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Forecasting the Future Pattern of Land Use and Land Cover Change in the Wetland Ecosystem of the Port-Harcourt Metropolis

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ABSTRACT

Changes in wetland area have notable effects on ecosystem processes and services. Forecasts on Land use and Land cover change have become a focal point in managing natural resources and monitoring environmental changes in wetland ecosystem. The Port Harcourt metropolis has witnessed extremely large growth in population in recent times and a proper evaluation would reveal a change in land use and land cover of the study area. Therefore, the model and direction of this change is not properly revealed in the works of art. However, this study was organized to forecast the future pattern of land use/land cover change in the wetland ecosystem of Port-Harcourt metropolis. In furtherance of this study, satellite imageries between 1984-2013 using Remote Sensing techniques as an analytical tools and Geo-referencing properties of 1984, 1999, 2003 and 2013 made up of universal Transverse Mercator (UTM) projection, and datum WGS 84, zone 32 were acquired. The satellite images covering the area were acquired and analyzed using ArcGIS10.0, ERDAS IMAGE 2014 and IDRISI Selva. The Markov transition probability matrix where employed in the study to forecast the future pattern of land use and land cover change in the wetland ecosystem of Port-Harcourt for the given period of 30 years (2023, 2033 and 2043).The study concludes that there will be further loss of wetlands and their resources in the metropolis, if factors contributing to it are not properly checked.

Keywords: *Land use/Land covers Change, Wetland, Remote Sensing, Landsat TM/ETM+, Markov*

INTRODUCTION

Wetlands are defined as areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters (RCS, 2007). The water found in wetlands can be salt water, fresh water, or brackish (Ramsar, 2011). Main wetland types include swamps, marshes, bog and fens (Keddy, 2010).

Changes in wetland area have notable effect on ecosystem processes and services. Concern about changes in the size and quality of many of the world's wetlands ecosystem has been growing as more and more wetlands are being converted to human settlement, exploration/exploitation of natural resources, urban land use and natural factors like drought (Ringrose, et al., 1988;Gerakis, and Kalburtji, 1998; Chopra et al.,2001). Port-Harcourt wetlands have been variously affected by conversion to developmental uses such as residential and commercial purposes. During the last quarter of the twentieth century, Port Harcourt experienced tremendous structural transformation due to population and economic growth, the development of its transportation and communication systems and the impact of globalization (Obinna, et al.,2010).

Some of the recent studies to identity or monitor wetlands and their changes with remote sensing and GIS, involve the assessment of the extent of changes in the mangrove ecosystem of Niger Delta (James et al.,2007); monitoring of land degradation along On do coastal zone of Nigeria (Abbas, 2008); the monitoring of wetlands in the semi-arid west, USA (Neale, et al.,2007); the mapping of Canada's wetland with optical, radar and DEM data (Li and Chen, 2005); the inventory monitoring of temporary and permanent wetlands of western Cape, South Africa (De Roeck, et al.,2008) and the spatial-temporal analysis of wetland losses in the Lagos coastal region (Taiwo and Areola, 2009). Tijani, et al., 2011) in their study of Eleyele Wetland in Ibadan through GIS based assessment, revealed a reduction in the riparian wetland forest of 1.25km2 as at 1984 to 0.70km2 by 2004 with a projected decline of 0.42km2 by 2014. One could strongly believe from the different empirical studies as mentioned above, that there is a serious effect of human induced action on the wetland ecosystem through urbanization, therefore, depriving human and aquatic lives the benefits of wetlands. To close this gap in literature, the study has used Markov's transition probability matrix to forecast the future pattern of land use and land cover change in the wetland ecosystem of Port-Harcourt for the given period of 30 years (2023, 2033 and 2043).

THE STUDY AREA

Port Harcourt metropolis is located within the humid tropics of the eastern Niger Delta of south-south geopolitical zone of Nigeria and situated on a relatively solid land about 66km from the Atlantic Ocean (Ukpere, 2005; Wali, 2015). Geographically, the Port-Harcourt metropolis is positioned between Latitudes 4◦ 45′ N, and 4◦ 55′ N and Longitudes 6◦ 55′ E and 7◦ 05′ E. Like many cities in Nigeria, Port Harcourt has recorded an increase in population growth 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,2002).However, by 2006, the population of the Port Harcourt Metropolis had grown to 1,000,908 (National Population Commission, 2006) with Obio-Akpor LGA having 462,350 persons while Port Harcourt LGA had 538,558 persons (NPC, 2006). The current figures for the two Local Government Areas give the cumulative population density of the study area as 2695per square kilometres. The main City of Port Harcourt is the Port-Harcourt City Local Government Area. It serves as the Headquarters of Rivers State (Alagoaand Derefaka, 2002). Today, the Port-Harcourt metropolis is made up of two Local Government Areas, namely Port-Harcourt L.G.A. and Obio-Akpor L.G.A. (Figs 1 and 2).

