



The effect of climatic changes on land use and land cover in spatial development in Port Harcourt: Nigeria

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Article History

Received: 18 May 2016

Accepted: 14 June 2016

Published: July - September 2016

Citation

Augusta Ayotamuno, Akuro Ephraim Gobo. The effect of climatic changes on land use and land cover in spatial development in Port Harcourt: Nigeria. *Climate Change*, 2016, 2(7), 223-234

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General Note



Article is recommended to print as color version in recycled paper. *Save Trees, Save Climate.*

ABSTRACT

The city of Port Harcourt has experienced a lot of changes on Land Uses and Land Cover which has had an impact on the spatial pattern of the city. This study hopes to identify how the varying climatic changes and elements have affected the spatial pattern of Port Harcourt and to ensure that there is sustainable development. The methodology used was Geographic Information Systems

(GIS) and remote sensing which provided a cost effective and accurate alternative to understanding landscape dynamics. Digital change detection techniques based on multi-temporal and multi-spectral remotely sensed data was also used. Objectives of the Study are to examine the spatial pattern of Port Harcourt between the periods of 1984 – 2014. To ascertain how climatic factors have affected the spatial pattern in Port Harcourt. To determine the present state of Land Use and Land Cover in Port Harcourt and how it has been affected by climatic elements. The result of the study showed that there have been climatic deviations in rainfall and temperature values and very obvious changes in the spatial pattern of Land Use and Land Cover between 1984 to 2014. The Built – Up area showed an increase from 16.50% in 1984 to 51.38% in 2014. A lot of development has taken place using up most of the Gallery Forest, Vegetation area and the Water Bodies. Development of Built – Up area needs to be controlled so that all of the vegetation is not used up because the city needs some vegetation to allow the city breath.

Key words: Climatic Change, Land Use, Land Cover, Spatial Development

1. INTRODUCTION

Over the years there has been global climatic changes which has transcended to the continents, nations and locally. These climatic changes do not just occur they are usually accompanied by some impact on the people and the environment. For these climatic changes to occur there are some climatic factors that interact to make these changes which may be gradual and but eventually over a long period of time cause significant impact. Climate is the average weather condition of a given place over a long period of time for about 30 – 35yrs. This is determined by the pattern of variations of several elements and their combinations. The principal climatic elements, when human comfort and building design are being considered are solar radiation, long wave radiation to the sky, air temperature, humidity, wind and precipitation (rain, snow, etc.). This research will concentrate on two of these climatic elements which are rainfall and temperature in Port Harcourt.

Temperature is the degree of hotness or coldness of an object which is measured in degree Celsius (°C). Temperature at a given site depends on wind as well as local factors such as shading, presence of water body, sunny condition, etc. When the wind speed is low, local factors strongly influence on temperature of air close to the ground. With higher wind speeds, the temperature of the incoming air is less affected by local factors.

Rainfall is liquid water in the form of droplets that have condensed from atmospheric water vapour and then precipitated, than it becomes heavy enough to fall under gravity. It is usually measured in millimetres (mm) by using a rain gauge.

Land is a natural resource which is in a scare commodity. It is a very essential component of the ecosystem. When land is redistributed in different areas sometimes it can offset the delicate balance that nature has already put forth between topsoil, organisms and other factors. Port Harcourt is conspicuous with its urban form surrounded by natural land constraints that have strong bearings on available land for physical development and the cost of provision of services in the city. As urban growth increases, so does the pressure on available land. It is a market where land always goes to the highest bidder. Thus land values continue to rise. Accessing land for development has become extremely stressful and expensive, way beyond the reach of the masses therefore the need to use land appropriately.

Land Use and Land Cover changes are associated with a wide range of environmental and landscape attributes including various water quality, land and air resources as well as ecosystem processes and function. Also climatic elements such as rainfall, temperature, humidity, Sunshine and wind all impact land. Land Use and Land cover are distinct, yet, closely linked characteristics of the earth's surface. Land Use which can be defined as the human activity associated with a specific piece of land, affects Land Cover and changes in Land Cover affect Land Use (Longley, 2001; Jensen, 2007). Land Use can be categorized into agriculture, industrialization, urbanization (settlement expansion) and mining/related activities. Land is very essential in the building sector and for any meaning development to take place, land must be affordable and available at where and when it is needed. It is an established fact that land cannot be replaced because it is finite and therefore it is imperative that it is used efficiently for sustainable development (Kantisen Shroff, 2015).

Land Use and Land Cover is dynamic therefore there is prevailing need to understand how these changes occur and how they are affected by climatic factors. Land has a multiplier effect because of the various uses it can be put into. Also if land is not put into proper use it becomes rundown, the land could be devalued and wasted. Land Use and Land Cover can be categorized into built-up area, gallery forest, vegetation and water. Vegetation cover plays an important role in soil retention and reducing soil erosion. Well compacted soil helps to filter out the impurities in fresh water and prevent organic contamination. The removal of natural vegetation cover and canopy tends to reduce evapo-transpiration losses and expose the soil surface to full kinetic energy of

the falling rain, causing breakup of the soil, clogging pores, reducing infiltration capacity and possibly even forming hardpans (Rana, 2005).

Many towns and metropolitan cities are experiencing challenges from climate change. The rising temperatures, changing rainfall patterns, higher sea levels are threatening to overwhelm settlements, urban infrastructure, services and management systems.

