AN URBAN GROWTH ANALYSIS OF WARRI AND ENVIRONS, DELTA STATE, NIGERIA: A REMOTE SENSING APPROACH

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Abstract: Urbanisation, though a welcome development in any society, is not bereft of certain negative effects especially when it occurs in an unorganised fashion resulting in the development of slums. The need to ensure adequate planning through inventory and monitoring using advanced technology becomes necessary. This scenario is the characteristic of Warri and its environs. This study was designed therefore to monitor the extent and pattern of growth of Warri and its environs, between 1987 and 2014, using Geographic Information System and Remote Sensing. Landsat thematic mapper and Enhanced thematic mapper satellite imagery for 1987, 2007 and 2014 were analysed for change detection. ArcGIS and Erdas Imagine were used to prepare the maps. A questionnaire survey involving one hundred and twenty respondents was carried out. The classification scheme was in the following manner: Built up area, vegetation, water body and bare land. An increase of 4% in 2007 and 27% in 2014, in the built up area were recorded. Vegetation land use increased by 9% by 2007, and decreased by 28% in 2014. The bare land and water body land uses were seen to fluctuate marginally through the period under study. The commercial land use was perceived to be the most dominant as asserted by 43% of the sample population. Congested road was perceived to be a major negative effect on the people, as asserted by 38% of the sampled population. The results imply an increasing rate of urbanisation which can be sustainably managed proactively adoption of regular periodical monitoring and collection of data to aid planning. In addition, environment friendly strategies and interventions such as reforestation/ afforestation, planting of green area parks should be adopted and implemented.

Keywords: Change detection, geographic information system, remote sensing, urbanisation, Warri

Introduction

Urbanisation is a phenomenon which gives any major city its definition. Urbanisation involves the provision and consistent upgrading of basic amenities, facilities based on a technology driven foundation. Consequently, urbanisation is synonymous with development and is therefore an expectation and aspiration of any nation or people. By consequence, the level of success of any government is affirmed by the extent of urbanisation of any government and is therefore intensely sought after. In most cases, the associated development progresses usually occurring in an unorganised form, resulting in the formation of slums or sprawls and usually associated with population explosion. This further results ultimately in ill-informed land use changes and choices, placing undue pressure on the environment. Sudhira *et al.* (2003) noted that a sprawl develops as a result of unchecked growth of urbanisation. By consequence, a sprawl is associated with attendant problems owing to lack of planning such as inefficient waste management, drainage/water supply crisis, health issues, environmental degradation, pressure on available infrastructure and amenities etc. Furthermore, Douglas (1994) noted that infrastructural developments in urban areas are not able to match up with the consistent and rapid increase in population. In addition to the slums, the city fringes are also impacted as the direction of growth is usually in that direction. The city fringes, usually rural areas, are therefore left to tackle new challenges for which they are ill equipped. This is common place in most developing countries, Nigeria not being an exception.

Warri, having a reputation of being an "oil city" as a result of playing host to a number of oil exploration companies, is a case in point. It has therefore, witnessed unprecedented growth, population and spatial, in recent times. It is therefore largely unplanned, being depicted by the occurrence of a number of slums. The case of Warri is further complicated by the fact that a larger section is located actually close to or below sea level, making it vulnerable to flooding. Prioritising the use of available land or optimal use of land therefore, is pertinent. A combination of the flood risk factor and the unplanned nature; therefore, reduces quality of life, while also posing a threat to their survival.

It therefore becomes imperative to ensure the need for effective management of cities, with the aim of mapping out ways or areas for planning. In doing this, information on the current status of the city, in terms, of the extent, direction and trend of growth of the city is required. In essence, a clear understanding of the growth dynamics of the city is necessary. For this to be achieved, real time, accurate and relevant data on the various growth factors and land use changes over time is also required. Geographic Information System (GIS) and satellite technology possess the capabilities of performing these tasks at the highest accuracy level. Gobo *et al.* (2014) carried out a change detection study from 1987-2007, using satellite imagery, however limiting its scope to Warri and the immediate environment of Effurun. This study however has extended its scope in terms of time and spatial extent, in order to be able to obtain a better understanding of the likely influence or spread to other communities. This study is designed therefore to monitor extent and growth pattern of Warri and its environs between 1987 and 2014, using GIS and remote sensing.

