Impact of Coastal Flooding on Resident Living in Victoria Island, Lagos State, Nigeria

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Abstract **–** Coastal flooding is among the most devastating natural hazards in the world, affecting more people and causing more property damaging than any other natural phenomena. This study was carried out to assess the environmental impact of coastal flooding on Vitoria Island, Lagos, Nigeria**.** Structural questionnaire and Geographic Information System (GIS) was used to collect the required data for the purpose of fulfilling the objectives of the study. The Coastal flooding of Victoria Island, Lagos was analyzed using topographic map of 1962 and satellite imageries of Landsat TM of 1984, ETM+ 2000 and 2011. Supervised digital image classification method using ILWIS 3.2 and ArcGIS 3.9 was used. The topographic map of 1962 and the imagery of 1984 was glued and crossed; 1984 and 2000; and the 2000 and 2011 were also crossed to get the changes in the shorelines in these years. The results of the analysis reveal that there was loss in landmass between 1962 and 1984 (31.4%) while between 1984-2000 (81.89%) and 2000-2011 (62.11%) there was increase in landmass gain over the periods respectively. To reduce the effect of coastal flooding, the study recommended construction of standard paved surface and drainages, law enforcement on waste disposal, integrated approach to flooding management and control and flood insurance policies. Correlation was used to test the relationship between flooding and refuse disposal. The result shows that there is strong correlation between incidence of flood and poor refuse disposal practices.

Key-Words: - coastal flooding, GIS, remote sensing, digital image, Victoria Island, refuse disposal

1 Introduction

All around us today, there is a clear evidence of environmental change due to buildup of earth warming gasses that induce climate change. Among the most important of these changes is the buildup of carbon dioxide and methane which is a result of human activities through combustion of fossil fuel and tropical deforestation [1]. In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Evidence of climate change impacts is strongest and most comprehensive for natural systems. Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influence. Due to sea-level rise projected throughout the 21st century and beyond, coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, coastal flooding, and coastal erosion [2].

Coastal floods caused by the combination of high tides, storm surges and storm generated wind waves are a major natural hazard in many parts of the world. Low lying densely populated and poorly defended coastal areas are susceptible. Where defences against coastal flooding and erosion exist they are designed to withstand storm situations which on average may occur once in a given number of years. Literature affirms that before the 1800s, the average temperature of the world was 15^0C or 29^0F but over the past 100 years, the average temperature has risen by, 0.7^0C or 1.3^0F. The atmospheric concentration of carbon dioxide has also risen from 280 parts per million in 1800, to 380 parts per million today. Due to an increase in the combustion of fossil fuels, scientists have projected that, by the year 2100, the average global temperature will increase by between 2.4^0C to 6.4^0C, or 4.3^0F to 11.5^0F .[3]. The study also confirmed that leading scientists, assert that, a rise of 0.9^0C or 3^0F would cause famine and drought, and threaten millions of lives.

It will also cause a worldwide drop in crops of between 20 and 400 million tons, threatening 400 million more people with famine, and put up to 3 billion people, at risk of flooding, and without access to fresh water supplies. Rising sea levels and changing storminess will reduce the effectiveness of coastal defences bringing the prospect of more frequent, more extensive and more damaging floods in the future and are consequently a major concern. Climate related changes in sea level; in particular high water levels are important because coastal defence structures which protect areas susceptible to flooding have lifetimes comparable with the timescale of significant changes in atmospheric CO_2. Most research effort on sea levels probably goes into studies of mean sea level with the aim of understanding and explaining its variability and identifying trends, but the behaviour of high or extreme water levels is of greater practical importance [3].

One widely accepted consequence of a changing climate is an increase in the rate of sea level rise [2]. Climate change may also result in other environmental impacts that will affect shorelines and the ecosystems they support. Some anticipated effects of climate change include: Altered hydrological cycles that may affect flooding and water resources, increasing sediment in glacier-fed rivers that may result in increased aggradation flooding and channel movement. Increased landslides, which may result in more sediment and wood inputs to streams, potentially increasing flooding, channel movement, and transport of wood to hazardous positions [4]. Extreme water levels generally occur as a combination of high water of a spring tide and a storm surge. An increase in mean sea level will of course affect extreme levels directly, but changes in the mean level and hence water depth can also influence the tidal component by changing its wavelength, and modifying the propagation and dissipation of tidal energy.

Although erosion and shoreline change have long been recognized as coastal hazards, it is only recently that the chronic problem of sea level rise has been closely connected to the acute threats of erosion and shoreline change. Indeed, Sea-level rise is large a result of warming ocean waters and melting ice caps is among the most certain consequences of climate change, although considerable uncertainty remains over the exact extent of rise both globally and along different stretches of the coastline. Sea level rise may accelerate from current trends and therefore increase the incidence, severity, and adverse effects of erosion and shoreline change. Rising sea levels will inundate low areas, increase erosion of beaches and bluffs, and increase the incidence of flooding from storm surges. When exploring the relation between sea-level rise and coastal erosion over a wide range of coastal sites, one has to consider the fact that sea level is not rising uniformly [5] and [6]; [7]. This is due to a number of factors which include; non uniform thermal expansion and salinity effects associated with ocean circulation changes and static effects due to the visco-elastic and elastic response of the solid Earth to past and present mass redistributions associated with last deglaciation called Glacial Isostatic Adjustment (GIA) and ongoing land ice melt [8]. In addition to the large scale regional variability affecting the absolute sea level, other processes cause vertical land motions (e.g., subsidence or uplift due to tectonic and volcanic activity, subsidence due sediment loading, ground water pumping and oil & gas extraction. Such local phenomena lead to relative sea level changes with respect to the ground and may either amplify or reduce the climate-related components. At a given location, the variable of interest is the total relative sea level variation, which is the sum of the climate-related global mean rise, plus low-frequency regional variability, plus the local land motions.

