Full Length Research Paper

Analysis of Landuse and Landcover Change around the City of Port Harcourt, Nigeria.

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The analysis of landuse / Landcover change is essentially the analysis of the relationship between man and land. Landuse and landcover change have become a central component in current strategies in managing natural resources and monitoring environmental changes. Landuse and landcover of region is a reflection of the level of development in that region on the one hand, and the level of development influences landuse and landcover. On the other hand landuse/ Landcover change becomes essential in monitoring development in a region. The city of Port Harcourt has witnessed tremendous growth in population in recent years and a cursory assessment would reveal a change in landuse and landcover of the area. However, the pattern and trend in this change is not properly documented in literature. Therefore this study was instituted to analyse the extent and trend of landuse/ Landcover change within and around Port Harcourt City. Using satellite imageries between 1986-2007 and GIS as analytical tools, the paper discovered a significant change in Landuse / Landcover change in Port Harcourt city and environs which is basically as a result of rapid urbanization and other anthropogenic activities. More significantly, is the decline in agricultural land and rise in built-up areas. Thus, if the decline in agricultural land remains unchecked, in the nearest future food production would be a serious challenge and rural livelihood would negatively be impacted. The paper therefore recommends proper landuse planning and enforcement of development control to forestall the negative environmental and socio-economic consequences of landuse and landcover changes.

Keywords: Development, Landuse / Landcover change, Port Harcourt, Remote sensing Residential use, Satellite Imagery.

INTRODUCTION / BACKGROUND

Land is the solid part of the earth surface and the basic natural resource of any nation or state on which human and economic activities take place. It is humanity's most valuable resource without which man could never have existed and on which his continued existence and progress depend (Fabiyi, 2006). Land is said to be the primary and permanent material for human existence. Land from time immemorial has been treated as a measure of wealth, status and power all over the world (Aloks and Navedeep, 2002). As a result of this land has also been the source of

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many bloody conflicts and disputes not only between nations, kings, but also between common people as this was the major source of their livelihood. It has also been the cause of family rifts, turning brothers into enemies. Hence land is used to meet a multiplicity and variety of human needs and to serve numerous diverse purposes.

The analysis of landuse change is essentially the analysis of the relationship between man and land. This relationship between man and land can be traced to the Holy Bible where it was clearly made known in several chapters that man cannot be detached from the land (Adeniyi, 2012). In the holy book of the Bible (Genesis, chapter 2 verse 7), it was stated that man was created from the dust of the land and will return to the land at the end of his life. It is also indicated that while, alive, man will keep on working, "tilling the land" for his or her survival. It was noted in the Holy book also, that land is our home, our means of survival, our place of rest, safety and enjoyment of good life. It is therefore not out of place to say that without land there would be no human existence since land provides human with items like food, fuel, clothing, shelter and medication which are very essential for survival. Just like it was during the biblical times, so it is today in Nigeria and other parts of the world where land is perceived as the essence of human self definition and socio-economic and cultural survival because the ability to own, control and use land is not only an important expression of both private and proprietary right but also a measure of economic wealth and power (Adeniyi, 2012).

Landuse is the term used to describe what goes on in the land. It is the way in which and the purposes for which human beings employ the land and its resources. The Natural Scientists define landuse in terms of syndromes of human activities such as agriculture, forestry and building construction that alter the land surface. While the social scientists and land managers define landuse to include social and economic purposes and contexts for and within which land is managed (Fred-Nwagwu, 2012). Landcover on the other hand, describes the physical or natural and biological cover over the earth surface including water, vegetation, bare land or artificial structures (Robert, 1998). It refer to the kind of vegetation (such as forest or grass cover) but it now includes structures such as buildings or pavement and other aspects of the natural environment such as soil, biodiversity, surface and ground water.

Landuse and landcover change are general terms for the human modification of Earth's terrestrial surface. It is an outcome of natural and socio-economic factors and their utilization by man in time, and space. Land is becoming a scarce resource due to immense demographic pressure. Though humans have been modifying land to obtain food and other essentials for thousands of years, but the current rate, extent and intensities of landuse are far greater than ever in history (Zubair, 2006). Hence information on landuse and landcover change emerged as a global phenomenon and the most significant regional anthropogenic disturbance to the environment in 20th century (Ademiluyi, et'al, 2008).