Materials and Methods

Study area

The study area is composed of two local governments namely Warri south and Warri north, located within Delta state. The study area is located between latitudes 5° 30′ N and 6° 00′N and longitudes 5° 00′E and 5° 30′E (Fig. 1). It has an estimated population of over 536,023 people (NPC, 2006). The Warri metropolis has expanded, over time, to include communities such as Effurun, Aladja amongst others. Warri is characterised by the tropical equatorial climate with mean annual temperature of 32.8 C and annual rainfall amount of 2673.8 mm (Efe, 2002). The vegetation of Warri is characterised by a combination of the tropical rainforest, freshwater swamp forest and the mangrove forest. Warri is drained by numerous rivers and tributaries and is underlain by the Sombreiro Warri deltaic plain sand (Olobaniyi and Owoyemi, 2004).

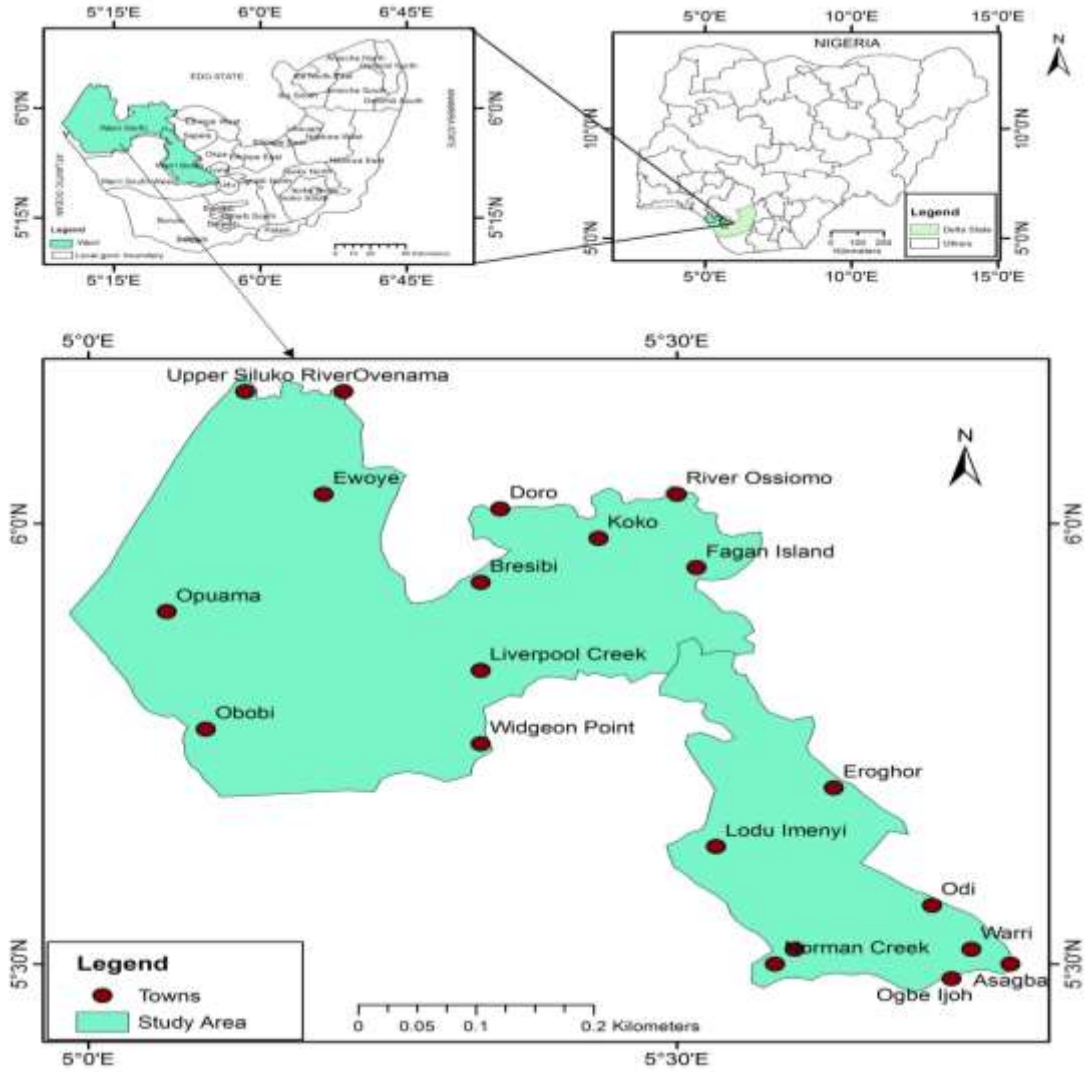

Fig. 1: Map of the study area

Methods

Landsat thematic mapper and enhanced thematic mapper satellite imagery for the years of 1987, 2007 and 2014, at the scale of 1: 250 000 were obtained. The 1987 Thematic Mapper image and the 2007 Enhanced thematic mapper were obtained from GLCF while the 2014 Enhanced Thematic Mapper image was obtained from USGS, all with a pixel size of 30m. The study area was sub mapped from these satellite images. Erdas Imagine software was used in resampling and in the development of a classification scheme. ArcGIS software was used in digitizing and vectorising the developed land use and land cover map. The various data analyses carried out in this study include: (i) Determination of areas of the various land use/ land cover for the individual years. (ii) Maximum likelihood classification (iii) Time series analysis for the prediction of change. Questionnaire survey was carried out randomly among one hundred and twenty respondents.

Results and Discussion

The maximum likelihood classification algorithm was used to determine the classification scheme. This was done based on the prior knowledge of the study area, in the following manner: built up area, vegetation, water body and bare land.

The Warri metropolis (Warri/Effurun) itself is located at the southernmost tip of the image and is characterised by evidence of urbanisation as depicted in the built up area in that location. The built up area around the Warri area is seen to be likely unconnected with the other patches of built up area all over the image, being likely due to distance. This may not be unconnected with the difficulty in terrain of the mangrove vegetation which is also an indicator of the occurrence of a network of creeks. In a similar study carried out by Owoeye & Ibitoye (2019) in Akure, a spatial spread and trend of the built up area was however observed, being influenced by certain factors bordering on development such as a road construction project as well as the presence of a residential estate. This goes to show that several location specific factors are usually responsible for direction of spread of built up area. The mangrove vegetation observed in 2007 generally, especially close to the Warri area, is seen to have reduced drastically in 2014 (Figs. 2, 3 & 4). This may likely be due to the influence of urbanisation. The spots of built up area observed close to the major river, to the north of the 2014 image, signifies the prevalence of urbanisation driven activities, though marginal.

