RESEARCH ARTICLE OPEN ACCESS

Impacts of Urban Land use changes on flood events in Warri, Delta State Nigeria

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Abstract
Land cover change for the period 1987, 2002 and 2007 was investigated using satellite remote sensing data. The investigation was necessitated to determine the changes over time and how this changes influence urban flooding in Warri Metropolis Delta State, Nigeria. Landsat images of the study area for the years 1987, 2002, 2007 show that in 1987 total built-up area was 83.15km^2 (16.7%) and by 2007 it was 236.76km (43.7%) this reflect an annual frequency of change of 1.09%. Marginal areas and vegetation were converted to residential areas which increased the total impervious cover of the study area and generally increased the peak runoff. The conversion of marginal areas also reduced the channel capacity thus leading to flooding. Questionnaires were also administered to get information on how the respondents perceive the cause of flood in the area, the data generated was subjected to ANOVA statistical tool using SPSS. The correlation matrix between Annual rainfall and frequency of flooding show that at $P<0.01$, $r = 0.460$ indicating a very significant relationship. The single Factor ANOVA, $F > F_{crit}$ at $P < 0.05$ show that uncoordinated or unregulated urbanization activities is similar in all the flood zones (Warri 1- Warr4).
Keywords: Urban flood, Urban centres, Urbanization, Land use change, Landsat.

I. Introduction

Urbanization, defined simply, is the shift from rural to an urban society, involves an increase in the number of people in the urban areas. It is usually the outcome of social, economic and political development that lead to urban concentration and growth of large cities, changes in land use and transformation from rural to metropolitan pattern of organization and governance (Angotti, 1993).

In Nigeria, urban growth is not a recent phenomenon. Since the emergence of ancient cities such as Benin, Kano and Zaria between the 14th and 17th century, there has been a steady evolution and multiplication of urban centres (Ojeifo and Eseigbe, 2012). The rate of multiplication however became greater from the 1960's with more urban centres emerging. As at 1960 only four major administrative centres existed, these centres were Lagos, Ibadan, Enugu, and Kaduna. By 1967, the centres rose to 13,it became 21 centres in 1987. The centres rose to 30 administrative State headquarters in 1991. Similarly administrative changes were undertaken at the local government level resulting in the emergence of towns which are now headquarters of local government areas (Onokerhoraye and Omuta, 1994). Available data reveal that Nigeria's urban population has been growing at an alarming rate. Nigeria cities and towns are exploding – growing in leaps and bounds. Urbanization rate for Nigeria is 4.4% and about 4.6% on the average for sub-Saharan Africa compared to 0. 4% urbanization rate in Europe (Arokoyu, 2002; Adeyemo, 2002).

The 1950 estimated percentage of Nigeria's population living in the urban areas was 15%, this rose to 19.2% in 1963, 23.4% in 1975 and 35% in 1991. It is currently estimated at 46% (Onibokun and Kumuyi 1999; Oluwasola, 2007). By the 2005 National population Commission estimates, Nigeria has a population of 132 million, rate of urbanization 5.5% while the annual population growth is 3.0%. By implication, approximately 60.7 million Nigerians are currently living in the urban areas. Using the 132 million estimates of 2005 and the rate of urbanization, it is believed that more than half of Nigerian population will be living in urban centres by the year 2020 (Oluwasola, 2007).

Mainly political and economic factors have been responsible for this rapid growth in urban population. Consequent upon this pull factors in towns and cities, the cities became attractive and rural-urban migration began to occur on a vast scale. The World Bank in 1993 estimated that the rural – urban migration is 84% this growth rate has vast implications on the urban land space. According to Adeleye and Oduwaye (2004) the morphology of Nigerian urban space has changed in a haphazard manner. The assertion of Adeleye and Oduwaye was echoed by

UNDP (2006) that Nigerian cities are growing without adequate planning which has led to the decay in varying degree of the natural and human environment. The problems and challenges posed by this urban growth are immense which include the proliferation of slums and squatter settlements in the cities. The very easily observable are the human and environmental poverty, inadequate housing and associated facilities such that many now live in substandard environment plagued by slums, squalor and indiscriminate use of urban land space without due regard to existing land use policies (e.g. erection of mechanic workshops, waste dump sites, etc) which has contributed to urban flooding in many Nigerian cities (Amangabara and Gobo, 2010)

It is on this premise that the Nigerian Government seeing the near comatose situation decided to strategize on how to make the urban areas functionally efficient by evolving in 2002 a National Housing and Urban Development Policy (Agbola, 2003) Prior to this policy, there were other policies and laws which were not properly defined and do not serve present day realities e.g. the 1861 Town improvement ordinance, the 1946 Town and Country Planning law cap 155 N0.4, the Local Government Reform of 1976 and the Land use Degree of 1978, The Nigerian Urban and Regional Planning Law Decree 88 of 1992.