Landuse and landcover change have become a central component in current strategies in managing natural resources and monitoring environmental changes. Mmom (2008) noted that the Landuse and landcover of region is a reflection of the level of development in that region on the one hand, and the level of development influences landuse and landcover of a region. In other words, development and Landuse/Land cover is like two sides of the same coin. The quest and strive towards industrialization, technological innovations, and the drive to modernism have resulted to modification and change in landuse and landcover of a region. It is pertinent to note that landuse and landcover changes have impacts on a wide range of environmental and landscape attributes such as the quality of water, land and air resources, ecosystem processes and function, and the climate systems. A lot of environmental challenges have arisen in recent times due to landuse and landcover change. Urban flood as a case in point has been on the increase due to poor landuse planning and landuse change. Most natural flood pathways and drainages have given way to high rise edifices for instance; natural vegetations have been cleared for paved roads and other social infrastructure. Thus, an unplanned change in the landuse and cover would mean exposure of man to many vagaries of nature that most times turn out to be disasters to human life and properties.

The Problematic

Land use and land cover change analysis is one of the most precise techniques to understand how land was used in the past, types of changes expected in the future as well as forces and processes behind the changes (Belay 2002, cited in Messay, 2011). The interaction between man and his environment have become increasingly complex and diverse especially in natural resource exploitation and development. This is as a result of lack of information on landuse and landcover. More recently, the need for thoughtful and careful stewardship of land, together with more intensive use and management of its resources, has emerged as a matter of major global concern. This has led to a re-evaluation of the need for information about land, the strategies and programme that may provide it. (Ojigi, et' al, 2011). It has been recognized that policy makers, planners, land administrators and individual citizens all have a need for information about land and make significant use of spatial data on a day-to-day basis. The accurate knowledge of natural resources, description and record of such knowledge are the essential prerequisite to

their rational use and conservation. As such land information has become a prime requisite for making decisions related to land investment, development and management.

Port Harcourt city since its inception in 1912 has witnessed remarkable growth in population, expansion and developmental activities which have resulted in increased land consumption and alteration of the earth surface (land). The increasing concern for the management of natural resources in recent times has been necessitated by the increasing demographic pressure and its associated anthropogenic activities which have led to serious environmental stress and ecological instability.

The outcome of the natural and socio-economic factors of landuse and landcover in Port Harcourt call for an accurate investigation in the causes, processes and rate of landuse and landcover change in the city and its environ. Several research works have been reported in literature on impact of land use change on urban floodplains (Mmom, et'al, 2008), implication of landuse change on hydro-meteorological events in Port Harcourt (Chukwu-Okeah, and Mmom 2012), Bekwe (2003), Abam (2008) and Fabiyi (2006). However, little is documented on the extent of landuse and landcover change as well as impact of landuse change around Port Harcourt city. It is in the light of the above gap in literature on Port Harcourt city that this paper derives its objectives of determining landuse and landcover change around Port Harcourt City and its environ and its implication on socio-economic development in the area. The paper also hopes to establish an inventory of landuse and landcover scheme, to determine the trend, rate, nature, location and magnitude of landuse and landcover change, and to map these changes. Against this backdrop that the following research questions become pertinent and providing answers to them form the central target of this work: Has there been land use and land cover change over Port Harcourt city in the past twenty (20) years? What is the extent / direction of land use and land cover change in Port Harcourt city and its environs? Is there documentary evidence of this change?

The study Area

Port Harcourt is located within the humid tropics of the southern part of Nigeria and sited on a relatively firm land about 66km from the Atlantic Ocean (Ukpere, 2005). The geographical coordinates of the city limit lies approximately within latitude $4^0 \, 40^1$ and $5^0 \, 01^1$ north and longitude $6^0 \, 50^1$ and $7^0 \, 01^0$ east (Papadaki 1961, cited in Bekwe 2002). Due to increase rate of urbanization and industrialization, Port Harcourt City and its environs has increased tremendously crossing its initial limits. This urban sprawl is continuing at an alarming rate engulfing more neighbourhoods.

The modern Port Harcourt metropolis is now made up of Port Harcourt City and Obio/Akpor Local Government Areas covering a total area of 360 km^2 (139sq mile) and 260 km^2 (100.4 sq mile) respectively.