The Intergovernmental Panel on Climate Change states that, “Discernible human influences due to observed increases in globally averaged temperatures very likely due to the observed increase in anthropogenic greenhouse gas concentrations now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns" One of the impacts has been an increase in sea level because of the melting of ice on land and thermal. [9] The effects of sea level rise in the coastal zone include displacement and loss of wetlands, inundation of low-lying property, increased erosion of the shoreline, change in the extent of flood zones, changing water circulation patterns, and more salt water intrusion into groundwater. It is also possible that due to climate change there could be changes in coastal storm patterns that alter the frequency and intensity of coastal flooding [10].

GIS is ideally suited for various coastal flood management activities such as base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths. For example, GIS was used to develop a River Management Plan for the Santa Clara River in Southern California. A GIS overlay process was used to further plan efforts and identify conflicting uses along the river and areas for enhancing stakeholder objectives [11]. A well-designed GIS' should be able to provide quick and easy access to large volumes of data; it must have the ability to select detail by area or theme, link or merge one data set with another, analyze spatial characteristics of data, search for particular characteristics of features in an area, update data quickly and cheaply, and model data and assess alternatives; and that it should have output capabilities (such as maps, graphs, address lists and summary statistics) which is tailored to meet particular needs.

For this purpose, the temporal dynamics of Satellite imageries data can play an important role in monitoring and analyzing spatial change/land cover changes in the Coastal areas. Accurate and up-to-date land cover change information is necessary to understand both human causes and environmental consequences of such changes [12].

The aim of this paper therefore is to assess coastal flooding and socio-economic implications on Victoria Island, Lagos State, Nigeria using digital mapping capabilities of GIS with a view to determining areas that are susceptible to flooding in the study area. The objectives are to;

1 determine the causes of coastal flooding in the Victoria Island area, Lagos State
2 assess the extent and implications of the coastal flooding at different periods
3 create a DEM map for the study area using GIS techniques
4 assess the effects of coastal flooding on the socio-economic characteristics of the residents in the study area
5 device strategies for managing coastal flooding in the study area

2 Study Area

Lagos State lies specifically on Latitude 6˚27′11″ N and Longitude 3˚23′45″E.It lies in the South-Western Nigeria on the Atlantic coast in the gulf of Guinea, as shown in fig 1. Lagos State has a population of about 7,937,932 [14]. Eti-osa is one of the 16 local government areas in Lagos State which has a population of about 283,791 [13]. The latitudinal location of Victoria Island and its environs enjoy the characteristics of the West African monsoonal climate, marked by distinct seasonal shift in the wind pattern. The rainfall pattern in the study area can be explained in terms of the movement of the Inter Tropical Convergence Zone (ITCZ).Computation from table 1 shows that the average monthly rainfall is about 151.83mm, with a high percentage of falling between the months of April and October. During the rainy season, the lowest monthly rainfall is December, while the highest monthly rainfall is June, July, September and October.

Table 1: Average monthly rainfall pattern in the study area over 1990-2010

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	28	46	99	145	277	450	267	66	142	208	69	25

Source: Nigerian Meteorological Service (1990-2010)

The entire area has "light" surface in terms of degree of roughness of terrain and slopes. The terrain could be described as almost flat. However, there are patches of elevated areas and depressions. The geological history accounts for the almost flat terrain, where most land areas are between 18 and 25 meters above the sea level. Victoria Island and the entire axis are surrounded by Atlantic Ocean. Expectedly, the areas drained by the various water bodies are low lying. The water bodies are key ecological elements in the area, with great impacts on temperature and humidity. The mass of water around the town is believed to have also influenced the pattern of growth on Victoria Island and the adjoining development Water Bodies. Figure 2 shows the layout of the study area as digitized from the SPOT imagery posted online at http://wwwgoogleearth.com. The study is limited to Victoria Island in Eti-Osa Local Government. The study was divided into four (4) zones, which were the major residential districts making up the Victoria Island (see Fig 2).