2.1 Study Area: Warri, Delta State.

In the Niger Delta Region of Nigeria, one city that has had its fair share of urban-rural pull is Warri in Delta State. Its history dates back to the 15th century, when it was visited by Portuguese missionaries (Ekeh, 2005). Subsequently it served as the base for Portuguese and Dutch slave traders. Warri developed into a major port city, during the late 1800s, when it became a center for the palm oil trade and other major items such as rubber, palm products, cocoa, groundnuts, hides, and skins serving as the cargo transit point between the Niger River and the Atlantic Ocean. Warri is located on northern bank of Warri River about 30miles (48Km) upstream from the port of Forcados on the Bight of Benin. It is a conurbation of several communities including Warri, Effurun to the North, Ekpan to the West, Aladja to the East and the Bight of Benin to the Southwest. It has a coastline of approximately 160km along the Bight of Benin. It occupies an area of about 499.81km^2. Located between Longitude 5^0 $41^{'}$ 39.58'' E to Longitude 5^0 $46^{'}$ 11.42''E and Latitude 5^0 $31^{'}$ 12.37''N to Latitude 5^0 $48^{'}$ 25.35''N Warri Metropolis is drained by an intricately woven network of rivers, creeks, rivulets and canals. It is a low-lying plain consisting mainly of recent unconsolidated sediments. There is marked absence of imposing hills that rise above the general land surface. General surface elevation is about 50msl. The area experiences long raining season and short dry season. Mean annual rainfall is about 2,716.89mm (Table 6). Relative humidity oscillates between 80 and 90%. There is dense cloud cover for most of the year. Average annual temperature is about 27^{o}C

2.2 Population Size and Growth of Warri.

According to the 1952 Census, the area now occupied by Delta State in the defunct Midwest State had a population of 883,651 and only one settlement, Sapele (33,639) was classified as urban centre. By the 1963 census, the population of the State had risen to 1,456,541. Two settlements were now classified as urban centres and that include Sapele (61,007) and Warri (55,254). According to Onokerhoraye (1980), there was a considerable movement of population within the State between 1952 and 1963 as a result, the growth rate of Warri rose to 6.71% and by 1991 National population census, when Delta State rose in population figure to 2,570,181; the population of Warri Metropolis rose to 363,382 (i.e. Warri town (217,584), Effurun (123,610) Ovwian (22,188). The 2006 population of Warri town (excluding the towns of Ekpan, Aladja and Ovwian) is 303,417 The rapid urban growth which Warri has experienced stemmed from its position as the headquarters of Warri South LGA and the zonal headquarters of federal parastatals as well as the oil and gas industry such as Nigeria National Petroleum Company (NNPC), Shell Petroleum Development Company (SPDC), many shipping and allied companies which have provided employment opportunities. The establishment of Warri Refinery and Petrochemical Company as well as the Aladja Steel Complex and its associated companies has in no doubts contributed to the rapid population growth as well as the urbanization process.