Port Harcourt has a relatively flat topography of about 3.3m above sea level, with poorly maintained drainage facilities. Its monotonous flat topography is essentially the product of the ever changing river channels of the distributaries of the Rivers Niger. This flat landscape comprises of Coastal plains tranversed by Labyrinth of swamps, creeks and waterways indicating a relatively scarcity of firm and extensive land areas (Umeuduji and Aisuebogun 1999, cited in Ukpere, 2005).

Historically, Port Harcourt the capital city of Rivers State otherwise known as Nigerian Garden City started as a small fishing settlement. It lies along the Bonny River and is located in the Niger Delta Region. Port Harcourt was founded on the very edge of the West African low land on 1912 by the British Colonial administration of Nigeria beside the farmlands called Obumotu, near the Cliffs of Iguocha of the Diobu Ikwerre village. Port Harcourt was formerly called Iguocha and was renamed by Frederick Lugard, the Governor General of Nigeria after Lewis Vernon Harcourt, the secretary of state for the colonies on 18th August 1913.

The purpose of creating Port Harcourt was to export the coal which geologist Albert Ernest Kitson discovered in Enugu in 1909. By 1920 Port Harcourt became the second Sea Port in Nigeria after Lagos and exported the first shipload of crude oil from Nigeria in 1958, after the discovery of crude oil in 1956 at Oloibiri.

Since then Port Harcourt became the centre of the Nigeria oil economy and subsequently reaped benefits of its associations with the petroleum industry by undergoing modernization and Urbanization. The city is a major industrial centre with a large number of multinational firms as well as other industrial business related to petroleum industries. It is the chief oil refining city in Nigeria having crude oil as its main export product. In fact, the city is now a major industrial centre with a large number of multinational firms. Port Harcourt City, "The Oil City and Garden City" as fondly called has witnessed tremendous growth in population since its' inception in 1912. The 1991 National Population Census puts the provisional population of Port Harcourt metropolitan area at 703,316 but the 2006 census puts Port Harcourt at 1,005, 904.

Based on this growth and urban sprawl being experienced, in 2009 the Government of the state passed an Edict through the state house of Assembly to spread development to other surrounding communities to decongest the city. This gave rise to the Greater Port Harcourt City Development Project (GPHC Project).

METHODOLOGY AND DATA

The major data input for this study are remotely sensed satellite images of varied resolutions obtained from GLCF (Global landcover facility), which covered the study area and its environs for a period of 30years. The three images used for the study are the landsat thematic mapper of 1986 with 30 meters resolution, landsat thematic mapper 1996 with 30 meters resolution and landsat image of 2007 with 30 meters resolution.

Pre-processing activities were carried out in order to enhance the quality of the image and readability of the features. Data preprocessing is a process whereby all the existing data in form of maps, images and tables are converted into a suitable form for permanent storage within the GIS database. A major preprocessing activity carried out was image restoration, which is concerned with the correction of distortion, degradations and noise introduced during the imaging process. These errors can degrade the quality of the remote sensor data collected, which may have impact on the accuracy of human or machine-assisted image. Thus, the landsat images of 1986, 1996 and 2007, collected from the Rivers State Lands and Housing Bureau were geometrically corrected and the projection was set to World Geodetic System (WGS 84) and into UTM zone 32. The overall accuracy level of the Landsat TM (1986), Landsat TM (1996), Landsat TM (2007) was found to be 91.79, 98.60, and 87.43 per cent.

The software, ArcGIS Version 9.3 and illwis version 3.6 were used to carry out the various spatial operations on the satellite imageries. The standard methods of visual interpretation techniques were employed for the interpretation, classification and delineation of landuse and landcover categories based on tone, texture, shape, size and pattern. Also areal changes were calculated for each landuse and landcover class in different time scale. Two major analyses were used in this research. They are (a) Area Calculation of the landuse and landcover (b) Overlay/cross operations for change detection.

RESULT AND DISCUSSION

Landuse and Landcover Classification Scheme Using the application of image classification methods, the supervised and maximum likelihood parameter were used for the classification and five major landuse and landcover types were identified in the study area. The landuse and landcover distribution for each study year of 1986, 1996 and 2007 images as derived from the classified images are presented in the table 1 below.