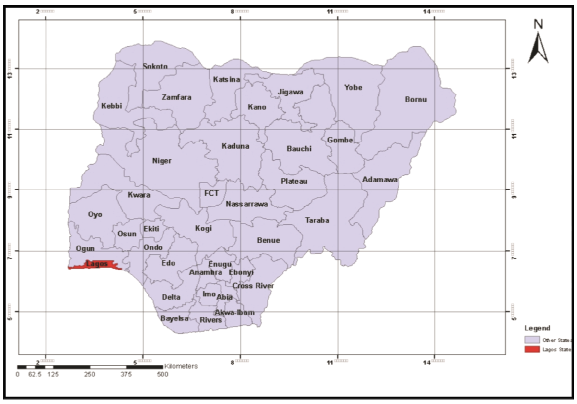


Fig. 1: Map of Nigeria showing Lagos State

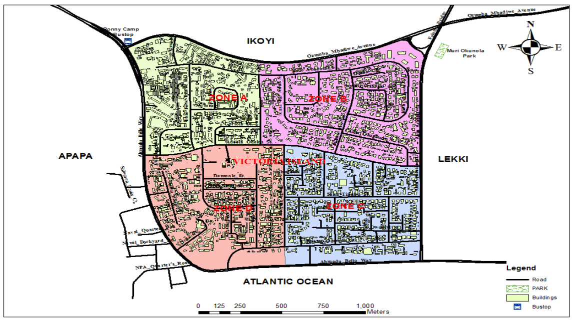


Fig 2: Map of the study area showing the four zones. Source: http://www@googleearth.com (Digitized by the author)

3 Data Acquisition and Preparation

The GIS software was used to acquire satellite imageries of the study area. This includes acquiring the Landsat imagery of the study area associated with shoreline change at different period intervals. Landsat satellite imageries of the shoreline of Eti-osa local government area were acquired for the years 1984, 2000, and 2011. These set of maps were helpful for the shoreline changes analysis on time series, collated and crossed with the use of GIS. The Topographic map was digitized to vector, polygonised and then converted to raster map of 10m pixel size. The supervised image classification was done for each year to classify the imageries into about six land use categories which include: built-up area, cultivation, dense vegetation, exposed soil, water body and wetland. For this study a topographical map of the study area was acquired. A Geographical Information System, using ILWIS 3.1 and ArcGIS 9.3 software were employed to obtain thematic information by the processes of scanning and digitizing of the topographical map for the purpose of delineating the extent of the study area and the different changes of the shoreline at various years. Since the study is interested in the assessment of coastal flooding changes, the capabilities of GIS and remote sensing (RS) were used to determine the levels of flooding hazard in the study area. The Digital Elevation Model (DEM) and slope maps of the study area were derived from the contour map, which were useful for the study of flood hazard in the study area.

The questionnaire method was used to generate attribute data for further enhance our information on the study area. For the purpose of this study, Samples were taken from the targeted buildings covering the four zones in the study area, systematic sampling technique was used. However, in this study, each respondent was selected at every 10^{th} interval of houses in each street of each of the four zones. Zone 1 has 799 buildings, zone 2 has 813, zone 3 has 749 and zone 4 has 887 buildings. 10% of the total buildings in each zone serve as the number of questionnaires administered in each zone. Three Hundred and twenty-five (325) samples were taken from all the four zones of the study area (see table 2).

Table 2: Questionnaires administered in each zone of the study area

Zone	Area (Hectares)	Area (square/ metres)	No of Buildings	Questionnaires administered 10% of Building
A	55	550507.12	799	80
B	73	734400.04	813	81
C	65	653565.27	749	75
D	68	679382.51	887	89
Total	261	2617854.94	3248	325

The questionnaire was designed to elicit information about the ecological problems and implication of annual flooding in the study area. All the questions asked were carefully analysed and considered in addition to spatial information from GIS analysis to arrive at our conclusions.

4 Results and Discussion

The results of the administered questionnaire and the GIS are presented below:

4.1 Socio-economic traits of the Respondents

The age structure of the respondents show that16.6% of the sample population were 35 years and below, 37.2% falls within the ages of 36-45 years and 46.2% were 46 years and above. The age structure shows that majority of the respondents are adults. These sets of people are active who is likely to bear the burden of flood menace. The children and the aged people rely on these set of age group for their livelihood. These will adversely affect the socio and economic life of people in this study.

The study of occupational status is very vital in the issue of flooding. According to Action Aid International [14], the key variables explain variation or impact of flood include occupation class, ethnicity, gender and health status, age and immigration status and the nature and extent of social network. The occupational status revealed that 1.0% of the respondents engaged in fishing, 3.0% were artisans, 24.0% engaged in trading and all forms of business activities, 35.0% are corporate and company workers while 37.0% are Civil servants. Critical observation into the occupational status of the respondents reveals that corporate/company workers and civil servants were more in the study area. This could be as a result of the fact the study area is an urbanized and civilized centre, which comprises residential buildings and some offices which serve as government offices and head offices of some companies.

Investigation revealed that 1.5% of the respondents received below N20,000 monthly, 15.4% received between N20,000-N30,000, 35.4% received between N40,000-N50,000 while 47.7% received above N50,000 monthly. The level of monthly income of the respondents shows that majority of the respondent still live below one dollar per day as indicated by the United Nation and this may affect the people's standard of living, their ability to demand for standard housing and requirement for other services [15], [16].The low monthly income of the respondents revealed why some of the respondents could not invest huge amount of money in the construction of standard drainage system meant for this type of environment (coastal area), which can convey freely large volume of water and in turn militate against flooding of the environment.