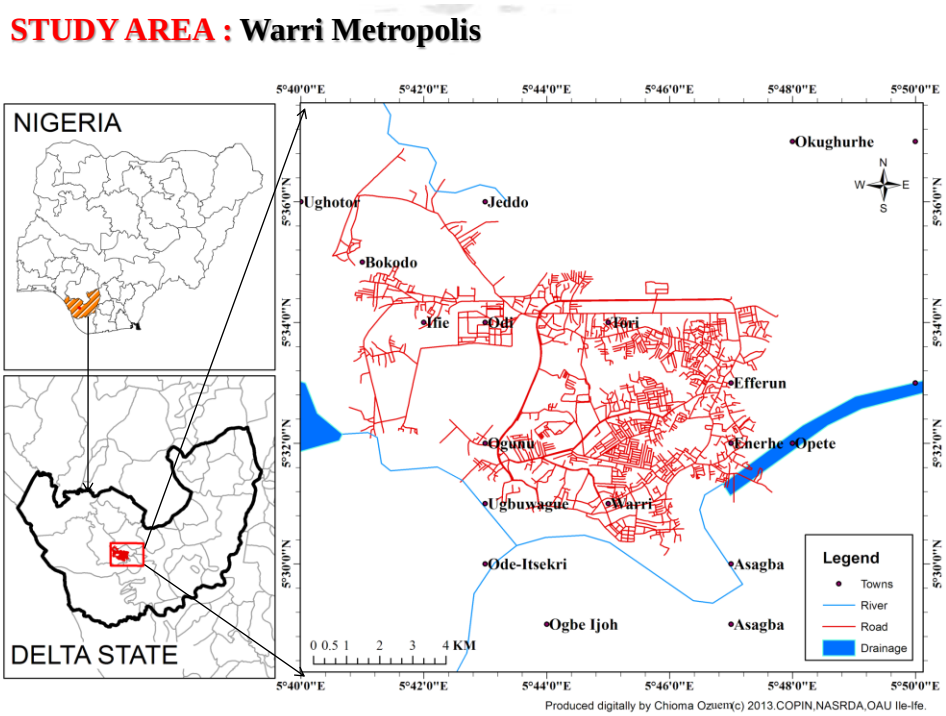


Figure 1. Map of Nigeria showing the Study Area

2.3 Urban land use changes on flood events in Warri.

One of the common land use changes associated with urban space is the pavement of urban space and roads making them impermeable. Unplanned urbanization also results in property development in marginal areas and the unhealthy practice of dumping refuse into drains etc, (Agobie, 2013; Amangabara and Gobo, 2007). According to Njoku *et* al (2013) this practice has led to urban flooding in some Nigerian cities like Port Harcourt, Aba, Lagos and Ibadan. Basically cities in coastal areas experiencing unplanned and unregulated urban expansion and population growth experience two types of flood regimes: Urban or flash flood and tidal flood or coastal inundation. A third type, channel floods can occur in urban towns that are traversed by major river systems. All of these floods can occur at the same time or independently depending on the weather and astronomic spring conditions.

Urban flood refers to the inundation of sections of urban areas. This is caused by a combination of high intensity rainfall and prolong rainfall leading to the development of flash floods (Gobo and Abam 1919). Growing urban population results in large areas of land surface covered with roofing materials, concrete and bitumen pavement which reduce infiltration of rainwater and increase surface runoffs leading to flood in the cities with adverse economic effect and health impact Ogbonna *et al.,* (2008). This type of flood is associated with the absence of run-off controls or defective runoff controls and the miss-use of urban drainage channels. Most roads are not equipped with drainages which should serve as conduits for the timely evacuation of runoff (Ogbonna *et al.,* 2011). Coastal floods on the other hand are types of floods within the coastlines and arises from storm surges as well as extra ordinary spring tides which are governed by the astronomical phenomena (i.e when the sun, moon and earth all line up), while channel floods occur around the peak discharge of the River Niger – Benue systems (usually between August and October) in Nigeria as well as prolong rainfall and occasioned by the inadequate channel capacity of river channels. Channel overflow is influenced by siltation of the rivers which reduce the carrying capacity of the river channel

Urban flooding is a serious and growing developmental challenge. Against the backdrop of climate change, demographic growth and urbanization trends, the causes of floods are shifting and their impacts are accelerating (Sanusi, 2013; Jha *et al.,* 2012). Warri being a coastal community experiences an average of 2,716.89mm of rainfall annually between 1977 and 2007 (Table 6). It has a coastline of 160km on the Bight of Benin and traversed by River Warri and its tributaries, all these are factors that cause flood elsewhere like Port Harcourt but have never caused serious flooding in Warri. Flood events are recent to Warri compared to other coastal cities like Port Harcourt, Lagos and Bonny. Flooding generally was not a common occurrence in Warri. However, flooding has become a common feature in the Warri Urban space in recent

years with several houses and streets remaining under water for several days (Fig 2). This large and evolving challenge needs investigation to avert associated risks and hazards of flooding. Understanding flood hazards requires a better comprehension of the types and causes of flooding, their probabilities of occurrence, and their expression in terms of extent, duration, depth and velocity (Nwoke and Okoro, 2012). This understanding is essential in designing measures and solutions which can prevent, or limit damage from specific types of flood. Equally important is to know where and how often flood events are likely to occur, what population and assets are at risk, how vulnerable the people who resides in the potentially flooded areas are.

Figure 2. Various Flood Scenarios in Warri and Environs between 1987 and 2007

The objectives of this paper include examining changes in urban growth in the Warri Metropolis using remotely sensed data and GIS techniques by identifying and mapping out the various land use change over time between 1987 and 2007. To find out the perception of the people on the cause(s) of flood in Warri and environs and how it has impacted their livelihood

III Materials and Method

i. Landsat images of 1987, 2002 and 2007 as well as Administrative map of Delta State were sourced from SPDC and Ministry of Land and Survey. ArcGIS technique was employed to analyze the images. A supervised classification (Maximum likelihood algorithm) was performed on false colour composite (bands 4, 3 and 2) into the following land use and land cover classes; Built-up area, Mangrove Forest, and water bodies. The results are presented in form of maps. Change Detection method was used to compare the various Landsat imageries collected over the same area at different times and to highlight features that have changed, area calculation in km² for each classes was done and the results are presented in form of tables, charts and graphs.

Table 1. Satellite Remote Sensing Data format & Sources

S/N	Name	Path & Row/sheet no	Date	Format	Source	Scale/Resolution
1	Landsat TM	p189,r56	1987	Digital	RECTAS	30m
2	Landsat ETM+	p189,r56	2002	Digital	RECTAS	30m
3	Landsat ETM+	p189,r56	2007	Digital	SPDC	30m
4	Administrative map of Delta state	First Edition	2000	Digital	Directorate of lands and survey, Asaba.	1:300,000

ii. Based on a field recognizance survey of flooded portions of the city, communities were clustered to form flood zone communities using the principle of nearest neighbor. Questionnaires were then administered to the residents (from Age 18years and above per house hold) in other to elicit their perception of the causes of flood in the area, the degree of damage done by flood, flood frequency and impact etc. The flood communities which are grouped into Warri 1 to Warri 4 are:
   a- Warri 1 > Warri main, Ekurede Itsekire, Ajamogha, NPA, GRA, Okere, Eboh, Igbudu, Essi layout
   b- Warri 2 > Okumagba layout, Ugborikoko, Enerhen
   c- Warri 3 > Ogunu, Ekurede Urhobo, Edegba, NNPC, Ekpan, Military Barracks
   d- Warri 4 > Effurun, Ugboroke, Bendel Estate, Isokoh Estate