The Port- Harcourt metropolis is characterized by muddy deposit pushed out of the River Niger into a relatively tide-less salt sea. The Port-Harcourt metropolis is drained by many rivers such as, Ntawogba, New Calaber, Amadi creek, Dockyard creek, Dick Fiberesima creek, Isaka River, Mini Apalugo, Elechi creek, Primose River, Mgbuodohia River, etc(Fig. 3). IzeoguC.V.and Aisuebeogun, (1989) viewed the beach ridge barrier islands as depositional land forms which receive fine coarse grained sands from the sea with elevation of just about 13m above sea level. Areola, (1983), describes the drainage of Port-Harcourt as poor, essentially because the streams in the area are south-flowing streams, which are turbid during the wet season as a result of discharge of clay and silt into the drainage channel.

With time, the metropolitanurban fringe moved up to Iriebe, Eleme, Elelenwo, RukpokwuIgwuruta, Omagwa, Aluu, Woji, Choba, Rumokwurusi and Onne (Wizor,2012). Owei, et al., (2008) see most of this growth as unplanned and unregulated. As part of the government's efforts to manage the city's growth, 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. The major aim was to decongest the metropolis. The area designated as Greater Port Harcourt City 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).

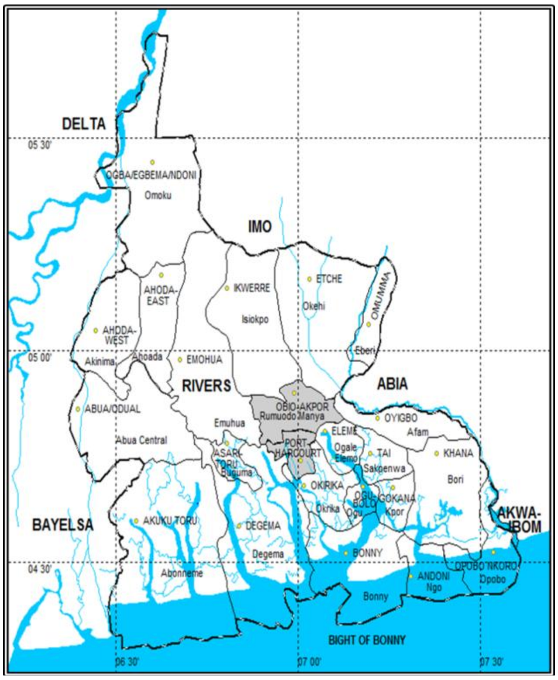

Figure1. *Map of Rivers State Showing Port Harcourt and Obio/Akpor L.GA.*

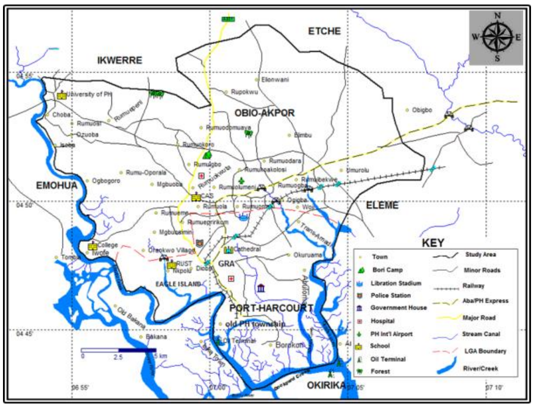

Figure2. *Map of Port Harcourt Metropolis*

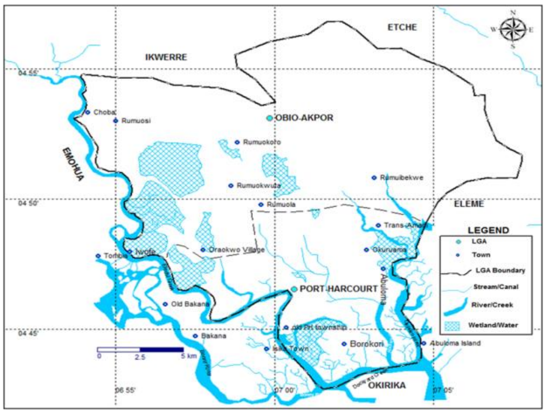

Figure3. *Wetland/ Drainage of Port Harcourt Metropolis*

METHODS OF STUDY

Land Use/Land Cover Projection

Recent advancement in technology and knowledge in respect of sensor design and data analysis are making Remote Sensing and GIS very practical and attractive for monitoring natural and anthropogenic wetland changes (Klemas, 2011).In this study, transition probability matrix was used and records the probability that each land cover category will change to the other category. This matrix was produced by the multiplication of each column in the transition probability matrix to be the number of cells of the corresponding land use in the later image (Oludare, *et al*.,2015; Zubair, 2006).The Geo-referencing properties of 1984, 1999, 2003 and 2013 made up of universal Transverse Mercator (UTM) projection, and datum WGS 84, zone 32, ERDAS Imagine (2014) were used for displaying processing, enhancement, classification of the imageries and also used for the delineation of the study area imagery. IDRIS SELVA was used for the development of land use land cover prediction classes for the study area. ArcGIS 10.1was used in developing, display and processing of the location maps. The spectral resolution of Landsat TM and ETM+ (30m) data makes it very useful for land use change and land cover classification and general mapping.

In the 5 by 5 matrix table presented below, the rows represent the older land cover categories and the columns represent the newer categories. Although this matrix can be used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, (Fig 4-7) it was however used for projecting land use and land cover for the longtime period of 2023, 2033 and 2043 respectively.