4.2 Causes of coastal flooding in the Study area

4.2.1 Distance of building to flood plain

Table 3 revealed that 5.8% of the sampled buildings fall between the distances of 20-50m from the flood plain while 94.2% of the buildings were 50m away from the flood plain. This revealed that most of the buildings in the study area have set backs above 50m from the flood plain. This may be as a result of the compliance to the building to stream set back standards, that the minimum distance between a building and a stream or other water body or a gorge shall be determined by the peculiar circumstance of each case, but shall not be less than 30metres in any case [17].

Table 3: Distance of Building to flood plain

Distance of Building to flood plain	Frequency	Percentage
between 20-50m	19	5.8
Above 50m	306	94.2
Total	325	100.0

Even though majority observed setback in the study area, it is discovered that the study area falls within the slope of 0-9.163m which constitutes about 90% of the total land area [18]. The implication of this is that, there is every possibility that water will be draining from the surrounding environment to the study area making this area to be waterlogged and consequently results to flooding. This is supported by [19]; [20] and [21]; that the coastal region in Nigeria experience perennial floods owing to its location, low-lying topography and heavy rainfall which is considered to be vulnerable to incessant flooding because of its location and slope characteristics.

4.2.2 Type of refuse disposal system

Table 4 shows the critical investigation into the mode of waste disposal system of residents in the study area. It was revealed that 26.2% of the respondents claim that the mode of refuse disposal is dumping in the drainages, 8.9% claim that they rely on natural course of the river, 6.2% claim they rely on communal refuse dump site system while 58.8% observed that the disposal of waste through government agency.

Table 4: Type of refuse disposal system

Type of refuse disposal system	Frequency	Percent
Disposal of waste in drainages	85	26.2
Disposal of waste along natural course of rivers	29	8.9
Disposal of waste in refuse dump site	20	6.2
Disposal of waste through government agency	191	58.8
Total	325	100.0

Source: Author's Fieldwork 2014

Despite the fact that, waste can be disposed through government agency, some of the residents especially the illegal occupants of the sand filled part of the sea in the study area still dispose their wastes indiscriminate along water ways, impeding the free flow of water. This may in turn result to flooding in the area. This is because dumping of refuse along the water way will prevent the free flow of water thereby resulting to flooding of the immediate environment (see fig 3).

Fig 3: Flooded Plain due to refuse disposal beside the Ocean in Eti-osa

4.2.3 Major causes of flooding in the Study area

Table 5 shows the responses of the respondents to the major causes of flooding in the study area. The table revealed that, 7.1% of the respondents observed that lack of drainage facilities is the major cause of flooding, 34.2% attributed the major cause to block and narrow drainages, 9.5% observed the major cause as a result of building close to river flood plain while 48.6% attributed the major cause of flooding in the study area as result of heavy rainfall. Apart heavy rainfall, it was discovered that the major causes of flooding in the study area are blocked/narrow drainages and heavy rainfall. The narrow constructed drainages cannot support the large volume of water flow during heavy rain fall resulting to the overflow of water from the drains thereby flooding the streets, roads and buildings in the study area. This implies that the areas without good and well-constructed drainage systems are prone to flood disaster (see fig 4).

Table 5: Major causes of flooding in the study area

Major causes of Flooding	**Frequency**	**Percentage**
lack of drainage facilities	23	7.1
blocked/narrow drainages	111	34.2
buildings close to river flood plain	31	9.5
heavy rainfall	158	48.6
high paved surface	2	0.6
Total	325	100.0

Fig 4: Poor drainage in off Bishop Oluwole Street, Victoria Island in Etio-osa

5 Hypothesis Testing

Table 6: Univariate Analysis of Variance
Dependent Variable: What type of refuse disposal system do you have here?

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	493.695[a]	4	123.424	597.440	.000
Intercept	361.700	1	361.700	1750.831	.000
v16	493.695	4	123.424	597.440	.000
Error	66.108	320	.207		
Total	3437.000	325			
Corrected Total	559.803	324			

Source: Author's Field Work, 2014
a. R Squared = .882 (Adjusted R Squared = .880)
While R Square = .880
Coefficient of determinant =R^2 = .880

Coefficient of correlation = R = 0.9381
Rank = 1- 0.9381 =0.0619

From table 6, the test hypothesis at a 0.00 significance level, that coefficient of the variables regression figure is low as 0.0619. The Null hypothesis is rejected, the regression coefficient is as low as 0.06. This indicates there is a marked relationship between flooding and refuse disposal system in the study area.

6 GIS Analysis

The 1962 topographic map, 1984, 2000 and 2011 Landsat ETM+ imageries are classified. Supervised image classification system was used to classify the images into different land use categories. Six land use classes have been identified. This includes: forest, built up area, cultivation, dense vegetation, exposed soil, wetland, and water body. Fig 5 is the digitized topographical map of 1962 of the study area and its environs. It serves as the base map for the study. Fig 6, 7 and 8 showed the results of the various processing itemized for the Landsats TM data sets. Tables 7, 8 and 9 showed the statistical results of the classification sets.