   Data from this survey were further subjected to statistical analysis using the SPSS package ver.17

iii. Daily rainfall data for the period 1977 – 2007 was sourced from the Nigeria Meteorological Services (NIMET) synoptic Station archives in Warri

IV Results

4.1 Land Use/Urban Growth of Warri

The land use and urban growth of Warri Metropolis for 1987, 2002 and 2007 is presented below as figures 3, 4 and 5

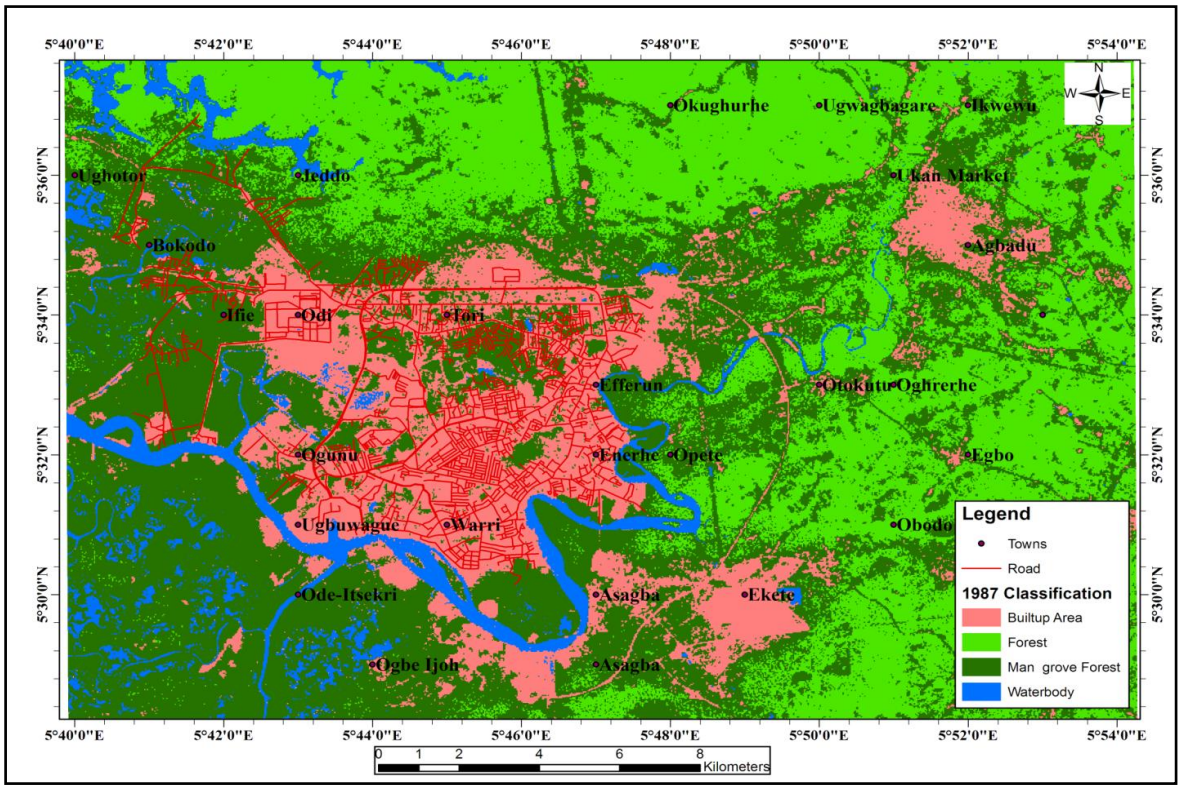