Analysis of landuse and Landcover distribution in Port Harcourt and environs between 1986 and 1997 as presented in table1 and figures 1, 2 & 3 above shows that water bodies reduced steadily from 11 % in 1996 t0 about 8 % in2007. This was the case for swamp landcover with a decrease of 26.75% in 1986 to 20.52% in 2007. This could be accounted for by the various lad reclamation activities that went on around the city as at then. The Borikiri sand field, Marine Base and Eastern Bye-pass, Okirika and Buguma sand fields were reclaimed during that period. Residential area also showed an increased change from 12.84% in 1986 to 23.94% in 2007. The rapid influx and urbanization that the city is experiencing has accounted for this. Table 1 and figures 1, 2 and 3 also showed a dramatic decrease of the farmland in 1996 and 2007 from 14.24 to 0.45 respectively. However, in terms of vegetation, there appears to be dramatic change. Vegetation rather increased from 35.16 % in 1996 to 47.01% in 2007. This increase, though paradoxical could have likely been accounted for by the increase in parks and gardens within and around the city.

While the annual rate of change = Observed Area change/ number of study year.

The rate of landuse and landcover changes for the study area and for the periods 1986-1996 and 1996-2007 as shown in table 2 was calculated using the following formula: Rate of change = (A-B)/B x 100

Where A= Recent year area of landuse/landcover in km^2

B = Previous year area of landuse and landcover in km^2

From the table 2 below there is a negative change in swamp which is a predominant landuse/landcover type in Port Harcourt as a result of its tropical monsoon climate. Also there is a negative change in farmland for the periods 1986-1996 and 1996-2007, these changes are as a result of modernization, urbanization and economic activities resulting from population migration into the city. Most of the swamp and farmland are sold, cleared and used to build structures for accommodation, industries and recreational centres. The table 2 also showed a positive change in residential landuse/landcover types. It is important to note that the city grew uncontrolled in area in the 1980s to date leaving the city highly congested, and this gave rise to the creation of Greater Port Harcourt as part of effort to decongest the city.

Nature and Locations of Change in Landuse/Landcover.

The nature of landuse and landcover change refers to what is changing and to what is it changing to. This change is due to human activities in the area owing to the fact that land is one of the most important natural resources on which human depends for livelihood. The landuse and landcover pattern of an area is an outcome of natural and socio-economic factors and their utilization by man in time and space (Bhagawat Rimal 2005). The information about the nature of change serves as a vital tool in decision making, it reveals changes that are desirable and

Table1. Landuse and landcover distribution of 1986, 1996 and 2007.

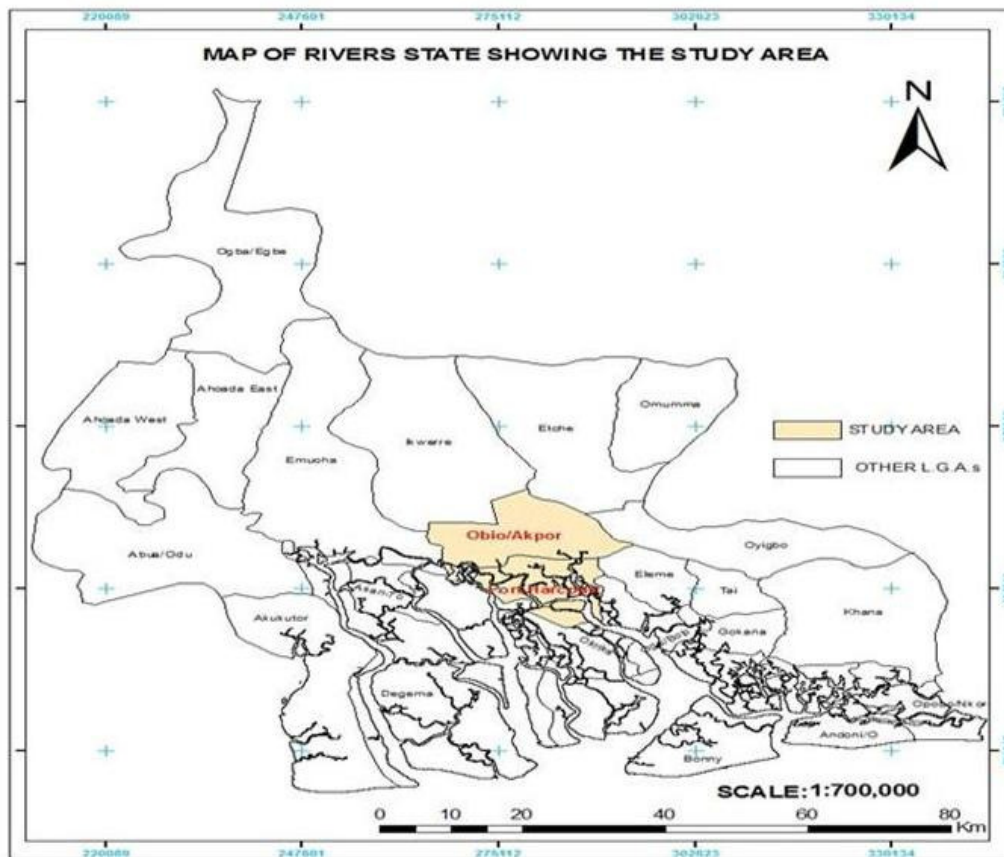| Landuse/Landcover Type	1986		1996		2007	
	Area km^2	% Area	Area km^2	% Area	Area km^2	% Area
Water bodies	9,865.89	11.00	8,853.48	9.87	7,227.81	8.06
Residential	11,520.50	12.84	20,039.34	22.35	21,471.51	23.94
Vegetation	31,525.65	35.16	35,072.48	39.11	42,150.84	47.01
Swamp	23,973.75	26.75	22,050.38	24.59	18,400.47	20.52
Farmland	12,771.27	14.24	3,641.42	4,06	406.41	0.45
Total	89,657.10		89,657.10		89,657.10	