The capability to monitor the dynamics of Land Use resulting from both the changes occasioned by increasing population and forces of nature acting on the landscape is imperative. These changes in the spatial pattern of the city could both be natural and manmade factors. The natural elements include the atmosphere, geosphere, hydrosphere and biosphere; while the human factors can include Land Use and consumption of other natural resources. Changes in any of these factors can cause local, regional, or even global changes in the climate. The relationship between People, Climate and Buildings is non-linear and complexly interdependent. Climate also affects the use of land, the type of crop that can be grown or the animal husbandry that can be practiced. These variations in the use of land can cause regional climatic changes- such as the spread of desert conditions due to deforestation. Microclimate variations can be caused by presence of trees, grass and water. Built up areas and cities would tend to have their own microclimate which would differ significantly from the climate of the region. Ground reflecting surfaces and artificial topographical features can affect wind flow, solar radiation and hence temperature patterns. It is now established that the consumption of energy in cities for buildings and transport etc. can make very significant changes to temperature.

Sustainable development as quoted by the Brundtland Report, "Our Common Future" proposed a definition for sustainable development, which has become the commonly used definition (Drexhage and Murphy, 2010) as "Development that meets the needs of the present, without compromising the ability of future generations to meet their own needs".

In the building industry, there has been growing concern for the environment which caused governments, practitioners, researchers and manufactures alike to be in constant collaboration to develop new technologies and techniques that will improve the quality of life, reducing economic waste and emitting minimal carbon to the environment (Kasahun Kitila Hunde, 2015a & 2015b). Sustainable buildings and sustainable technologies; The main objectives of sustainable designs are to reduce, or completely avoid, depletion of critical resources like energy, water, and raw materials; prevent environmental degradation caused by facilities and infrastructure throughout their life cycle; and create built environments that are liveable, comfortable, safe, and productive.

Over the years the city of Port Harcourt has experienced a lot of changes on Land Uses and Land Cover which has had an impact on the spatial pattern of the city. This study hopes to identify how the varying climatic changes and elements have affected the spatial pattern of Port Harcourt and to ensure that there is sustainable development.

Goal of the Study

The study identifies what the spatial pattern of the city was and to note the changes that have occurred particularly in the built up area. To determine the present state of Land Use and Land Cover in Port Harcourt and how it has been affected by climatic elements.

Objectives of the Study

- 1.To examine the spatial pattern of Port Harcourt between the period of 1984 – 2014.
- 2.To ascertain how climatic factors have affected the spatial pattern in Port Harcourt.
- 3.To identify the factors that have caused the changes in the spatial pattern of Port Harcourt and how it affects housing development.

2. BACKGROUND INFORMATION ABOUT THE STUDY AREA

Port Harcourt was created by the British colonial administration between 1912 and 1914 to aid, through its coastal port, in the evacuation of agricultural produce, coal and for handling of trade from the hinterland. Initially the study area, which was named after the then British Secretary of State for Colonies, Lewis Harcourt, was just 30,000 acres, but with the discovery of oil in 1955 in Olobiri, Port Harcourt expanded quickly beyond its original boundaries (presently about 470km²). Port Harcourt is located within latitudes 6° 58' N to 7° 6' N and Longitude 4° 40' to 4° 55' E. The climate falls within the sub equatorial climate belt. Temperature and humidity are high throughout the year. The area is marked by two distinct seasons – the wet and the dry seasons – with 70% of the annual rains falling between April and August, while 22% is spread in the three months of September to November. The driest months are from December to March. It falls almost entirely within the lowland rain forest ecological zone and is flanked in the east, west and southern limits by mangrove swamp forest (Ayotamuno and Gobo 2004).

The growth of Port Harcourt and its region has been phenomenal since its inception. Growth has been experienced in terms of population and space. Two years after its founding, the population was 5,000. Census figures for the city through its history are

7,185 in 1921; 15,201 in 1931 and 71,634 in 1953. The 1963 census gave the city's population as 179,563 and in 1973 it was 213,443 (Ogionwo, 1979). The 1991 census fixed the population of Port Harcourt and Obio/Akpor Local Government Areas at 645,883. The projection for 1996 by the National Population Commission is 832,471 for the two local governments and the interim figures for the 2006 national census is over one million. Spatially too, Port Harcourt city has grown to cover much of the Upper Bonny River Basin. Originally the city covered a 25km² area between the UTC junction and the New Layout Market. In the land use and vegetation map of Nigeria (1975/76) the built-up area of Port Harcourt covered 17.4km². Twenty years later, a similar map showed the extent of the city as 89.4km. This is a five-fold increase. By the 1976 Local Government Reform, the Port Harcourt Local Government Area Council stretched from Choba and Rukpokwu in the north, Iriebe in the east and the main western channel of the Bonny River in the west. This is an area of over 239.6 km². It was therefore known as the Garden City. There was a Master Plan of 1975 by the Specialist Consult a Swedish Company. The 1975 Master Plan was to last a period of 30yrs which expired in 2005. This plan was largely unimplemented and there was no legal instrument to ensure compliance of the 1975 Master Plan. At its expiration there was a vacuum hence the need for a new Master Plan. Port Harcourt is still growing very fast and therefore the need for the Greater Port Harcourt City (GPHC).

Port Harcourt is the treasure base of the nation and the fastest growing city in the Niger Delta and Nigeria; there is therefore a need to control its development. The Rivers State Government therefore engaged Arcus GIBB, a multi-disciplinary consulting South African firm in 2009 to develop a Master Plan for the Greater Port Harcourt Area (GPHCDA).