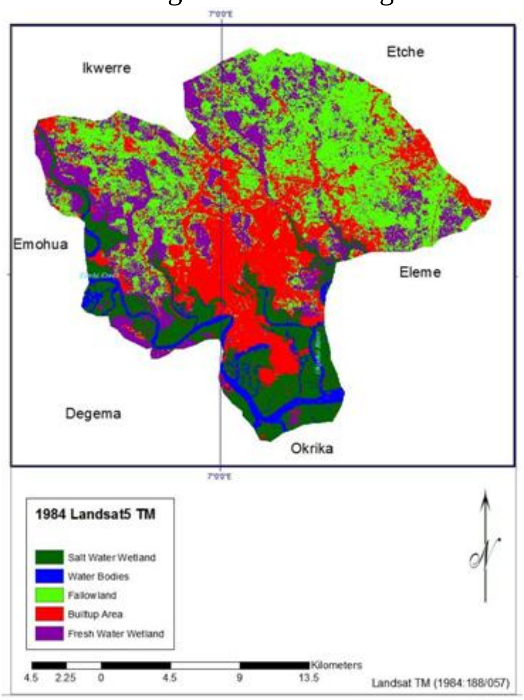

Figure4. *1984 Landsat5 TM Image*

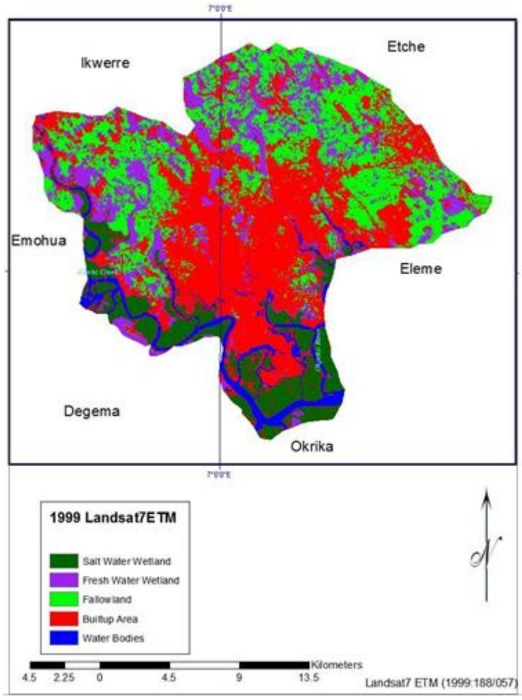

Figure5. *1999 Landsat7 ETM*

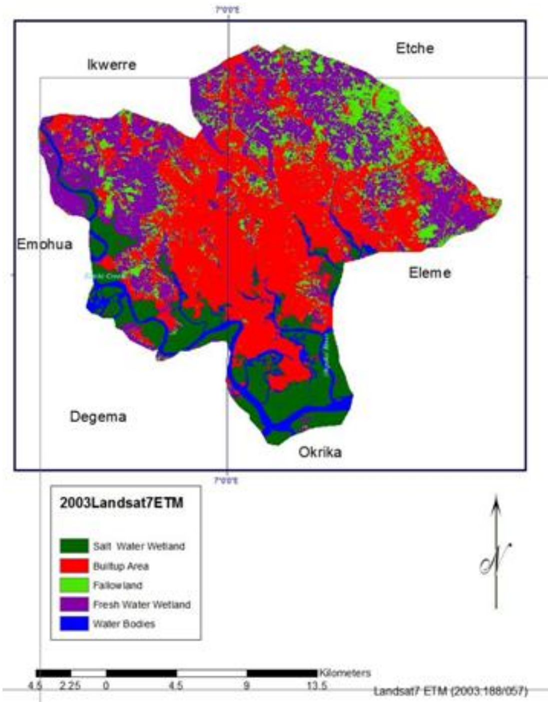

Figure6. *2003 Landsat7 ETM Image*

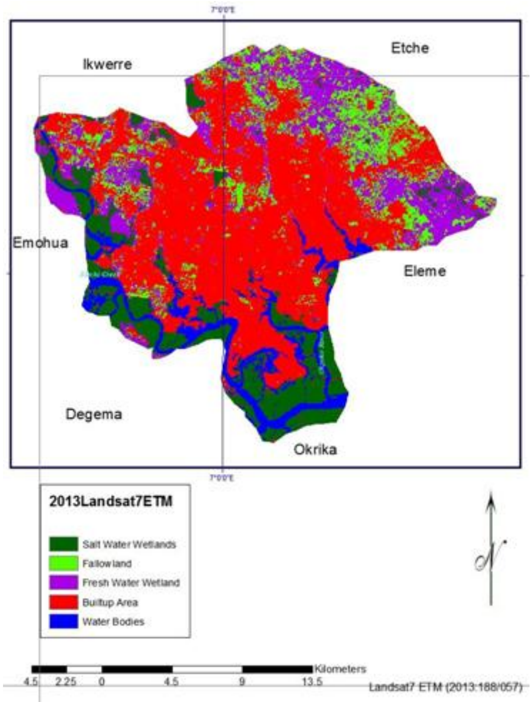

Figure7. *2013 Landsat7 ETM Image*

Results and Discussion

From Tables 1–3,row categories represent land use/ land cover classes while columns represent what is being changed to progressively from left to right in 2023, 2033 and 2043 as seen from the table below.

Table 1, statistics showed that the probability of saltwater land use changing to itself is 0.2877, changing to fallow land is 0.0000, changing to freshwater is 0.3588, the probability of changing to built-up areas is 0.3531 and changing to water bodies is as low as 0.0000.The probability of fallow land changing to saltwater is 0.0000, fallow land changing to itself is 0.6910, changing to fresh water wetland is 0.0796, changing to built-up areas is 0.0086 and changing to water bodies is 0.2207. The probability of fresh water wetland changing to saltwater is 0.0886, the probability of the same land use changing to fallow land is 0.0000, while the probability of it changing to freshwater wetland is 0.8604; changing to built-up areas is 0.0345; and changing to water bodies is 0.0163. The probability of built-up areas changing to saltwater wetland is 0.1560, the probability of the same land use changing