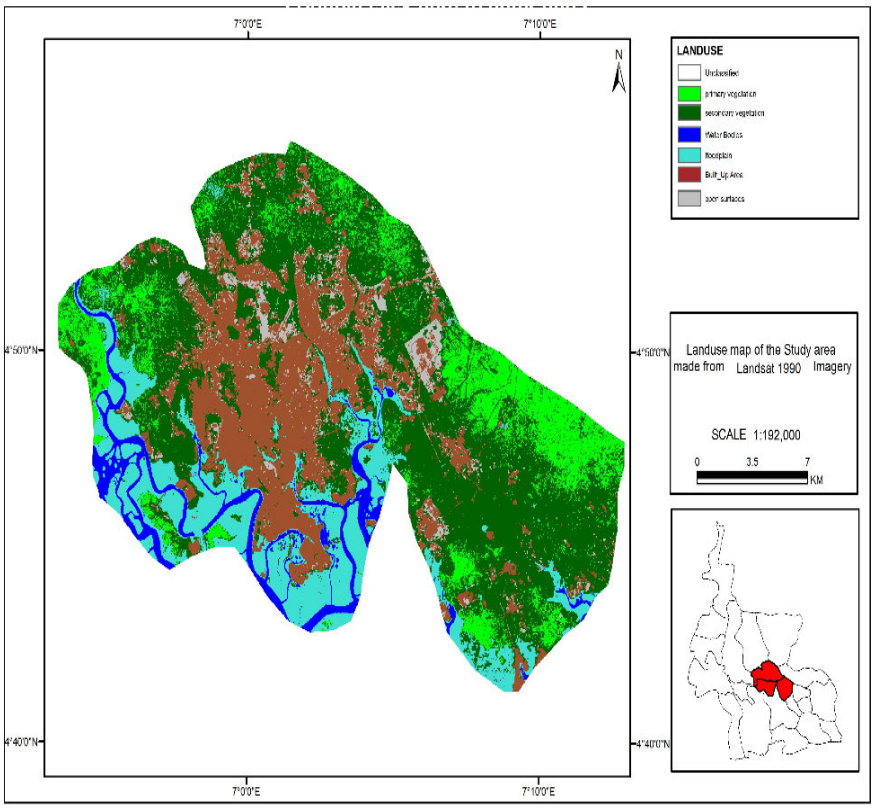

Figure 2. Land Use Map of Port Harcourt Metropolis (Adapted from LandSat 1990 Imagery)