The Greater Port Harcourt City Development Authority (GPHCDA) was established as The Greater Port Harcourt City Development Authority (GPHCDA) on April 2, 2009, the legal instrument being "The Greater Port Harcourt City Development Authority" Law No. 2 of 2009, with a mandate to facilitate the implementation of the Greater Port Harcourt City Master Plan and develop the New City. A number of factors were paramount in the decision to redevelop Port Harcourt, including:

- The need to modernize the old City (Port Harcourt) and re-awaken it to its once thriving Garden City status;
- The need to improve the standard of living of all people in the city by providing better living environment that is properly serviced and gives access to social services and infrastructure;
- The need to create a modern business node that will accelerate economic growth and development supported by appropriate economic policies and governance; and
- The need to attract private sector investment and participation in infrastructure, housing, retail, offices and other commercial facilities (GPHCDA, 2009).

The methodology used was Geographic Information Systems (GIS) and remote sensing which provided a cost effective and accurate alternative to understanding landscape dynamics. Digital change detection techniques based on multi-temporal and multi-spectral remotely sensed data was also used. This demonstrated great potential for understanding landscape dynamics especially on how to detect, identify, map and monitor differences in Land Use and Land Cover patterns over time (Jensen, 1996).

Models of land-use change relied on simple parameters, including the urban area's present extension, main transport routes, distances to workplaces and goods, topographical conditions, and the existence of land with special conditions, e.g., protected areas. The main purpose of modelling is to identify the physical and socio-economic factors that determine or condition pressure for land-use change at the urban-rural interface (White and Engelen, 2000). The two prevalent approaches to modelling spatial land-use change patterns are Regression-based models and models based on spatial transition (Theobald and Hobbs 1998, Brown et al. 2002 and Pijanowski et al. 2002). In the former approach, a relationship is established between a wide range of predictive variables and the probabilities of Land-Use change; the latter approach is an extension of Markov's a spatial technique and a form of stochastic cellular automaton (Zhou and Liebhold 1995). A spatial database was generated between 1984 – 2014 using geo-referenced digital aerial photographs. Thematic coverage maps were obtained using photo-interpretation techniques and included urban Land Use.

3. STUDY FINDINGS

Land Use and Land Cover have depreciated over the years as it undergoes through several climatic conditions as well as some human activities. Some of the climatic conditions looked at in this study are annual rainfall and temperature for a period of 33yrs. Below is a table 1 that shows the annual rainfall and temperatures.

From Fig 2 and 3 rainfall values for Port Harcourt from 1977 – 2010 showed maximum as 2618.30mm in 2006 and minimum as 1632.00 in 1983 while the temperature values for Port Harcourt from 1977 – 2010 showed maximum as 26.850C in 2006 and minimum as 25.600C in 1978 respectively. Water Bodies have some impact on the environment, so when the temperature gets extremely hot a lot of evaporation takes place. Nearness to a large water body influences the climate of the area. Water bodies are sources of atmospheric moisture through evaporation and areas near them experience higher rainfall. In 1984 the area covered by

water bodies was 11.38% and by 2014 it has been reduced to 9%. This clearly shows that the water bodies in Port Harcourt may be drying up due to high temperatures. Also some the water bodies have being reclaimed over the years for several developments. Water, having a higher specific heat than land is normally warmer in raining season and cooler in dry season and usually cooler during the day and warmer at night, than the terrain. Accordingly, the proximity of bodies of water which moderates extreme temperature variations and in raining season raises the minimums, in dry season lowers the heat peaks.

Natural Vegetation:- Forested and wetland areas contribute to the atmospheric vapour through transpiration leading to the formation of rainfall. Areas without vegetation or limited vegetation experience less rainfall. In 1984 the natural vegetation was 47.90% and by 2014 it has been reduced to 21.04%. More than 50% of natural vegetation has been used for development. Vegetation plays an important role in changing the climate of a city. It is also effective in controlling the microclimate. Plants, shrubs and trees cool the environment when they absorb radiation for photosynthesis. They are useful in shading a particular part of the structure and ground for reducing the heat gain and reflected radiation. By releasing moisture, they help raise the humidity level. Vegetation also creates different air flow patterns by causing minor pressure differences, and thus can be used to direct or divert the prevailing wind advantage. Gallery Forest Areas was 1984 in 24.23% and by 2014 it has been reduced to 18.13%.

Built -up Area includes land for infrastructure, transportation and housing. The built – up area was 16.50% in 1984 and it has increased to 51.38% by 2014. This is more than 300% increase in development which has been used in the built environment. In the city the Land Use was predominantly for Built –Up Area, Gallery Forest, Vegetation and Water Body. Presently the Land Use is predominantly for residential use because of the current high population density. This can be seen in the spatial map in Fig 1.

The study considered Land Use Cover in general. The vegetated areas generally have lower air temperatures because of moisture in the air. Port Harcourt has experienced higher temperatures because of so much human activities are high – density urban areas, combined with densely built – up areas which trap and radiate heat emissions. Port Harcourt faces serious problems related to urbanization especially in providing affordable housing and livelihood options. The need for more housing and business area decreases the green area in this city. Impermeable land surfaces are dominating air temperatures, which is unavoidable. Encourage and monitor the promotion of green roofs which will reduce heat level in the city. The rainfall pattern showed change in climatic pattern which has significant impacted in the Land Use.