Fig 3. 1987 Warri Landsat Image Classification

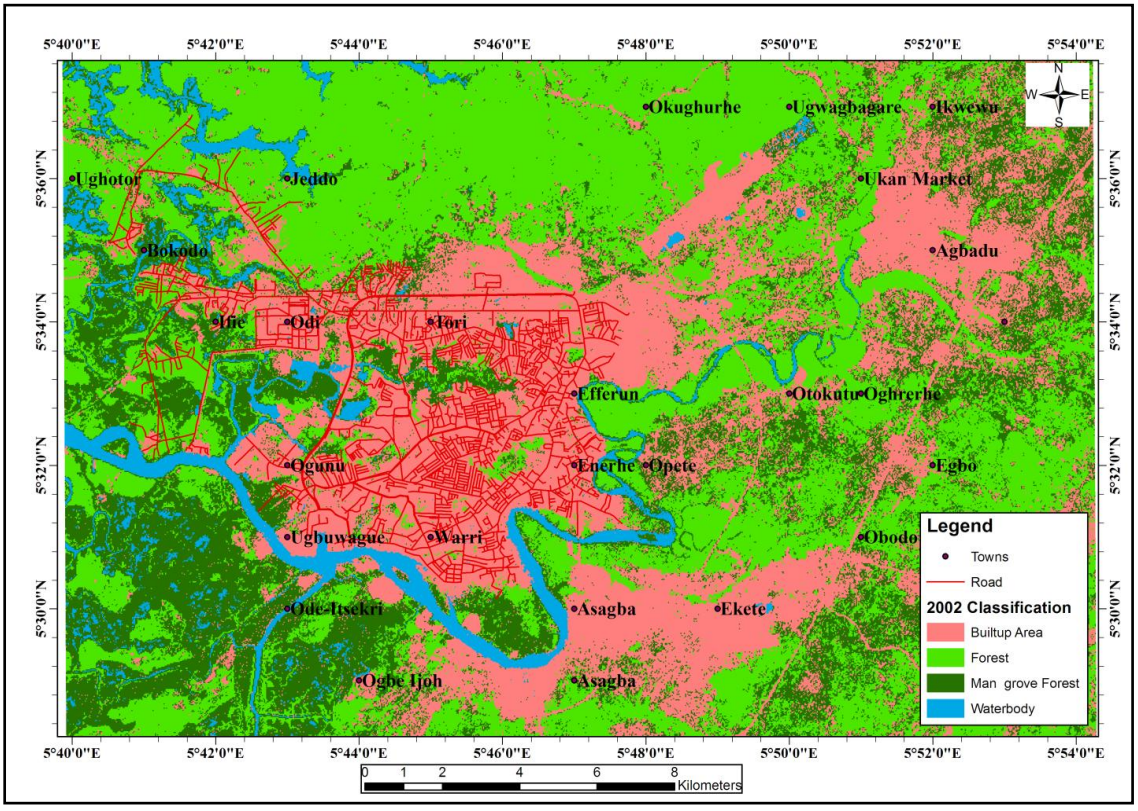


Fig 4. **2002 Warri Landsat Image Classification**

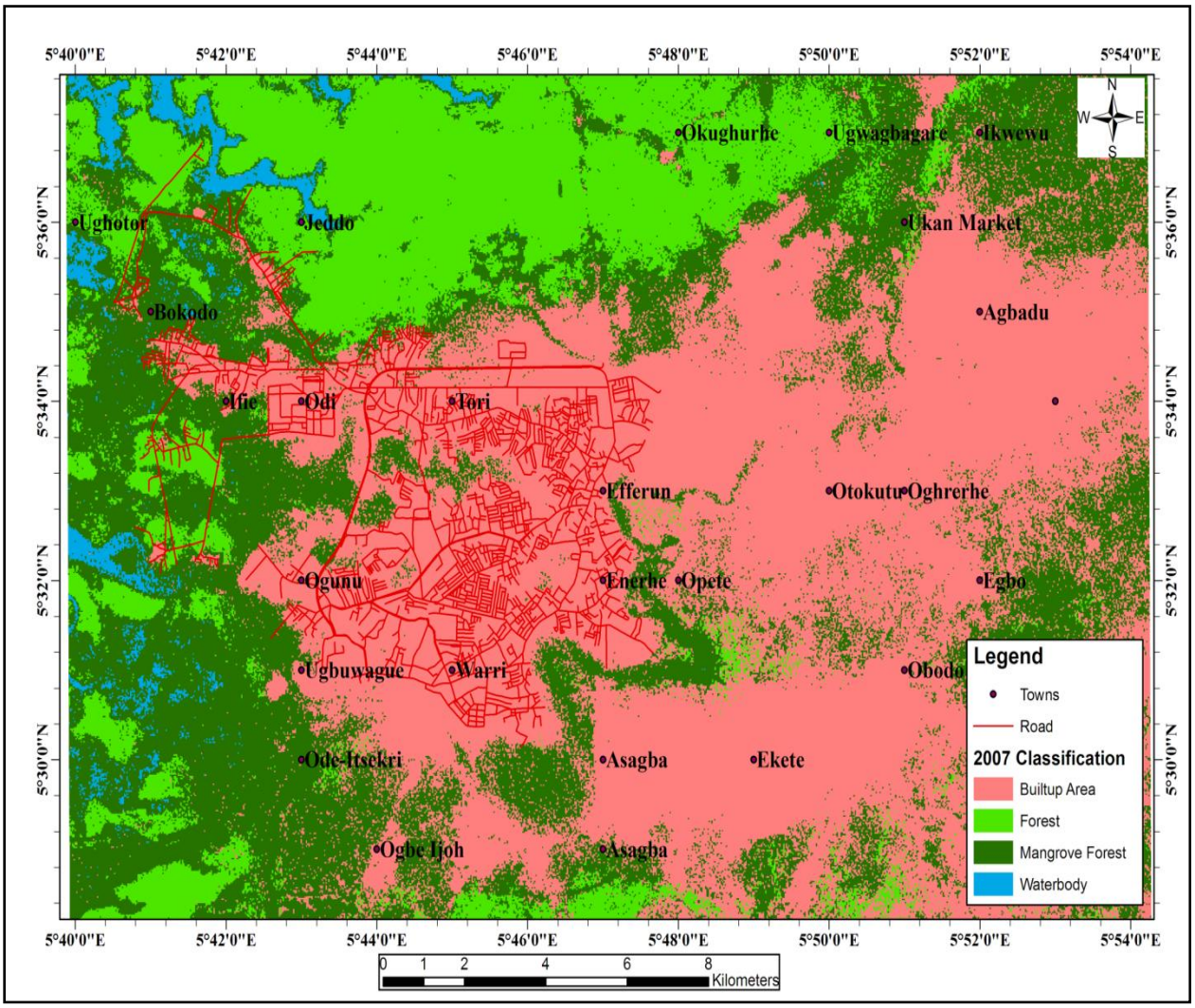
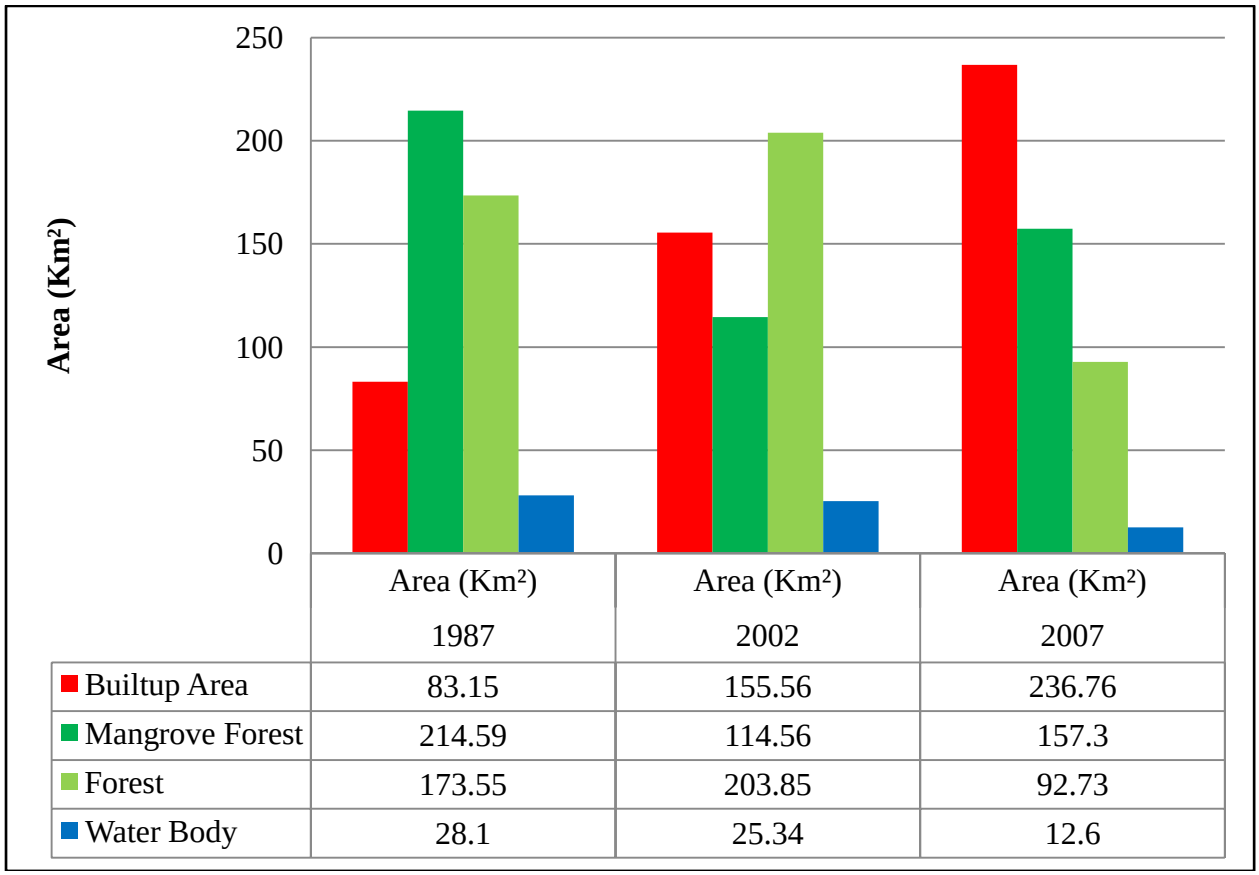