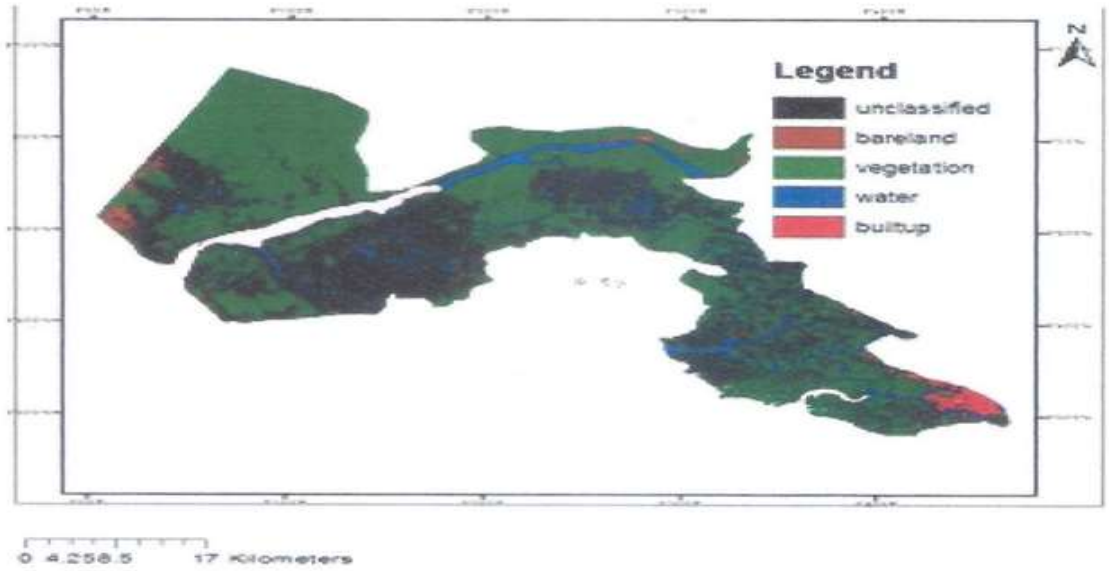

Fig. 2: Analysed satellite image for 1987

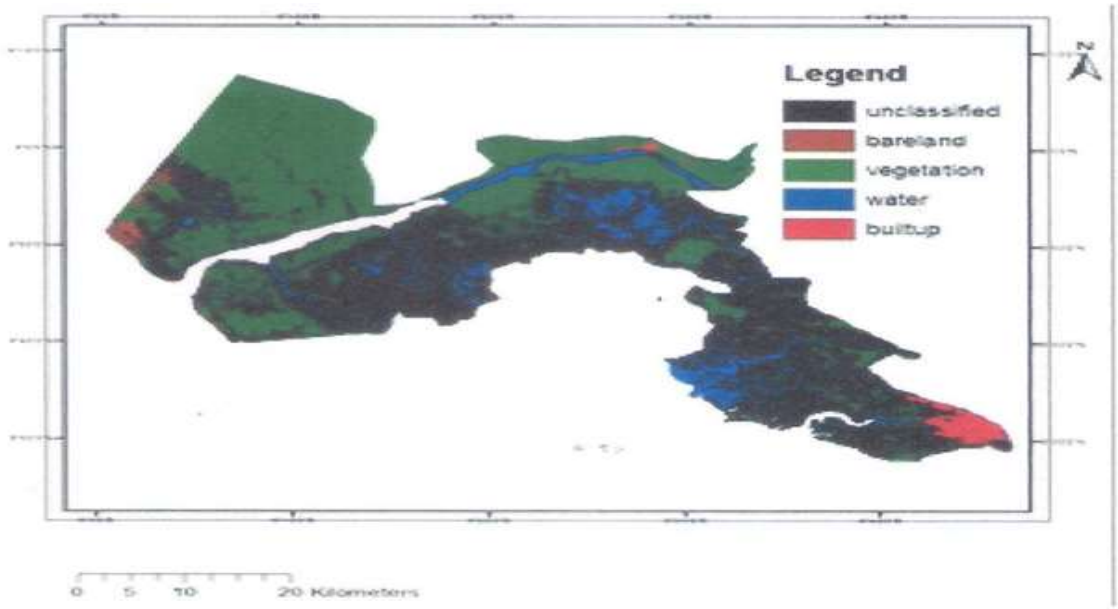

Fig. 3: Analysed satellite image for 2007

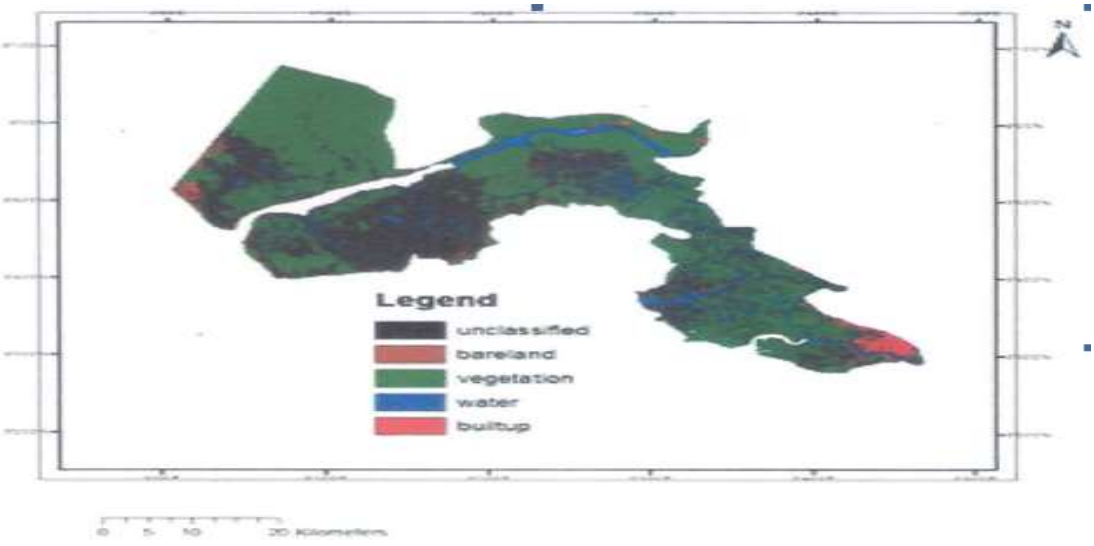

Fig. 4: Satellite image for 2014

The Table 1 shows the area and percentage change in the various categories of land use, through the period of 1987 - 2014.