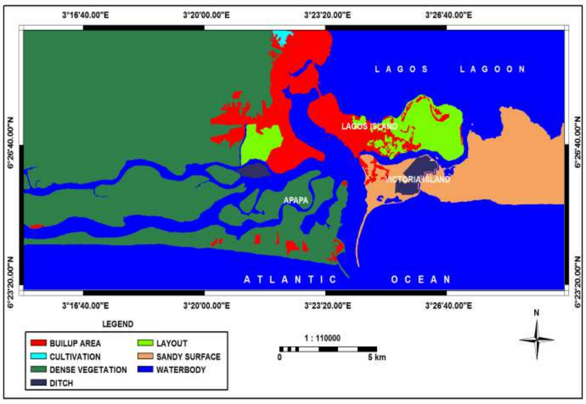


Fig 5: Lagos Coastline 1962, Digitized from the Topographic Map of 1964
Source: http://www@googleearth.com (Digitized by the author).

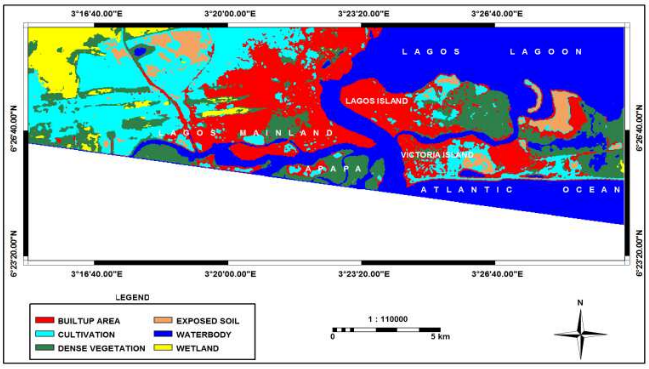
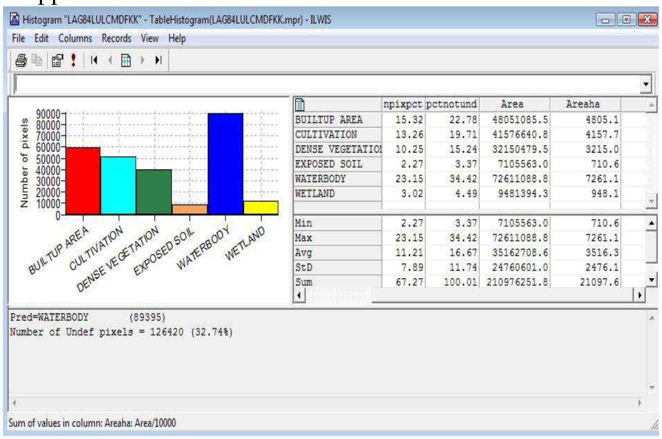


Fig 6: Supervised Classification of Landsat Thematic Mapper 1984
Source: http://www@googleearth.com (Digitized by the author).

Table 7: Statistical Result of Classified Landsat Thematic Mapper 1984



Histogram "LAG84LULCMDFKK" - TableHistogram(LAG84LULCMDFKK.mpr) - ILWIS

	npixpct	pctnotund	Area	Areaha
BUILTUP AREA	15.32	22.78	48051085.5	4805.1
CULTIVATION	13.26	19.71	41576640.8	4157.7
DENSE VEGETATIOI	10.25	15.24	32150479.5	3215.0
EXPOSED SOIL	2.27	3.37	7105563.0	710.6
WATERBODY	23.15	34.42	72611088.8	7261.1
WETLAND	3.02	4.49	9481394.3	948.1
Min	2.27	3.37	7105563.0	710.6
Max	23.15	34.42	72611088.8	7261.1
Avg	11.21	16.67	35162708.6	3516.3
StD	7.89	11.74	24760601.0	2476.1
Sum	67.27	100.01	210976251.8	21097.6

Pred=WATERBODY (89395)
Number of Undef pixels = 126420 (32.74%)

Sum of values in column: Areaha: Area/10000

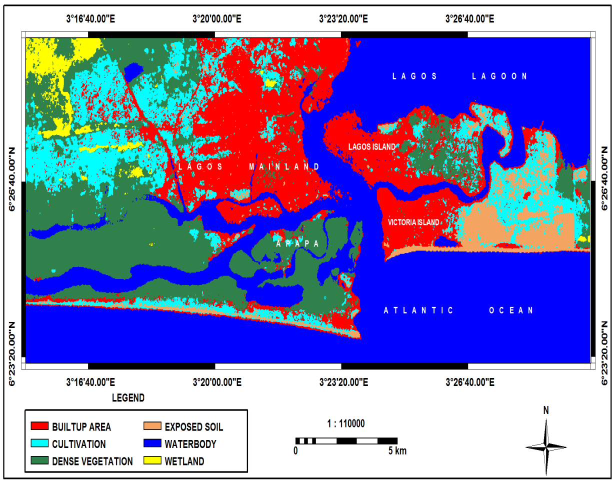
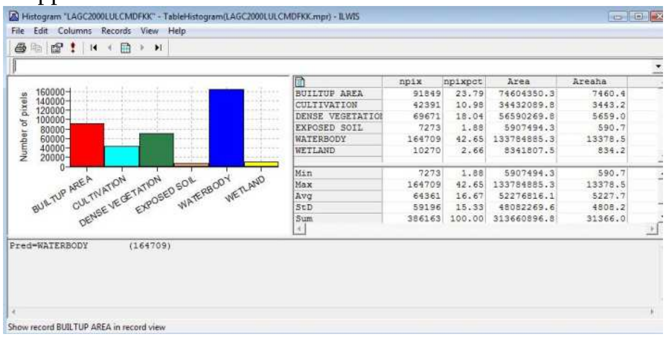