to fallow land is 0.1785, and the probability of changing to freshwater wetland is 0.1633. Then, the probability of the same land use changing to itself is 0.5022; the probability of it changing to water bodies is as low as 0. 0000. The probability of water bodies changing to saltwater wetland is 0.0000, the probability of the same land use changing to fallow land is 0.2850; the probability of changing to freshwater wetland is 0.0890; the probability of changing to built-up areas is 0.0000; then the probability of water bodies changing to itself is 0.6260.

Furthermore, the probability of built-up areas changing to other land use, predicted that salt water wetland is 0.1560, for fallow land it is 0.1785, for freshwater wetland it is 0.1633, while probability of it changing to water bodies is 0.6260. The probability of water bodies changing to saltwater wetland and built-up areas is as low as 0.0000. At the same time, the probability of fallow land changing to saltwater wetland is as low as 0.0000.

Table1. *Given Land use/ Land Cover) = Probability of Changing to 84 – 2013 (2023 10 years)*

Land use Class	Saltwater Wetland	Fallow land	Freshwater Wetland	Built-up Area	Water Bodies
Saltwater Wetland	0.2877	0.000	0.3588	0.3531	0.0000
Fallow land	0.0000	0.6910	0.0796	0.0086	0.2207
Freshwater Wetland	0.0886	0.0000	0.8604	0.0345	0.0163
Built-up Area	0.1560	0.1785	0.1633	0.5022	0.0000
Water Bodies	0.0000	0.2850	0.0890	0.0000	0.6260