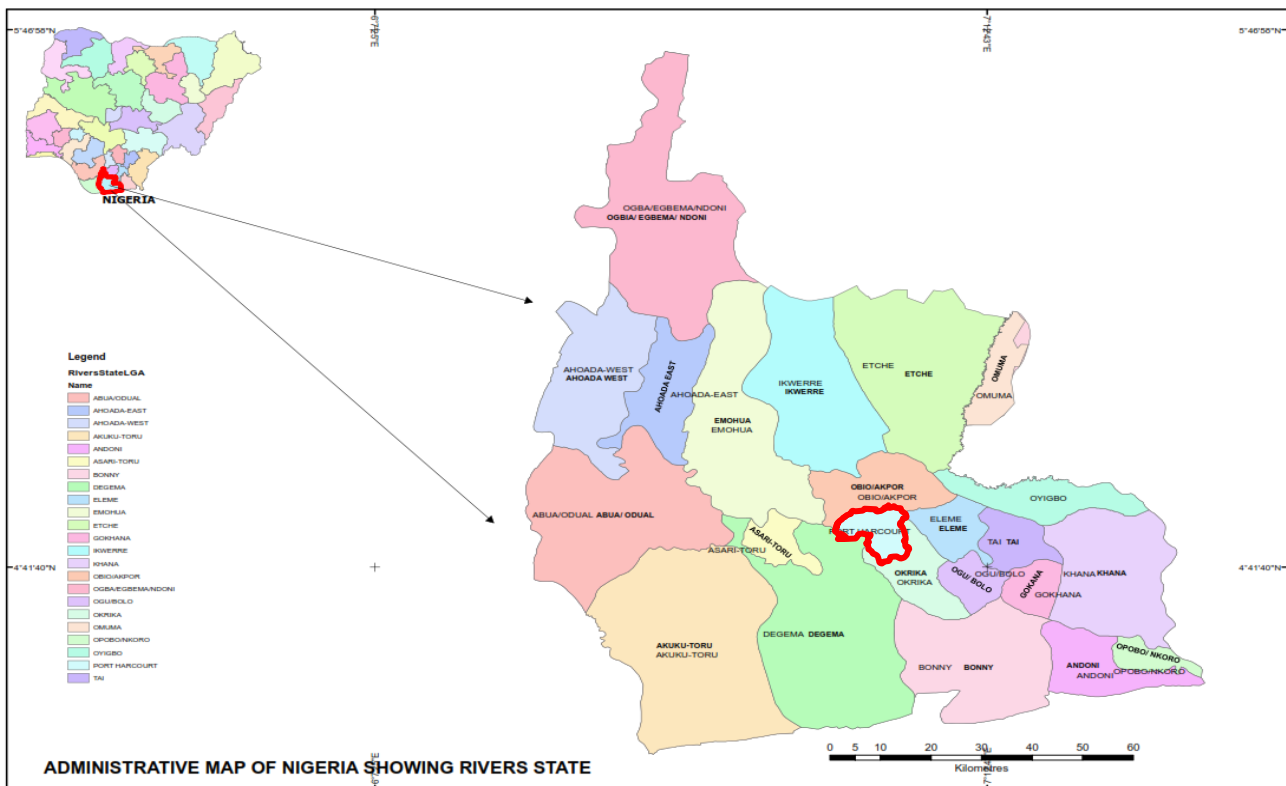


Figure 1 Map of Nigeria showing Rivers State and Port Harcourt Methodology

Table 1 Rainfall and Temperature Range showing their Standard Deviation

Year	Mean Annual Rainfall X (Mm)	$\bar{X-X}$	Mean Annual Temperature Y ($^{\circ}$ C)	$\bar{Y-Y}$
1977	2502.3	244.59	26.08	-0.19
1978	2291.2	33.49	25.6	-0.67
1979	2235.5	-22.21	25.98	-0.29
1980	2544.9	287.19	26.08	-0.19
1981	2158.3	-99.41	25.73	-0.54
1982	1991.5	-266.21	25.72	-0.55
1983	1632	-625.71	26.18	-0.09
1984	2096.8	-160.91	25.96	-0.31
1985	2395.6	137.89	25.98	-0.29
1986	2283.1	25.39	26.02	-0.25
1987	2261.3	3.59	26.71	0.44
1988	2420.9	163.19	26.36	0.09
1989	2159.7	-98.01	25.98	-0.29
1990	2073.3	-184.41	26.47	0.20
1991	2094.4	-163.31	26.2	-0.07
1992	1962.2	-295.51	26.09	-0.18
1993	2542.4	284.69	26.03	-0.24
1994	2374.2	116.49	26.2	-0.07
1995	2589.3	331.59	26.43	0.16
1996	2339.7	81.99	26.32	0.05
1997	2329.4	71.69	26.31	0.04
1998	2569.3	311.59	26.79	0.52
1999	2479.6	221.89	26.03	-0.24
2000	2068.9	-188.81	26.44	0.17
2001	2153.5	-104.21	26.23	-0.04
2002	2186.2	-71.51	26.44	0.16
2003	2407.8	150.09	26.49	0.22
2004	1877.5	-380.21	26.52	0.25
2005	2022.9	-234.81	26.62	0.35
2006	2618.8	361.09	26.85	0.58
2007	2357.6	99.89	26.62	0.35
2008	2011.2	-246.51	26.38	0.11
2009	2564	306.29	26.6	0.33
2010	2166.7	-91.01	26.77	0.50