Fig 7: Supervised Classification of Landsat Thematic Mapper, year 2000
Source: http://www@googleearth.com (Digitized by the author).

Table 8: Statistical Result of Classified Landsat Thematic Mapper 2000



Histogram "LAGC2000LULCMDFKK" - TableHistogram(LAGC2000LULCMDFKK.mpr) - ILWIS

	npix	npixpct	Area	Areaha
BUILTUP AREA	91849	23.79	74604350.3	7460.4
CULTIVATION	42391	10.98	34432089.8	3443.2
DENSE VEGETATIOI	69671	18.04	56590269.8	5659.0
EXPOSED SOIL	7273	1.88	5907494.3	590.7
WATERBODY	164709	42.65	133784885.3	13378.5
WETLAND	10270	2.66	8341807.5	834.2
Min	7273	1.88	5907494.3	590.7
Max	164709	42.65	133784885.3	13378.5
Avg	64361	16.67	52276816.1	5227.7
StD	59196	15.33	48082269.6	4808.2
Sum	386163	100.00	313660896.8	31366.0

Pred=WATERBODY (164709)

Show record BUILTUP AREA in record view

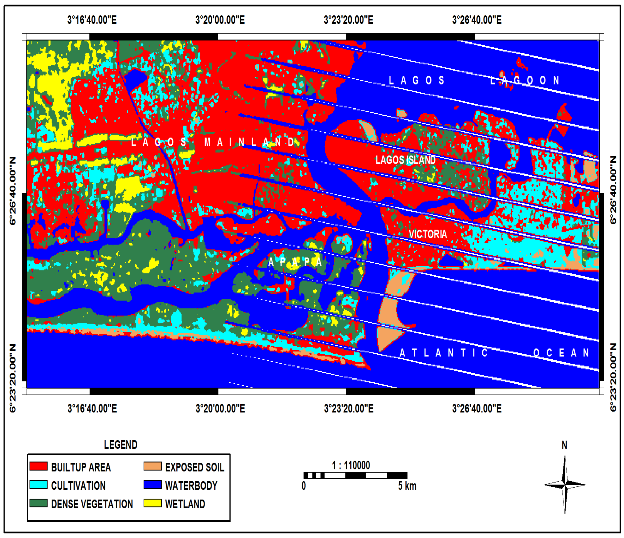
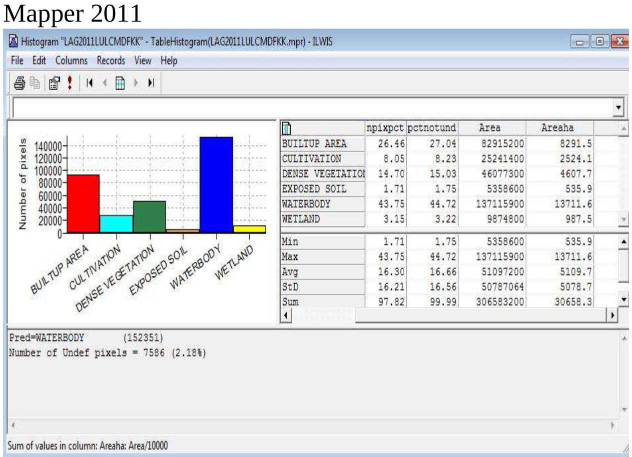


Fig 8: Supervised Classification of Landsat Thematic Mapper, year 2011

Table 9: Statistical Result of Classified Landsat Thematic Mapper 2011



Histogram "LAG2011LULCMDFKK" - TableHistogram(LAG2011LULCMDFKK.mpr) - ILWIS

	npixpct	pctnotund	Area	Areaha
BUILTUP AREA	26.46	27.04	82915200	8291.5
CULTIVATION	8.05	8.23	25241400	2524.1
DENSE VEGETATIOI	14.70	15.03	46077300	4607.7
EXPOSED SOIL	1.71	1.75	5358600	535.9
WATERBODY	43.75	44.72	137115900	13711.6
WETLAND	3.15	3.22	9874800	987.5
Min	1.71	1.75	5358600	535.9
Max	43.75	44.72	137115900	13711.6
Avg	16.30	16.66	51097200	5109.7
StD	16.21	16.56	50787064	5078.7
Sum	97.82	99.99	306583200	30658.3

Pred=WATERBODY (152351)
Number of Undef pixels = 7586 (2.18%)

Sum of values in column: Areaha: Area/10000

It was discovered figure 6 and table 7 that as at 1984, built up area covers 4805.1 ha (22.78%), cultivated area of 4157.7 ha (19.71%), dense vegetation of 3215.0 ha (15.24%), exposed soil of 710.6 ha (3.37%), water body of 7261.1 ha (34.42%) while wetland is 948.1 ha (4.49%). From the analysis it was discovered that water body has the highest hectares, 7261.1(34.42%) of the land-use land-cover of Victoria Island and its environs of 21097.6 hectares of land. This reveals that the study area and its environs contain water land (water body) than any other land-use land-cover. The implication of this is that, area with such water body is prone to flood hazards.