Figure 1. Map of Rivers State showing the study Area.

LANDSAT IMAGE CLASSIFIED OF PORT HARCOURT CITY AND ITS ENVIRONS, 1986

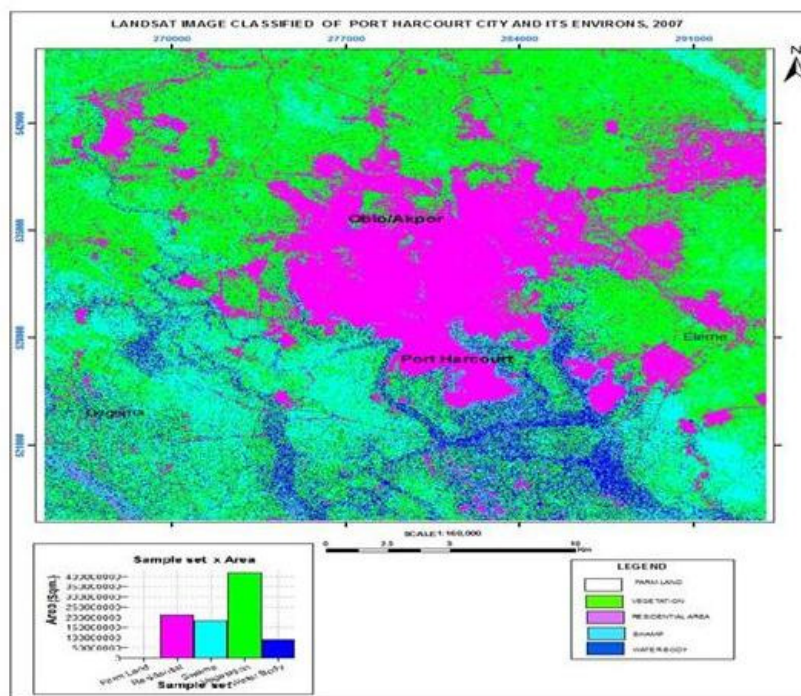LANDSAT IMAGE CLASSIFIED OF PORT HARCOURT CITY AND ITS ENVIRONS, 1996
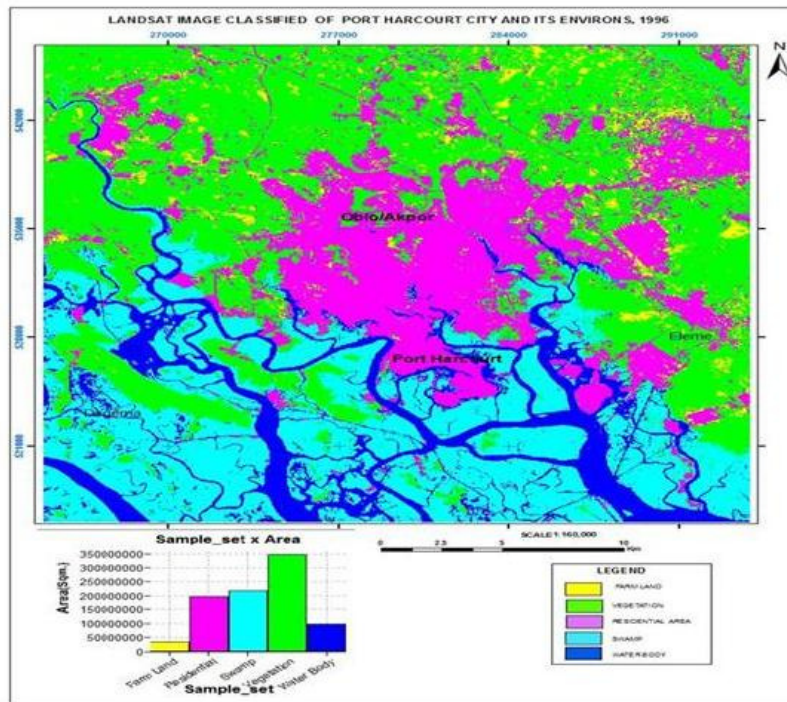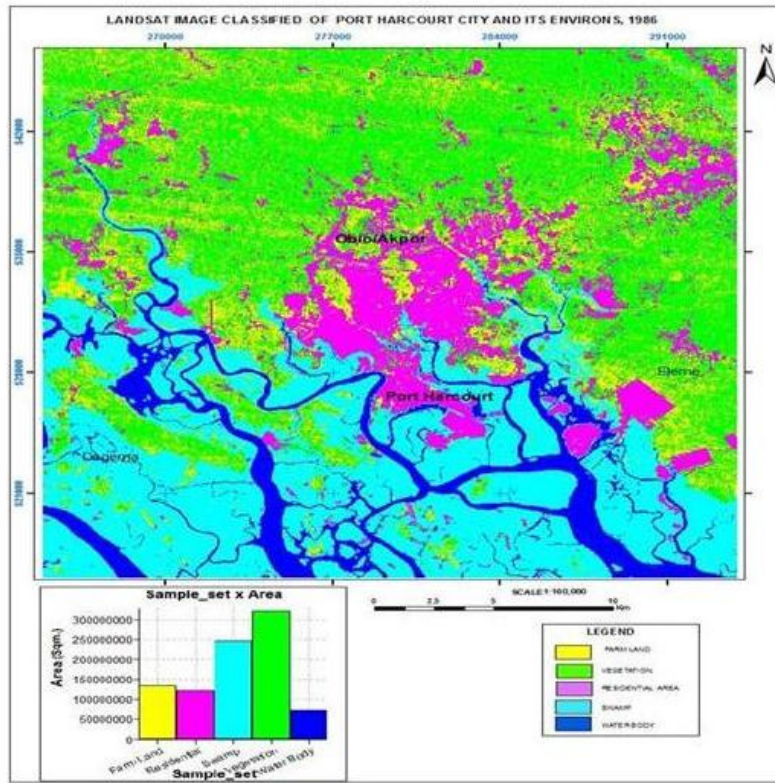
Table 2. Trends and rate of changes in landuse and landcover (change statistics)

Landuse/ Landcover type	1986-1996		1996-2007		1986-2007 Annual rate of change	
	Area km^2	% change	Area km^2	% Change	Area km^2	% change
Water bodies	-1012.41	-10.26	-1625.67	-18.00	-2638.08	-125.62
Residential	8518.80	73.00	1432.25	7.00	9951.03	473.85
Vegetation	3546.83	11.00	7078.36	20.00	10625.19	505.96
Swamp	-1923.37	-8.00	-3649.91	-16.00	-5573.28	-265.39
Farmland	-9129.85	-71.00	-3235.01	-88.00	-12364.86	-588.80