Source: Institute of Geosciences & Space Technology, RSUST, Port Harcourt

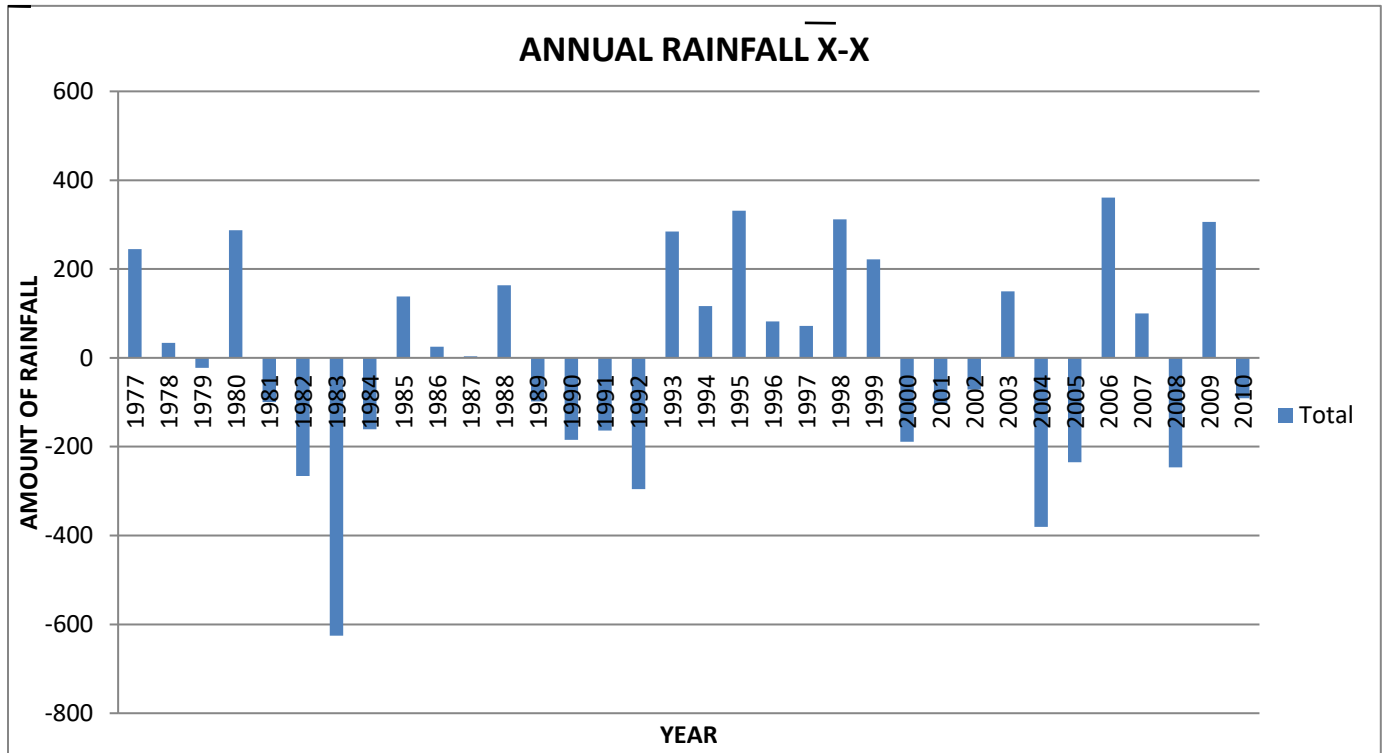


Figure 2 Annual Rainfall between 1977 - 2010