The change detection results showed that the built up LU/LC increased by 4% in 2007 and by 27% in 2014. While comparing the twenty-year period from 1987 through 2007 and the seven-year period from 2007 through 2014, it can be concluded that the rate of urbanisation has increased over the time period and is likely to increase its tempo in the near future. The vegetation land use reduced by 9% through 2007, and further by 28% through 2014. The water body reduced in 2007 by 4% from 1987, and increased slightly by 1% through 2014. Bare land increased by 4% through 2007 and further by 1% through 2014 (Table 1).

Table 1: Land use change from 1987 - 2014

LANDUSE	1987 (Ha/%)	2007 (Ha/%)	2014 (Ha/%)
Built-up Area	41 566 (3)	62 566 (7)	306 929 (34)
Vegetation	993 720 (80)	655 448 (71)	389 778 (43)
Water Body	191 459 (15)	172 355 (19)	180 459 (20)
Bare Land	22 107 (2)	33 212 (4)	27 436 (3)

Source: Author (2014)

The land use denoted as unclassified (Figs. 2, 3 & 4) has been identified to be mangrove vegetation, from information made available through ground truthing. It is observed that the mangrove vegetation reduced drastically in the southern part of the image (Fig. 4) which is located close to Warri metropolis itself. In spite of this reduction in the mangrove LU/LC areas, a greater portion of the study area is still covered by mangroves. A similar trend was observed in Port Harcourt in a study carried out by Wizor & Eludoyin (2018). An increase in swamp LU/LC (which incorporates mangroves) between the period of 2005-2010, as against that of this study which was during the period of 2010-2014. An increase in mangroves/swamp is remarkable taking into consideration the corresponding consistent decline in vegetation through the same periods. This is likely linked to the issue of seasonal influence based on their location close to the coast.

The trend of increase in built up LU/LC area and reduction in vegetation agrees with that of the study carried out by Gobo *et al.* (2014). In 2014, this trend continued, however the differences between the percentages for various land uses were smaller than in the preceding years. The built up area is observed to be skewed to certain areas, which is likely due to the prevalence of mangroves. This study disagrees with the assertion by Owoeye *et al.* (2016), in a study carried out in Akure, the spread of the built up area was towards the low lying areas. In this study the lowest lying areas were not desirable, owing to the difficulty in terrain and the presence mangrove vegetation. This thereby implies that in all locations, there are certain location specific factors in operation. The continuous increase in built up area through the period under study (1986-2014), is an evidence of the effect of urbanisation. The period between 2007 and 2014 are characteristic of rapid urban growth. The rise in the built up land use and the corresponding decline in the vegetation land use was drastic and significant between the years of 2007–2014. Confirming this, Atubi *et al.* (2018) in a study carried out in Warri, reported similar findings, however with the aforementioned drastic changes commencing in 2004. They further noted that the changes observed comprise basically of changes in vegetation and built area. Ofuoku and Chukwu (2012) noted that this period was characterised by the inward movement of people from the neighbouring communities through rural-urban migration. Evidence of this is observed in the corresponding decline in the vegetation land use between 1987 and 2014 (Table 1).

The increase in the water body land use, through 1986-2014, could likely be as a result of the effects of climate change characterised by rise in water level. The slight increase in water body observed between 2007 and 2014 may not be unconnected with the severe occurrence of flooding which occurred in 2012, affecting a number of areas especially within the Niger Delta area. Ezeamaka *et al.* (2019) observed a similar increase in a study in Kaduna and attributed it to an increase in impervious surfaces as a result of increasing development, culminating in heavy overland flows. This situation may also be the case in this study. The aforementioned justifications are intertwined, as the increase of impervious surfaces is a major contributor to climate change. According to Adepoju *et al.* (2006) in a study carried out in Lagos, a marginal increase in the waterbody LU/LC was observed during the 1994-2001 time period. They however, attributed this increase to difference in sensors or canalization of projects. A similar marginal increase in water body, in a study carried out across Nigeria, occurred during the period of 2001-2009.