Note: % change rate = (A-B)/B x 100

Where A= Recent area of landuse/landcover in km^2

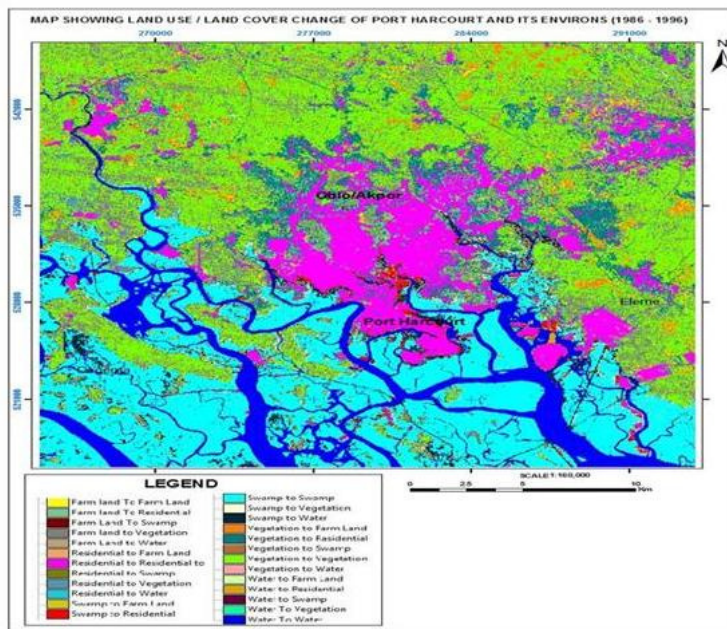   B = previous area of landuse and landcover in km^2

Figure 4. Land use and Land cover change of Port Harcorut City and its environs (1986-1996)

Table 3. Table Depicting Changes in Percentage after Crossing 86_96

S/NO	CHANGE	AREA IN KM2_ 1986-96	% PERCENTAGE
1.	Farm land to Vegetation	9240.3	10.31
2.	Vegetation to Vegetation	23060.7	25.72
3.	Farm land to Residential Area	2700.0	3.01
4.	Vegetation to Farm Land	2241.0	2.50
5.	Farm land to Farm Land	803.8	0.90
6.	Vegetation to Residential Area	6349.8	7.08
7.	Residential Area to Residential Area	9953.9	11.10
8.	Swamp to Farm Land	3.6	0.004
9.	Residential Area to Vegetation	1626.3	1.81
10.	Farm Land to Water body	45.9	0.05
11.	Vegetation to Swamp	490.23	0.55
12.	Swamp to Vegetation	891.45	0.99
13.	Swamp to Swamp	20420.19	22.78
14.	Swamp to Water body	2631.96	2.94
15.	Farm Land to Swamp	640.8	0.71
16.	Residential Area to Farm Land	339.84	0.38
17.	Vegetation to Water body	43.47	0.05
18.	Swamp to Residential Area	686.07	0.77
19.	Residential to Swamp	182.52	0.20
20.	Water body to Water body	7067.07	7.88

Table3. Continue

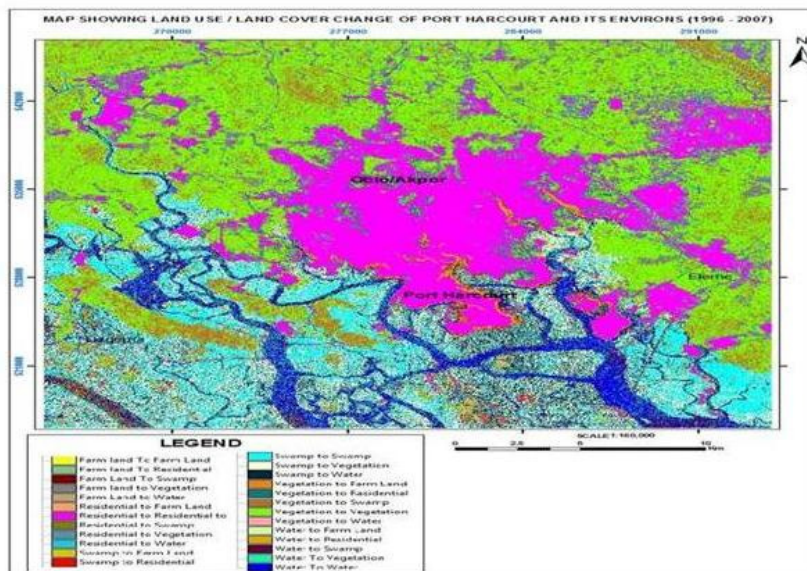|			
21.	Water body to Swamp	63.54	0.07
22.	Water body to Residential Area	96.48	0.11
23.	Residential Area to Water body	77.49	0.09
24.	Water body to Vegetation	0.63	0.001
25.	Water body to Farm Land	0.09	0.0001
26.	**TOTAL**	**89657.1**	**100.00**

Source: Authors' calculations

Figure 5. Land use and Land cover change of Port Harcorut City and its environs (1996-2007)

undesirable and it involves a pixel to pixel comparison of the study year images through cross or overlay operations. The nature of landuse and landcover change shows the direction of change, and the landuse and landcover classes with no change (which indicate the locational or spatially consistent or unchanged part of a particular landuse and landcover class).