Fig 5. 2007 Warri Landsat Image Classification

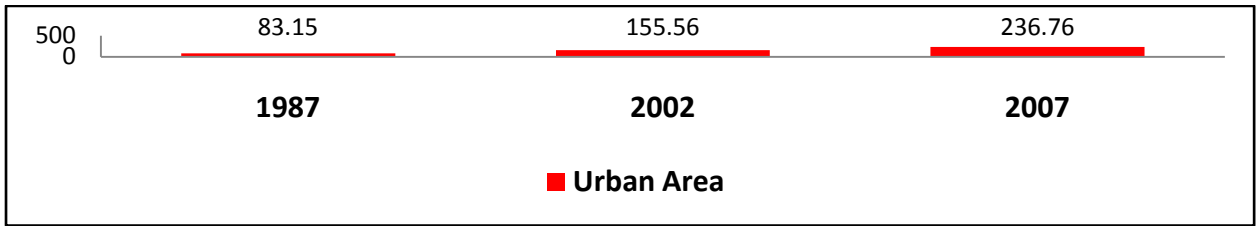


	Area (Km²) 1987	Area (Km²) 2002	Area (Km²) 2007
Builtup Area	83.15	155.56	236.76
Mangrove Forest	214.59	114.56	157.3
Forest	173.55	203.85	92.73
Water Body	28.1	25.34	12.6

Fig. 5 Summary of Total Area occupied by Built-up Area/Vegetation and Water body for 1987, 2002 & 2007 deduced from the Landsat imageries of our study area.

Table 2: Annual Change Frequency and Percentage Change

	1987	**2007**	**Magnitude of change**	**Annual Change Frequency**	**Percentage of change (%)**
Built-up Area	**83.15**	**236.76**	**153.61**	**1.09**	**184.7**
Mangrove Forest	**214.59**	**157.3**	**-57.29**	**-0.31**	**-0.26**
Forest	**173.55**	**92.73**	**-80.82**	**-0.35**	**-0.46**
Water Body	**28.1**	**12.6**	**-15.5**	**-0.26**	**-0.55**
sum	**499.39**	**499.39**			



4.2 **Perception of the People to the Flood events**

The tables below show how the residents of the flooded areas in Warri perceive the problems of flood (the causes of flood, magnitude of flood and the financial implications of those impacted).

Table 3.1 Causes of Flood

Causes of Flood	Warri 1	Warri 2	Warri 3	Warri 4
Heavy Rainfall	80	79	82	80
Lack of Drains	24	27	25	28
Blocked Drains	30	19	28	25
Defective Drains	16	20	18	19
Building along water ways	50	52	40	42
Uncontrol property Dev.	20	22	27	26
Total Respondents	220	220	220	220

Table 3.2 SPSS output of Correlations Analyses

		Annual_Rainfall	Freq_Flooding
Annual_Rainfall	Pearson Correlation	1	.460**
	Sig. (2 tailed)		.009
	N	31	31
Freq_Flooding	Pearson Correlation	.460**	1
	Sig. (2 tailed)	.009	
	N	31	56

** Correlation is significant at the 0.01 level (2 tailed).

Result: r = 0.460 at P<0.01.

Table 3.3 SPSS Output of ANOVA: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Column 1	20	558	27.9	105.9895
Column 2	20	50	2.5	1.315789

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*p-value*	*F crit*
Between Groups	6451.6	1	6451.6	120.2476	2.48E-13	4.098172
Within Groups	2038.8	38	53.65263			
Total	8490.4	39				

4.3 Impacts of Flooding

Perception of respondents on flood impacts and coverage.

Table 4.1 Flood Coverage of Affected Area/impacts

	Warri 1	Warri 2	Warri 3	Warri 4
Most part of the community are flooded	38	35	32	30
The whole street is flooded	56	58	54	57
Whole household is flooded	30	43	36	38
Most streets in the area are flooded	40	42	34	31
Movement & Commercial activities hindered	28	20	21	22
Roads are blocked for upward of 3hrs	24	11	25	23
Total Respondents	220	220	220	220

Table 4.2 SPSS out for ANOVA: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Column 1	24	880	36.66667	128.058
Column 2	24	60	2.5	1.304348

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*p-value*	*F crit*
Between Groups	14008.33	1	14008.33	216.5752	5.11E-19	4.051749
Within Groups	2975.333	46	64.68116			
Total	16983.67	47				

TABLE 5 ANNUAL RAINFALL OF WARRI (mm)

Year	Annual Rainfall (mm)
1977	2,092.2
1978	2,382.2
1979	2,778.9
1980	2,502.8
1981	2,042.9
1982	3,060.2
1983	2,330.8
1984	2,698.1
1985	2,971.2
1986	2,915.8

1987	2,797.8
1988	2,717.4
1989	2,511.5
1990	2,460.5
1991	2,912.3
1992	3,200.9
1993	3,021.2
1994	2,892.8
1995	3,437.8
1996	2,694.2
1997	3,227.3
1998	2,492.8
1999	3,185.5
2000	2,317.3
2001	2,776.7
2002	3,368.2
2003	1,387.1
2004	3,065.0
2005	2,368.0
2006	2,958.3
2007	2,655.9