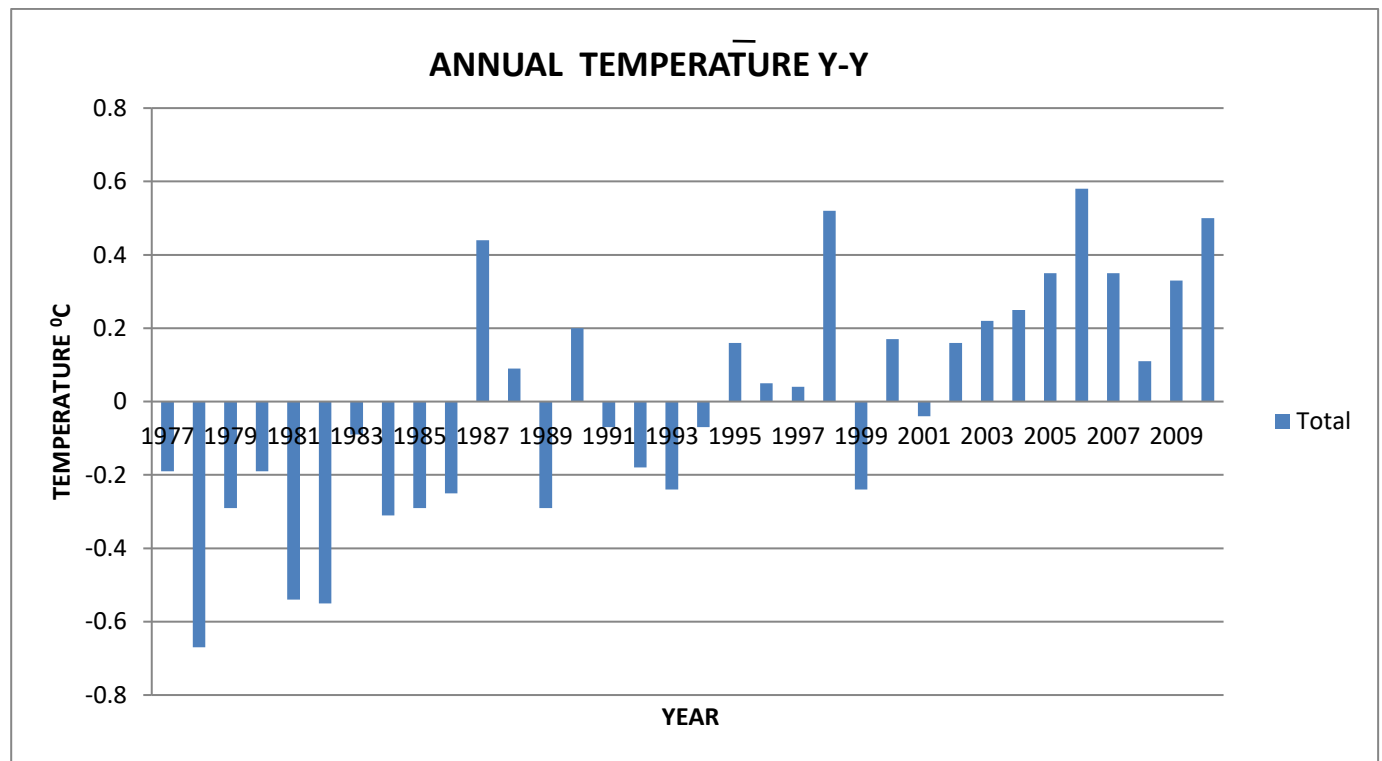


Figure 3 Annual Temperature between 1977 - 2010

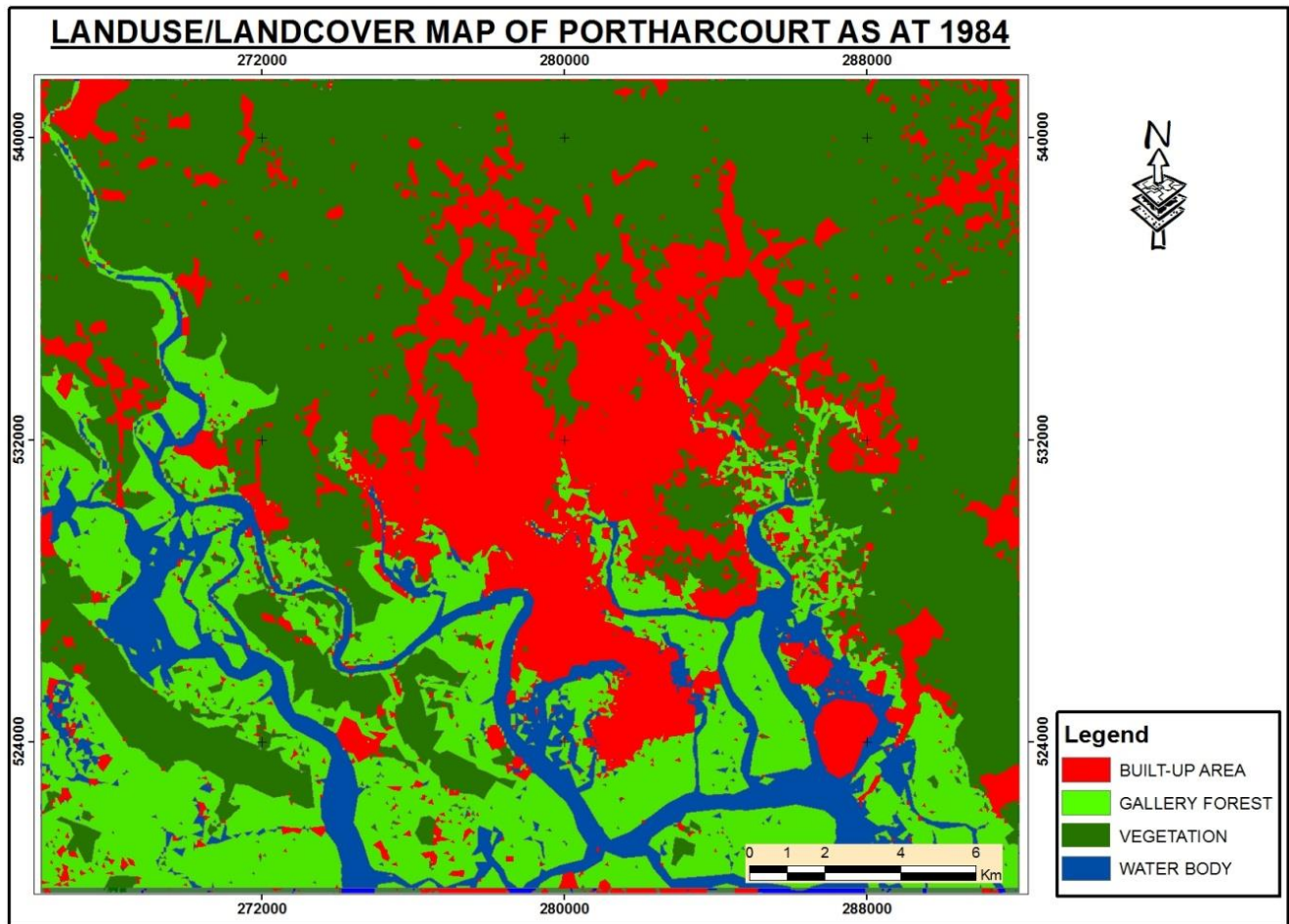


Figure 4 Land Use/Land Cover Map of Port Harcourt as at (1984)