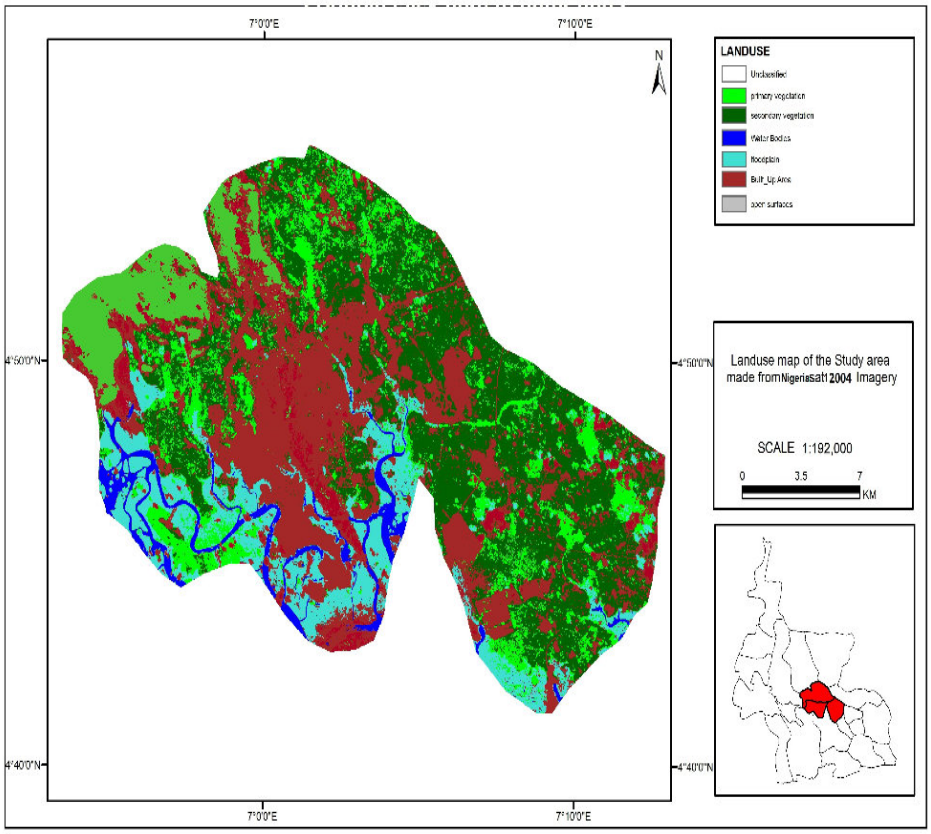

Figure 3. Land Use Map of Port Harcourt Metropolis (Adapted from NigeriaSat1 2004 Imagery)

Analysis Result

The results are analyzed as follows:

- **Change Detection:** The post-classification change detection technique was employed, which is efficient in detecting the nature, rate and location of changes, and has been successfully used in a number of researches done in urban environments (Hardin *et al.,* 2007)**.** Firstly, the areas for the different land cover types of the classified images were computed from the attribute table of the classified images in ERDAS IMAGINE 9.2 environment. The classified images were later imported in Arc Map 9.2 environment. An overlay procedure using the intersect function of Arc Map 9.2 was adopted with each of the classified image and towns boundary layer. The attribute data including the area of change of the different land cover type measured in hectares were then exported to excel for further comparison. The comparison of the land use land cover statistics assisted in identifying the percentage change, trend and rate of change between 1986 and 2004. In achieving this goal, the first task was to develop the figures showing the area in hectares determining the percentage change for each year (1986, 1990 and 2004) measured against each land use land cover type. To determine the trend of change, the observed change was divided by the sum of changes multiplied by 100:

(Trend) percentage change = observed change * 100
Sum of change

The trend area change measured against two land use land cover type was calculated as follow: the difference between the observed change in area (i.e. built-up area) in later period q (e.g. 1990 year) and observed change in area (i.e. built-up area) in early period p (e.g. 1986 year)

Trend area changed = observed change q- observed change p

In obtaining annual rate of change, the area changed is divided by the number of study 1986-1990(4 years), 1990-2004(14 years)

Annual rate of change = Trend area change
Number of study years

The results are thus:

Table 1. Trend Change in Percentage from 1986 to 2004

CLASS NAME	TREND CHANGE IN HECTARES		TREND CHANGE IN %	
	1986-1990	1990-2004	1986-1990	1990-2004
Built-Up Area	3,654.45	4,603.32	7.81	33.62
Water Bodies	164.61	677.16	0.35	4.95
Primary Forest	25,280.64	137.07	54.05	1
Secondary Vegetation	14,257.26	5,636.61	30.48	41.17
Open Surfaces	465.17	911.33	1	6.66
Floodplain	2,952.18	1,725.75	6.31	12.6
Total	46,774.31	13,691.24	100	100

Author's Computation

Table 2 Annual Change Rate Computation from 1986-2004

CLASS NAME	ANNUAL CHANGE IN HECTARES		ANNUAL CHANGE IN %	
	1986-1990	1990-2004	1986-1990	1990-2004
Built-Up Area	913.61	328.81	7.81	33.62
Water Bodies	41.15	48.37	0.35	4.95
Primary Forest	6,320.16	9.79	54.05	1
Secondary Vegetation	3,564.32	402.62	30.48	41.17
Open Surfaces	116.29	65.1	1	6.66
Floodplain	738.045	123.27	6.31	12.6
Total	11693.57	977.96	100	100

Author's Computation

From the tables above the built-up area recorded a trend change of 3,654.45 hectares representing 7.81% change within 1986-1990 periods and from1990-2004, a trend change of 4,603.32 hectares was recorded representing 33.62% change. The annual trend change of the built-up area within the 1986-1990 periods was recorded as 913.61 representing 7.81% change annually while within 1990-2004 the annual trend change was recorded as 328.81 hectares representing 33.62% change annually.

This implies that residential area has become one of the most important land use types within the periods under review. It could be seen as a major type of land use in the northern and eastern part of the metropolis. Also, the expansion of area under residential use could be seen in and around the old settlement. An important point noted here is that most of the new areas under the land use (built up) are residential indicating the growing influence of Port Harcourt metropolitan City. The population growth of this city overtime supports this point. In 1973, the population was 213,443. It increased to 645,883 in 1991 and over one million in 2006. This two-fold increase in population supports that there is more residential development.