V Discussion

The Landsat images of Warri for the years 1987, 2002 and 2007; the urban growth of Warri city experienced an overall increase in the built-up area by 184.7% from about 83.15km² (16.7%) in 1987, 155.56km² (32.1%) in 2002 and finally 236.76km² (47.3%) in 2007. All other land use or land cover classes such as mangrove forest, forest, and water bodies experience reduction as man convert these covers into residential and commercial uses. In terms of magnitude of change, Built-up area has 153.61 with an annual Frequency of change of 1.09% and percentage change of 184.7%. No other land uses experience this magnitude of change. This extensive growth creates difficulties in the lack of adequate infrastructure and creates various negative environmental impacts. Several of the most obvious changes are the loss of valuable vegetation including agricultural lands. For example, the conversion of forest areas into urban use increases the total impervious cover of the City while the conversion of marginal areas like floodplains and river corridors contributes to the reduction in channel carrying capacity of the streams; this is reflected in the channel in-ability to accommodate peak surface runoff which leads to the catastrophic floods experienced in the area, flooding occurs very quickly due to faster flow times, sometimes in a matter of minutes.

The discovery & exploration of crude oil couple with rapid industrial, commercial and economic growth of Warri city influenced the Immigrants from the rural hinterland leading to population pressure on the existing housing facility, this has led to the uncoordinated development of the marginal lands and suburbs of the city thereby leading to the development of squatter's settlement at the pre-urban zones (Warri 3 and Warri 4). These suburb are not planned into conventional design layouts and are not well linked to others for accessibility purposes., beyond the immediate social ills such as unemployment, poor quality of housing, traffic congestion, poverty, poor quality of standard of living, overcrowding (which put pressures on the State and local governments to provide basic social amenities and infrastructures for the growing population), they contribute to the overall total impervious layer of Warri which translates into surface runoffs whenever there is precipitation

The rainfall pattern of the area is typical of a coastal settlement couple with global climate change. Table 5; indicate that rainfall of 2,600mm can fall 50% of the time within a given raining season, coupled with increasing impervious cover, reduction of the channel carrying capacity as a result of encroachment as well siltation/blockages resulting

from dumping of refuse into flooding can be expected in the areas highlighted in this study. This observation is in alignment with the perception of the residents in Warri (Tables 3.1 and 4.1) the correlation matrix between Annual rainfall and frequency of flooding show that at $P<0.01$, the $r = 0.460$ indicating a very significant relationship (table 3.2). Furthermore, the single Factor ANOVA, $F > F_{crit}$ at $P < 0.05$ (table3.3) show that uncoordinated or unregulated urbanization activities is similar in all the flood zones (Warri 1- Warr4). Unregulated urban land use translate into building on flood pathways, dumping of refuse into water ways etc and may in addition to other factors contribute to the recent flood events experienced in the city. The perception of the respondents on the spread and impacts of flood across the four flood zones show that there is no significant difference on the spread or impact.

VI Conclusion

Urban areas are centres of economic activities with vital infrastructure which needs to be protected. This vital infrastructure has been the attraction for rural-urban migration in Nigeria. Rapid urbanization, particularly the growth of large cities, and the associated problems of unemployment, poor sanitation, urban slums and environmental degradation pose a formidable challenge in many developing countries. Statistics have shown that more than half of the world's 6.6 billion people live in urban areas, crowded into 3 percent of the earth's land area (Angotti, 1993;). The proportion of the world's population living in urban areas, which was less than 5 percent in 1800 increased to 47 percent in 2000 and is expected to reach 65 percent in 2030. However, more than 90 percent of future population growth will be concentrated in cities in developing countries. The question that arises is whether the current trend in urban growth is sustainable considering the accompanying urban challenges such as, slum development, and environmental degradation, especially in the developing countries. Warri Metropolis has experienced accelerated growth in its urban space from about $83.15km_2$ in 1987 to $236.76km_2$ the city grew by 184.7% in ten years with an annual frequency of change into urban space at 1,09. This urban growth has led to the unregulated development of marginal areas which has affected both the land cover/ land use and by extension increased the total impervious cover of the area on the one hand and the unsanitary habit of people dumping refuse into stream channels while also building along the flood pathways. When rain falls, runoff peaks at less than no time resulting in the inundation of the urban space; the result has been an increasing level of damage and destruction wrought by the flood. Other than increasing impervious cover which promotes runoff, some other likely factors that can bring about flooding include the blockage of flood channels with refuse, building along river channels, roads are without drains, the ones that has drains are either defective in design

The area expansion of Warri metropolis is now over 100sqr.km with a bourgeoning population there is need to control urban sprawl and land use change. New city concepts in planning should be adopted in developing small towns around Warri city. This will absorb the excess population of the city, and reducing spatial expansion of this city to adjoining marginal lands. Development and legislative measures should be adopted as to regulate growth in the study area by urban planners, town administrators, ministries etc.

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