From the fig 7 and table 8, it was discovered that as at 2000, built up area covers 7460.4 ha (23.79%), cultivated area of 3443.2 ha (10.98%), dense vegetation of 5659.0 ha (18.04%), exposed soil of 590.7 ha (1.88%), water body of 13378.5 ha (42.65%) while wetland is 834.2 ha (2.66%). From the analysis it was discovered that water body has the highest hectares, 13378.5 (42.65%) of the land-use land-cover of Victoria Island and its environs of 31366.0 total hectares of land mass. This reveals that the study area and its environs as at the year 2000 were made up of Water land (water body) than any other land-use land-cover. The implication of this is that Victoria Island and its environs are prone to flood hazards.

From the fig 8 and table 9, it was discovered that as at 2011, built up area covers 8291.5 ha (27.04%), cultivated area of 2524.1 ha (8.23%), dense vegetation of 4607.7 ha (15.03%), exposed soil of 535.9 ha (1.75%), water body of 13711.6 ha (44.72%) while wetland is 987.5 ha (3.22%). From the analysis, it was discovered that as at the year 2011, water body constitutes the highest area in hectares, 13378.5 (42.65%) of the land-use land-cover of Victoria Island and its environs of total of 30658.3 hectares of landmass. This reveals that the study area and its environs as at the year 2011 were made up of Water land (water body) than any other land-use land-cover. The implication of this is that Victoria Island and its environs are prone to flood hazards.

6.1 Digital Elevation Model generation (DEM)

Fig 9 shows the contours of Victoria Island and its environs, this is generated from the topographic map of the study area. The contour line is a line joining places of equal heights. The map reveals that most parts of the study area are zero metres high above the sea level. This implies that the study area is almost the same height with the sea.

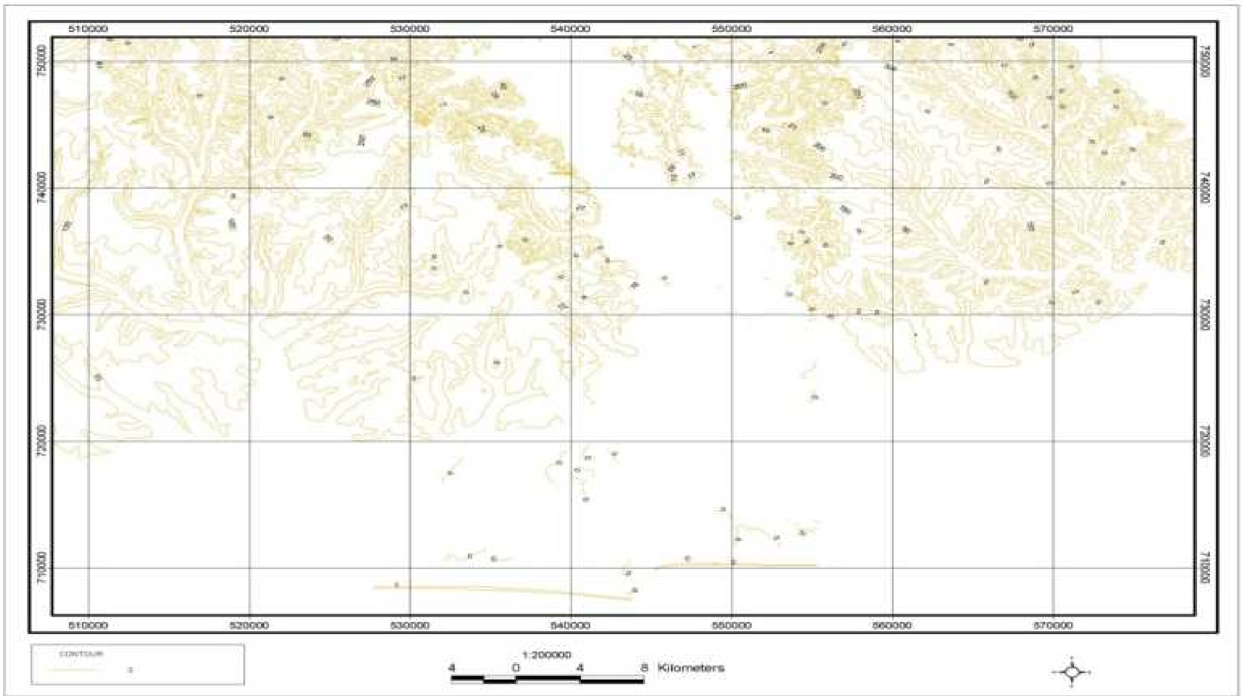


Fig 9: Contour Map of Victoria Island and its environs.