The water bodies experienced a trend change of 164.61 hectares within 1986-1990 periods this represents 0.35% increase while within 1990-2004 the trend change was 677.16 hectares constituting 4.95% change. The annual trend change in area within 1986-1990 was recorded as 41.15 hectares annually representing a 0.35% annual increase while within 1990-2004 the annual trend change in area was recorded as 48.37 hectares annual increase representing 0.95% increase annually.

Primary vegetation recorded a high trend change of 25,280.64 hectares within 1986-1990 representing 54.05% increase. While within 1990-2004 the trend change was 137.07 hectares representing 1% increase. The annual trend change in area was recorded as 6,320.16 hectares within 1986-1990 representing 54.05% increase annually while in 1990-2004 the annual change rate was recorded as 9.79 hectares annually representing 1% increase annually.

Secondary vegetation recorded a trend change of 14,257.26 hectares a 30.48% change within 1986-1990 periods and within 1990-2004 the trend change was recorded as 5,636.61hectares representing 41.17% change. The annual change rate within 1986-1990 was 3,564.32 hectares representing 30.48% while within 1990-2004 the annual change was recorded as 402.62 hectares representing 41.17% change.

The trend change of open surfaces within 1986-1990 was recorded as 465.17 hectares representing 1% change within the period. And within 1990-2004 the trend change was 911.33 hectares representing 6.66%. The annual change of open surface within 1986-1990 was 116.29 hectares annually representing a 1% increase annually while within 1990-2004 the annual change in area was 65.1 hectares representing a 6.66% increase annually.

The floodplain recorded a trend change of 2,952.18 hectares representing 6.31% change while within 1990-2004 the trend change was 1,725.75 hectares representing 12.6% change. The annual change rate for 1986-1990 periods was recorded as 738.05 hectares representing a 6.31% change annually while within 1990-2004 the annual change was 123.27 hectares representing 12.6% change annually within the period.

The results above are further shown on **Table 3 and Figures 4, 5, 6 and 7 below** for a better appreciation of the landuse dynamics in Port Harcourt metropolis.

Table 3. Land use Dynamics in Port Harcourt Metropolis
Author's Computation

Class Name	Size 1986		Size 1990		Size 2004	
	Area (hectares)	%	Area (hectares)	%	Area (hectares)	%
Built_Up Area	7491.96	14.02	11146.41	25.49	15749.73	27.56
water bodies	1678.14	3.14	1842.75	4.21	2519.91	4.41
Primary Forest	31780.8	59.48	6500.16	14.86	6363.09	11.13
Secondary vegetation	2651.49	4.96	16908.75	38.66	22545.36	39.45
Open Surfaces	877.55	1.65	1342.72	3.07	2254.05	3.94
floodplain	8947.98	16.75	5995.8	13.71	7721.55	13.51
	53427.92	100	43736.59	100	57153.69	100

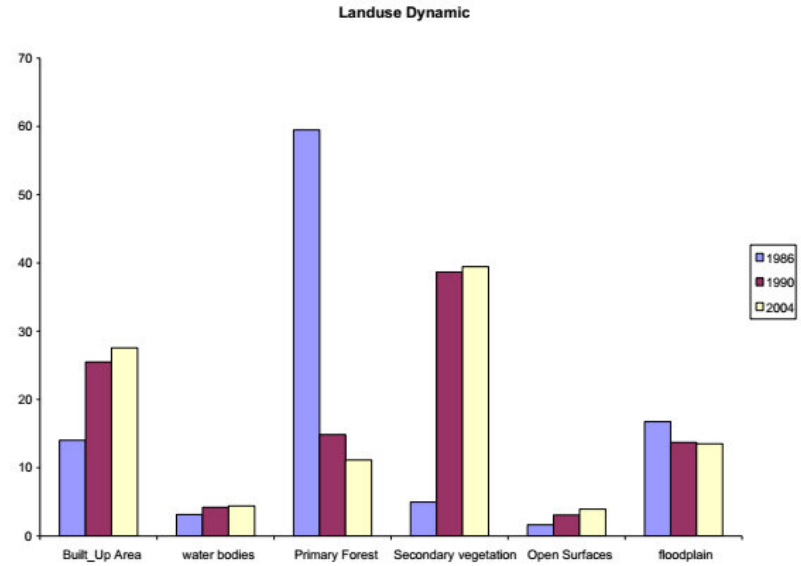

Fig. 4 Land Use Dynamics 1986 – 2004 (%)