Table 2, predicts that in the next 20 years, the tendency for saltwater wetland to change to itself is 0.2425; for it changing to fallow land it is 0.0133; for the same land use changing to freshwater is 0.4238; for it changing to built-up areas is 0.3178 and for it changing to water bodies is 0.0020. For fallow land, the probability level of it changing to saltwater wetland is 0.0009, the probability for the same land use changing to itself is 0.6108, the probability of changing to freshwater wetland is 0.1322, the probability for it changing to built-up areas is 0.0131 and the probability of changing to water bodies is 0.2429.The tendency of freshwater changing to saltwater wetland is 0.1001, then the probability of the same land use changing to fallow land is as low as 0.0060, freshwater wetland changing to itself is 0.8126, for the same land use changing to built-up areas is 0.8126 and changing to water bodies is 0.0213. Concerning the same 20 years' prediction, built-up areas will change to 0.1505 of salt water, for the same land use changing to fallow land is 0.1893, changing to freshwater wetland is 0.2480 then changing to itself is 0.2480 and the same land use changing to water bodies is 0.0000. Lastly, the probability of water bodies changing to saltwater wetland is 0.0000, changing to fallow land is 0.3186, for the same land use changing to freshwater is 0.1402, for water bodies changing to built-up areas the tendency is 0.1402 and for the same land use changing to itself (water bodies) is 0.5412.

Table2. *Given (Land use/Land Cover) = Probability of changing to 84 – 2013(2033 20 years).*

Land use Class	Saltwater Wetland	Fallow land	Freshwater Wetland	Built-up Area	Water Bodies
Saltwater Wetland	0.2425	0.0133	0.4238	0.3178	0.0020
Fallow land	0.0009	0.6108	0.1322	0.0131	0.2429
Freshwater Wetland	0.1001	0.0060	0.8126	0.8126	0.0213
Built-up Area	0.1505	0.1893	0.2480	0.2480	0.0000
Water Bodies	0.0000	0.3186	0.1402	0.1402	0.5412

Table 3, showed the Markov's probability of land use changing for the period of 30 years (2013-2043). The statistics showed that the probability of saltwater wetland changing to itself is 0.1603, 0.0663 probability for it changing to fallow land, the same land use changing to freshwater wetland is 0.5157, for the same land use changing to built-up areas is 0.2568 with the probability level of changing to water bodies as low as 0.0000. Likewise, fallow land changing to saltwater wetland is 0.0071, the same land use changing to itself is 0.4924, the probability for the land use changing to freshwater wetland is 0.1920,the probability level of changing to built-up areas is 0.0142 and changing to water bodies is 0.2943.Probability of freshwater wetland changing to saltwater wetland is 0.1149, then changing to fallow land is 0.0153, then the same land use changing to itself is 0.7457, to built-up areas is 0.0985, to water bodies is 0.0250.

For built-up areas , the probability level of changing to saltwater wetland is 0.1345, of the same land use changing to fallow land is 0.2044, for it changing to fresh water wetland is 0.3702, the probability of built-up areas changing to built-up areas is 0.2658 and 0.0247 changing to water bodies. Lastly, for water bodies changing to saltwater wetland is 0.0007, the tendency of changing to fallow land is 0.3902, the same land use changing to freshwater is 0.1999, changing to built-up is as low as 0.0000 and the same land use changing to itself is 0.4092.

Table3. *Given (Land use/Land Cover) = Probability of changing to 84 -2013(2043 30 years).*

Land use Class	Saltwater Wetland	Fallow land	Freshwater Wetland	Built-up Area	Water Bodies
Saltwater Wetland	0.1603	0.0663	0.5157	0.2568	0.0000
Fallow land	0.0071	0.4924	0.1920	0.0142	0.2943
Freshwater Wetland	0.1149	0.0153	0.7457	0.0985	0.0250
Built-up Area	0.1345	0.2044	0.3702	0.2658	0.0247
Water Bodies	0.0007	0.3902	0.1999	0.0000	0.4092

CONCLUSION

Wetland management is a somewhat new area for development in Nigeria. The study aims at creating awareness of the subject matter, and drawing the interest of government and the communities involved. Wetland resources in Nigeria have been threatened by over exploitation and degradation of wetland ecosystem through urban development and population pressure. The land use and land cover changes shown in this research may not provide the ultimate explanation for all problems related to land use / land cover changes, but will serve as a basis to understand the patterns and possible consequences of land use and land cover changes in the study area. The study reveals a very alarming rate of wetland reduction and expansion of built-up area. If no adequate measures are taken, our wetland resources in the Metropolis may be so grossly depleted that they become extinct. Therefore, sound planning is needed to protect and preserve wetland ecosystem. There is need for more study, development strategies, sustainable management and utilization of valuable resources to protect wetland ecosystem. The forecast showed that there will be further loss of wetlands and their resources in the metropolis, if factors contributing to it are not properly checked.

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