Change Matrix

This is an important aspect of change detection as it determines which landuse/landcover class is changing to the other type of class. This process involves pixel to pixel comparison of the study year images through cross operation or analysis.

From the change matrix tables 5 and 6 above of 1986-1996, 30,000 and 70553 pixels of farmland and vegetation was changed to Residential in 1996, 102670 of farmland in 1986 was changed to vegetation in 1996.While in 2007, 9296 and 26685 pixels of farmland and vegetation was changed to Residential and vegetation.

SUMMARY AND CONCLUSION

The research study made use of Remote Sensing images and GIS techniques to analyse the changes in landuse and landcover around Port Harcourt City and its environs. It revealed land use and land cover changes that have

Table 4. Table Depicting Changes in Percentage after Crossing 96_07

S/NO	CHANGE	AREA IN KM2 1996_07	% PERCENTAGE
1.	Vegetation to Vegetation	24955.02	27.83
2.	Vegetation to Swamp	6255.90	6.98
3.	Vegetation to Water body	1206.81	1.35
4.	Vegetation to Residential Area	2401.65	2.68
5.	Residential to Vegetation	3191.49	3.56
6.	Farm land to Vegetation	2356.20	2.63
7.	Farm land to Residential Area	836.64	0.93
8.	Residential to Swamp	255.60	0.29
9.	Residential Area to Residential Area	16257.15	18.13
10.	Farm Land to Water body	45.00	0.05
11.	Residential Area to Water body	81.99	0.09
12.	Residential Area to Swamp	150.48	0.17
13.	Water body to Vegetation	2628.45	2.93
14.	Swamp to Vegetation	8613.27	9.61
15.	Swamp to Swamp	8585.46	9.58
16.	Water body to Swamp	2746.62	3.06
17.	Swamp to Water body	4013.91	4.48
18.	Swamp to Residential Area	584.64	0.65
19.	Water body to Residential Area	985.05	1.10
20.	Water body to Water body	3505.77	3.91
21.	**TOTAL**	**89657.1**	**100.00**

Table 5. Change Matrix of 1986/1996

1996	Farmland	Residential	Swamp	Vegetation	Water	Unclassified	Accuracy
Farm land	8931	3776	40	24900	1	0	0.24
Residential	30000	110599	7623	70553	1072	0	0.50
Swamp	7120	2028	226891	5447	706	0	0.94
Vegetation	102670	18070	9905	256230	7	0	0.66
Water body	510	861	29244	483	18523	0	0.71
Reliability	0.06	0.82	0.83	0.72	0.98		

[**]Overall accuracy 68.38

Table 6. Change Matrix of 1996/2007

2007	Farmland	Residential	Swamp	Vegetation	Water	Unclassified	Accuracy
Farm land	0	0	0	0	0	0	
Residential	9296	180635	6496	26685	10945	0	0.77
Swamp	1672	2840	95394	69510	30518	0	0.48
Vegetation	26180	35461	95703	277278	29205	0	0.60
Water body	500	911	44599	13409	38953	0	0.40
Reliability	0.00	0.82	0.39	0.72	0.36		

[**]Overall accuracy 59.45%

occurred around Port Harcourt City and its environs over the period of years under review (1986-2007). The residential landuse around Port Harcourt City and its environs had a noticeable increase, from the analysis we can see that residential development is very high and a decreasing trend in agricultural farmland, swamp and water bodies. The causes of changes in landuse and landcover in the city Port Harcourt and its environs are mainly socio-economic pressures which include: Land tenure system, population growth and livelihood as well as rapid industrialization and urbanization. Thus, if the rate of decline in agricultural land remains unchecked, in the nearest future food production would be a serious challenge and rural livelihood would negatively be impacted. Landuse and landcover change is a difficult task to perform accurately. The landuse and landcover changes shown in this research may not provide the ultimate explanation for all problems related to landuse / landcover changes, but will serve as a basis to understand the patterns and possible consequences of landuse and landcover changes in the study area. Finally it is assumed that this study will go a long way to develop new comparative research on the pattern and processes of landuse and landcover change in Port Harcourt City and its environs. There is therefore need for proper landuse planning and enforcement of development control to forestall the negative socio-economic consequences of landuse and landcover changes.

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