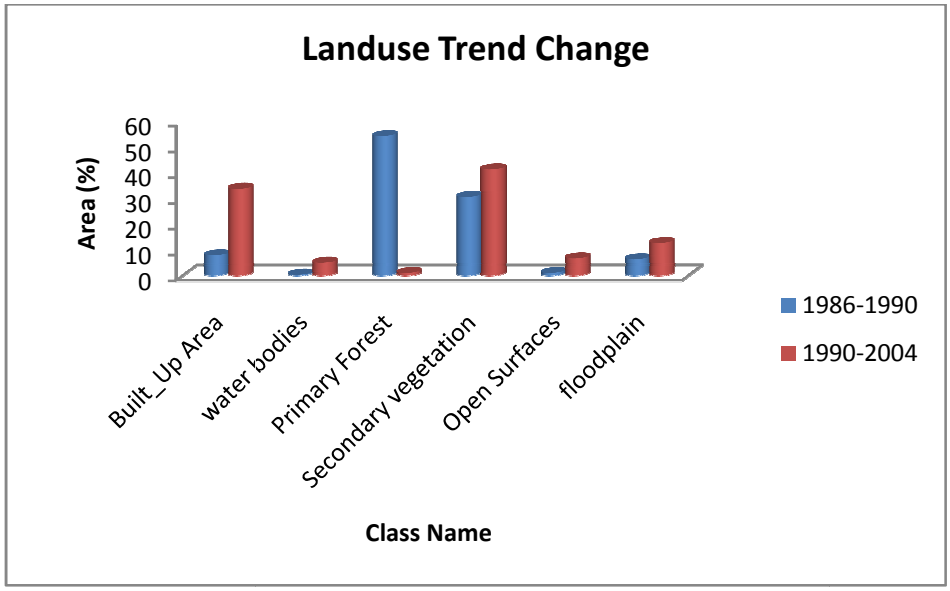

Figure 5. Land use Trend Change (Area %)

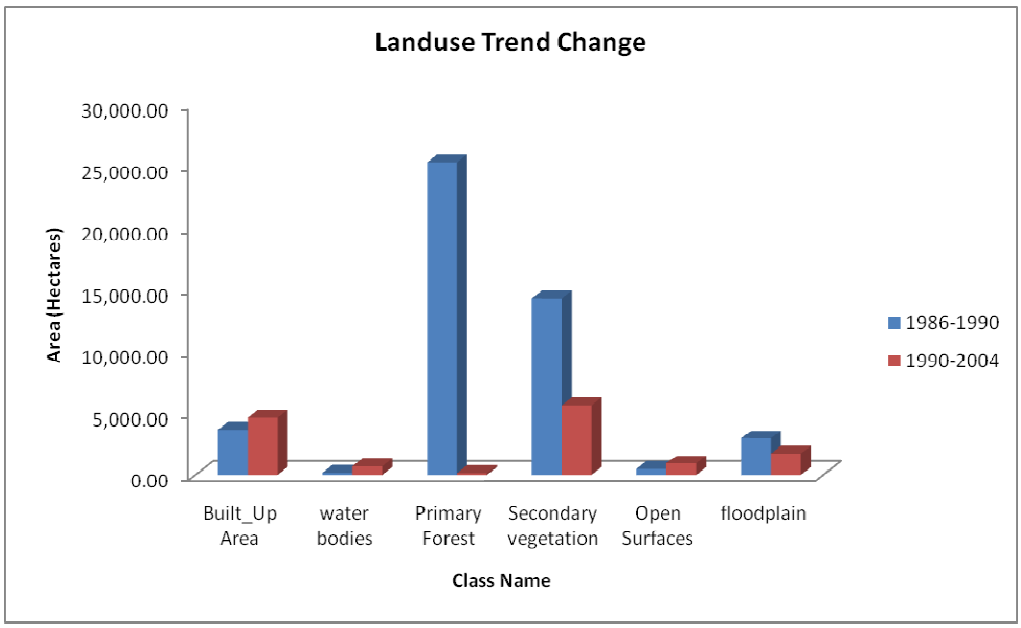

Figure 6. Land use Trend Change (Area Hectares)