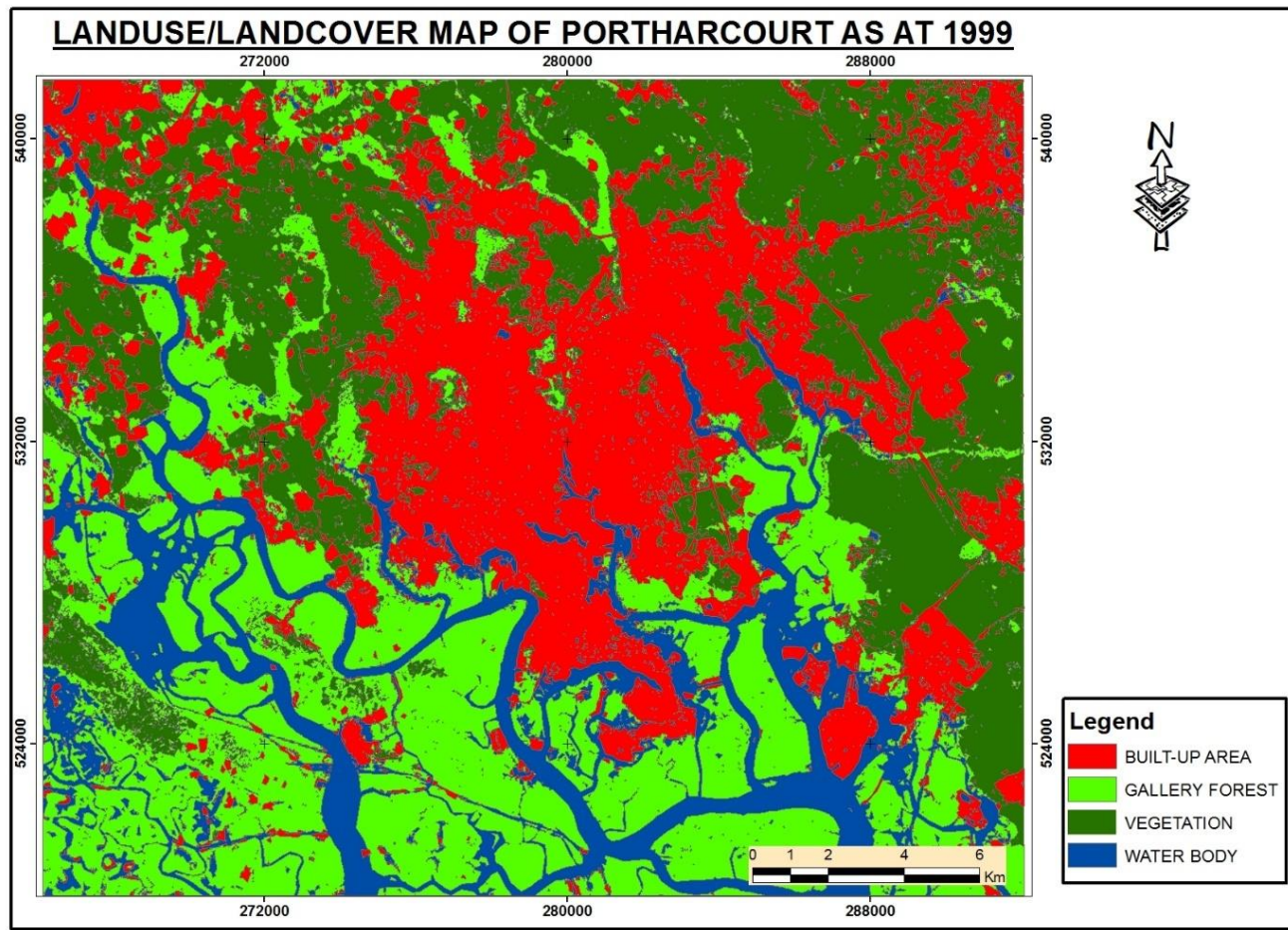


Figure 5 Land Use /Land Cover Map of Port Harcourt as at (1999)