The low percentages and marginal variations of bare land observed is suggestive of the consistence of ongoing anthropogenic activity such that bare lands are consistently put into use and rarely left bare for a long period. This brings to the fore, the underlying issue of pressure on available land. It further gives evidence of the active use of land for various other purposes, apart from being built up. The increase in bare land observed in 2015 in Port Harcourt, according to Wizor and Eludoyin (2020) was attributed to been driven by driven by developmental activities culminating in increased deforestation. This matches the situation in study, as both Warri and Port Harcourt are similar in relief and drainage.

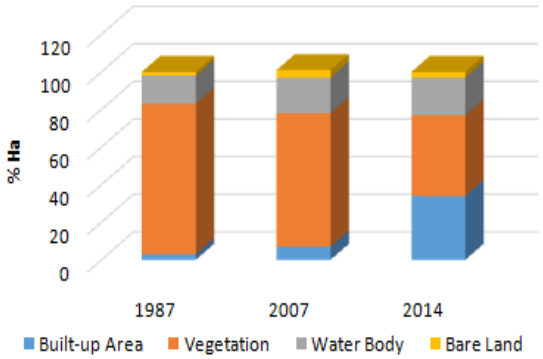

Fig. 5: Bar chart showing land use change through the three periods

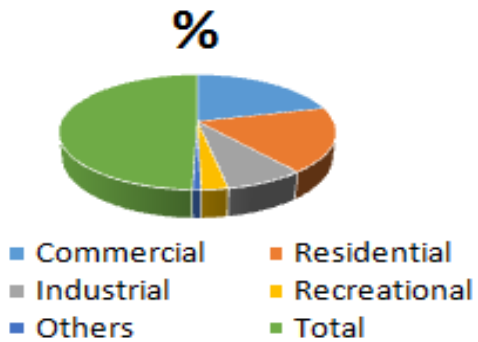

Fig. 6: Percentage of dominant land use type in respondents' location within the study area

The following factors were asserted to be effects of urban expansion of the study area in order of importance, namely: congestion of roads, overpopulation and increase in crime rate (Table 2).

Table 2: Perception of the effects of city expansion

Effects of city expansion	%
Congestion of roads	38
Over population	27
Increase in crime rate	32
Others(pollution, improper waste disposal)	3
Total	100

Source: Author (2014)

The percentages of the dominant land use in the various respondents' locations are seen in Fig. 6. The commercial land use had the highest percentage as dominant land use (43%), being closely followed by the residential land use (37%). Recreation and other unspecified land uses, formed the lowest percentage of approximately 3.0 and 2.0%, respectively. This infers that the built up land use observed in the satellite image is comprised majorly of commercial land use. This further suggests that the basic character of the study area is commercial. This factor is therefore likely to be responsible for the attraction depicted by in-migration from surrounding areas. The oil companies in a chain reaction are also seen to be influencing the commercial thrust of the study area. Congestion of roads was perceived to be a major effect of urbanisation, closely followed by crime rate increase and then over population (Table 2). Congestion of roads suggests the deplorable state and level of inadequacy of basic facilities on ground. Improper planning is the likely culprit, which further results in the lowering of living standards and consequently resulting in crime rate hike.

Conflict of Interest

Authors declare that there is no conflict of interest reported in this work.

Conclusion

This study has shown the potential for the increase in the effect of urbanisation through the increase of built up area. This increase in built up area needs to be efficiently planned to avoid the ugly situation of the formulation of slums/sprawls. As has already been observed the effect on vegetation negatively is profound. Steps need to be taken, therefore to ensure sustainable management of vegetation through the adoption of strategies such as the setting up of green areas/parks amongst others. It is pertinent to note that sustainable development, on all fronts, should be embraced, more importantly through enforcement and implementation of environment friendly laws. The need for planning cannot be overemphasized in tackling the aforementioned issues of urbanisation and its effects. A major ingredient for success required, in this regard, is regular monitoring and data gathering on a periodic basis.

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