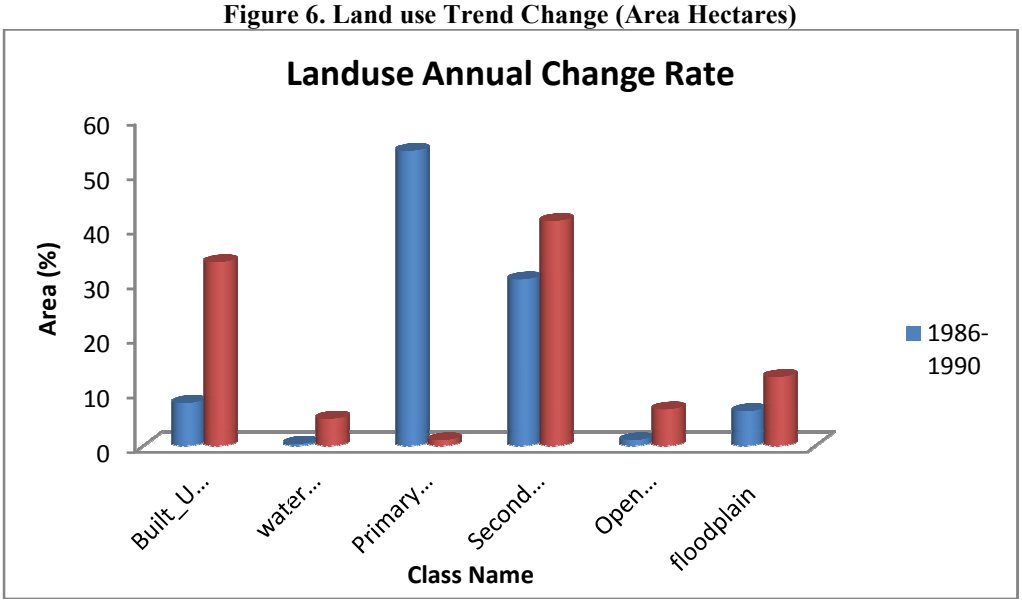

Figure 7. Land use Annual Change Rate

The implication of the above result is that there has been a major shift from agricultural land use to residential land use validating urban influence and possible suburban development. The result from the land use changes between 1986 and 2004 in the study area has prominent residential conversion from the agricultural land. Thus, housing dynamics is an important part of Port Harcourt restructuring process and it takes shape in the periphery as the development of large public and private houses together with gated towns continues unabated.

Conclusion

Residential development changes in Port Harcourt metropolis indeed calls for concern of all stakeholders in the city. The result from the processing and analysis of the two LandSat Thematic Mapper (TM) and Enlarged Thematic Mapper Plus (ETM+) multi-seasonal images of 19 December 1986 and 22 December 1990; and NigeriaSat1 image of April 2004 showed the urban development dynamics of Port Harcourt metropolis. For instance, the built-up area recorded a trend change of 3,654.45 hectares representing 7.81% change within 1986-1990 periods and between 1990-2004, a trend change of 4,603.32 hectares was recorded representing 33.62% change. The annual trend change of the built-up area within the 1986-1990 periods was recorded as 913.61 representing 7.81% change annually while within 1990-2004 the annual trend change was recorded as 328.81 hectares representing 33.62% change annually.

This implies that residential area has become one of the most important land use types within the periods under review. It could be seen as a major type of land use in the northern and eastern part of the metropolis. Also the expansion of area under residential use could be seen in and around the old settlement. An important point noted here is that most of the new areas under the land use (built-up) are residential indicating the growing influence of Port Harcourt metropolitan City. The result in general showed that the urban fabric of Port Harcourt metropolis has undergone dramatic changes in the last decade.

There is the need therefore to invigorate planning machinery and activity in Port Harcourt metropolis to incorporate and integrate new planning paradigm into planning of the city and to introduce measures to manage smart growth. This rapid developmental dynamics has generated problems for urban management. The settlements that have experienced this growth in the urban fringes have generally suffered the lack of urban services and lack of access roads. There is usually no planning. This has reduced the liveability and functionality of the metropolitan city. While it is clearly impossible to put an end to sprawl development, it is possible, it can be controlled, such that development proceeds in a planned and regulated manner. This is perhaps the greatest challenge to urban planners in Nigeria in a rapidly urbanizing context. Efficient urban physical planning in the form of planned lay outs, development control and other regulatory mechanisms must be put in place. The way that land enters the development process, especially registration of title and decisions on what land is used for should also be properly addressed at all levels of government. It is obvious that indigenous land owners must be part of this process. The political class must realize that they have roles to play in other to have a functional city. Thus, there is need to strengthen urban governance, by improving human capacity, proper funding and building institutions that are efficient.

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