Fig 10 is the Digital Elevation Model (DEM) map of the study area, this map is generated from the contour map of figure 9, the study area, and it shows and determines the flood plain. Figure 10 shows that the Elevation range of the study area is between 0-16.667m.This reveals that the height of the study area above the sea level is between 0-16.669m. Lagos is a state below the sea level and constantly being threatened with the challenge of climate change and ocean surge [18]. The implication of this is that, the area is a flood plain, which makes it prone to incessant flood hazard due to the fact that the height of the area above the sea level is low. Victoria Island is between the height of 1.1m and 4m above the sea level, this height value is low and insignificant, which means that everywhere in this area is liable to flooding, because water level can rise anytime thereby flooding the entire parts of Victoria Island especially during the raining season.

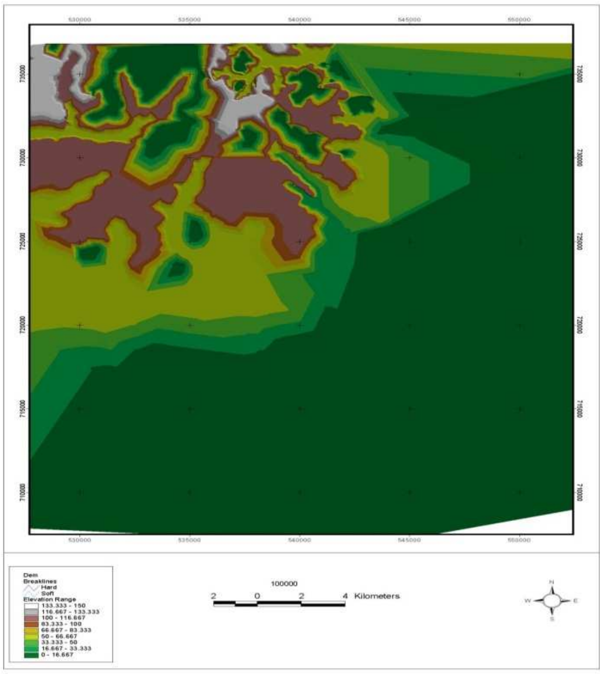


Fig 10: Digital Elevation Model (DEM) of Victoria Island and its Environs.

7 Conclusion

The study has assessed the impact of coastal flooding on Victoria Island in Eti-Osa Local Government of Lagos State, Nigeria. The study revealed that most of the buildings in the study area have set backs above 50m from the flood plain, it is important to state that few buildings erected between 20-50m close to the flood plain, are the shelters erected by the illegal occupants of the sand filled portion of the sea in the study area are prone to flooding. Findings also revealed that the study area always enjoy high rainfall throughout the year, poor drainage to convey the volume of water that flows through it especially during the raining season which often lead to destruction of lives and property in the study area, deterioration of buildings, deterioration of environmental infrastructure, obstruction of movement and economic activities, prevalence of malaria disease, soaking and water mark on the wall of the building and result to homelessness. The Contours Map of Victoria Island and its environs revealed that the contour line of the study area is between 0-100m which implies that the area is extremely low. The digital elevation model (DEM) map of the study area shows that the study area is between 0-33.33m while the surrounding area is higher between 116.667-133m. Findings from the slope map shows that the Elevation range revealed that about 90% of the study area is between the heights 0-16.667m while the surrounding area is higher; this revealed the reason for the incessant flooding in Victoria Island. Victoria Island is between 0-9m high above the sea level, making the area to be almost the same level with the sea; this is one of the reasons why the study area is prone to incessant flooding.

8 Recommendations

This study therefore advances some recommendations as a way of preventing the menace of coastal flooding in the study area. The recommendations are both behavioural and structural.

On the behavioural aspects: Government should come to terms with its duty of enforcing environmental laws. People should be made aware of their social responsibility of caring for the environment. Part of the means of achieving this is charging a fee for wastes generated to complement the waste management efforts of government. All envisaged measures concerning coastal flood prevention and protection should be compiled in a comprehensive action plan covering up to several decades. An integrated action plan for reducing coastal flood damage must draw long-term conclusions for preventive action in water management, land use, settlement policy and finance. The activities of State Environmental Protection Agency (SEPA) and Federal Environmental Protection Agency (FEPA) should be widened in the study area.

On the structural aspects: construction of standard paved surface and drainages in the study area will help to combat flood hazard especially in the built up areas. The paved surface enables the run offs to move freely because it does not have the ability to retain water. Provision of adequate drainages is of paramount importance in road design and cannot be overemphasized. Culverts should be placed technically where necessary so that debris can pass freely through them to avoid blockage which may consequently results to overspill of water to the environment.

There should be collaboration and sharing of experiences among different bodies especially the environmentalists and the international bodies on sustainable flood management. Flood maps should be used for the reduction of damage potential by integrating its outputs into spatial planning and emergency planning. Lastly there is need by the agency concerned for early warning and flood forecasting particularly in flood plain areas at immediate and high risk.

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