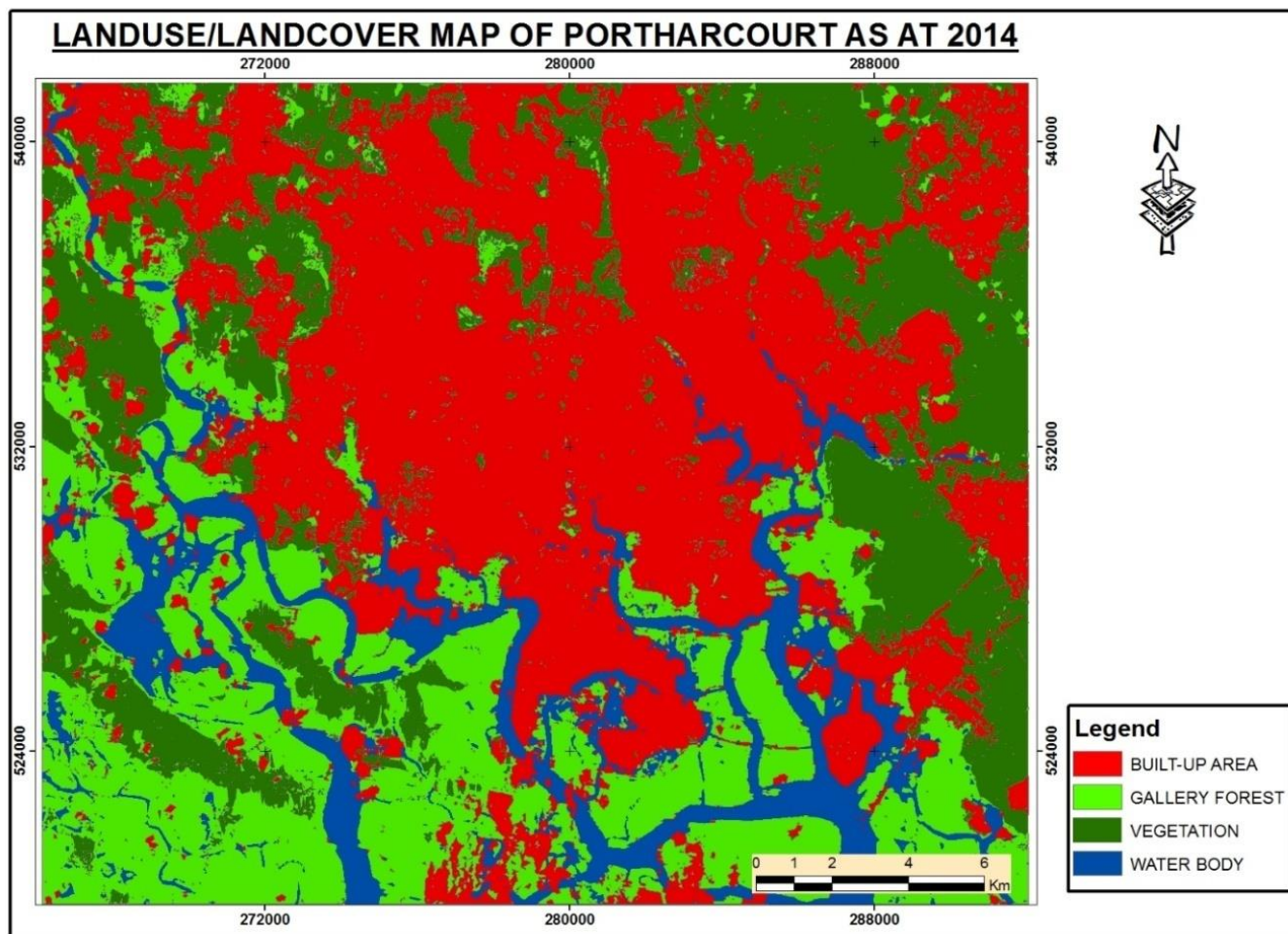


Figure 6 Land Use / Land Cover Map of Port Harcourt as at (2014)

Table 2 Land Use/ Land Cover Statistics in Hectares and Percentage

LANDUSE	Year	Area (Hect.)	Area (%)	% Diff
BUILTUP AREA	1984	9228.79	16.50	0
	1999	17522.90	31.32	14.83
	2014	28993.51	51.38	13.35
GALLERY FOREST	1984	13552.74	24.23	0.00
	1999	12472.46	22.30	-1.93
	2014	10140.28	18.13	2.98
VEGETATION	1984	26795.81	47.90	0.00
	1999	19881.49	35.54	-12.36

	2014	11772.75	21.04	-14.49
WATERBODY	1984	6364.50	11.38	0.00
	1999	6064.99	10.84	-0.54
	2014	5035.29	9.00	-1.84

Table 2 shows how the spatial Land Use and Land Cover have changed between the period of 1984 to 2014. The built – up area in 1984 was 9228.79, in 1999 it was 17, 522.90 and 28,993.51 Hectares in 2014, which shows an increase from 16.50% in 1984 to 51.38% in 2014. Gallery Forest area in 1984 was 13,552.74, 1999 12,472.46 and 10,140.28 Hectares in 2014, which shows a decrease from 24.23% in 1984 to 18.13% in 2014. The vegetation area in 1984 was 26,795.81, 1999 19,881.49 and 11,772.75 Hectares in 2014, which shows a decrease from 47.90% in 1984 to 21.04% in 2014. The water-bodies area in 1984 was 6364.50, 1999 6064.99 and 5035.29 Hectares in 2014, which shows a decrease from 11.38% in 1984 to 9.00 % in 2014.

4. CONCLUSION

The study showed that there have been climatic deviations in terms of rainfall and temperature values and very obvious changes in the spatial pattern of Land Use and Land Cover between 1984 to 2014. The Built – Up area showed an increase from 16.50% in 1984 to 51.38% in 2014. A lot of development has taken place using up most of the Gallery Forest, Vegetation area and the Water Bodies. Statistically the Gallery Forest also showed decreased from 24.23% in 1984 to 18.13% in 2014. The vegetation area showed a decrease from 47.90% in 1984 to 21.04% in 2014. The water- bodies showed a decrease from 11.3 8% in 1984 to 9.00 % in 2014.

RECOMMENDATIONS

There should be regular monitoring of development by the River State Housing Authority and the Ministry of Lands and Housing in the city of Port Harcourt to ensure that development adhere strictly to the Town Planning rules laid out for the city. This can be achievable by having periodic surveys and having a data bank of the various changes in the spatial development. The water bodies should not be encroached or dredged without approval or licence because when they are encroached on for building houses, the natural water ways will be blocked which will eventually result to flooding in later years. Also development of Built – Up area needs to be controlled so that all of the vegetation is not used up because, some areas of the city need to remain as vegetation to allow the natural ecosystem for sustainable development as well as allow the city breath.

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