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Environmental Impact of Flooding on Kosofe Local Government Area of Lagos State, Nigeria: A GIS Perspective

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Abstract
The study identified and assessed the environmental impact of flooding on Kosofe Local Government Area of Lagos state, Nigeria. This was with a view to suggesting an integrated strategy and management plan for sustainable environment in the study area. The study therefore integrated IKONOS and Land-SAT Images of 2010 with spatial resolution of 5m and 30m respectively. Aerial photography of 2010 was also acquired with ground truthting to carry out the exercise. Structured questionnaire was administered to elucidate data on socio economic characteristics of the residents; building use; distance of building from floodplain; source of land acquisition and impact of flooding on the environment among others. Digital image processing was carried out for satellite imageries. Land uses were identified and classified from the satellite imageries. Digital Elevation Model (DEM) was generated using ILWIS 3.4 software to depict the topography of the study area. Chi-Squared statistical test was adopted for the study. Results obtained show that there is strong correlation between incidence of flooding (FLOOD) and poor refuse disposal practices (REFUSE), inadequate setback from rivers (SETBACK) and lack of building plan approval from relevant authority (APPROVE). The study recommended enlightenment programmes for the residents of the study area to increase their level awareness about the causes, consequences and control of flooding.
Keywords: Flood, GIS, Kosofe LGA

1.0 Introduction

Flood is an overflowing or irruption of a great body of water over land not usually submerged (Hornby, 2005). Smith (1996) as cited by Etuenovbe (2011) opines that flood is an extreme weather event naturally caused by rising global temperature which results in heavy downpour, thermal expansion of the ocean and glacier melt, which in turn results in rise in sea level, thereby causing salt water to inundate coastal lands. Flooding is the most common of all environmental hazards and it regularly claims over 20,000 lives per year and adversely affects around 75 million people world-wide. Etuenovbe (2011), citing Askew (1999), opines that floods cause about one third of all deaths, one third of all injuries and one third of all damage from natural disasters. In Nigeria, the pattern is similar with the rest of the world. Flooding in various parts of Nigeria has forced millions of people from their homes, destroyed businesses, polluted water resources and increased the risk of diseases (Baiye, 1988; Akinyemi, 1990; Nwaubani, 1991; Edward-Adebiyi, 1997). In addition, Record shows that more than two hundred people have lost their lives to flooding while hundreds of thousands have been rendered homeless and properties worth billions of Naira have been destroyed as a result of devastating floods across the country (Abugu, 1988; Oluduro, 1988; Sunday Times, 1988; Oyo Ministry of Information,

Etuenovbe (2011), reports that for residents of Lagos and most Nigerian towns and villages, the rainy season is undoubtedly not the best time of the year. This period comes with the perennial problems of flooding which leaves many homes swamped with the resultant loss of property and sometimes human lives. Properties estimated at several millions of Naira were destroyed in many communities in the Ikorodu axis in 2010. It was gathered that the persistent overflow of River Ogun caused the disaster in the State. Also, the exceptional rainfall being witnessed globally this year (2012) had made the Atlantic Ocean level to rise, and this in turn forced Lagos Lagoon water to rise and spread into the flood prone areas of River Ogun.

Floods in its history has brought great calamities, on human. Their aftermath can be as damaging as their physical effects through destruction of basic infrastructures, housing and breakdown of transport for food, temporary shelter and emergency services (Awosika, 1995). Flood also brings about destruction of settlements, properties, great suffering and loss of life. Flooding has been identified as one of the major factors that prevents Africa's growing population of city dwellers from escaping poverty and stands in the way of United Nations 2020 goal of achieving significant improvement in the lives of urban slum dwellers (Action Aid, 2006). This is because many African cities lack the infrastructure to withstand extreme weather conditions.

Poor urban planning together with other urban governance challenges contributes to making African urban slum dwellers stand at risk. Poor urban planning or lack of planning as urban development increases is evident in the way new development are not prevented on areas at risk of flooding, leaving unprotected areas that should be left undeveloped, for instance wetlands, because of their role as buffers against flooding risks and also not providing safer sites for the urban poor. McGranahan et al. (2007) note that, while economic activity and urban development often increase the environmental pressures that lead to flooding, it is the low income settlements and poor groups within all settlements that tend to be the most vulnerable. About one third of land in Nigeria is at an elevation less than eight meters above sea level; as a consequence, up to thirty percent (30%) is often covered with flood water.

Causes of flood tend to vary from one locality to another depending on the available protection and management process. Urbanization and or the concentration of settlements have continued to raise the flood damage, as settlements continue to encroach on the flood prone areas. Also, over reliance on safety provided by flood control infrastructure such as levies, dykes, reservoirs, dam can also result in flood disaster. For example dyke though a flood protective structure can collapse, thereby resulting into immense water destruction. Human action also causes flooding; there is the tendency to encroach on flood plains which attract development due to their flatness, soil fertility and proximity to water. Other causes of increasing flood risk include increase in the proportion of impervious area; deforestation and channel interference e.g. channel suffocation by solid waste. Nigeria in recent time had also experienced many flood occurrences with several consequences especially in Lagos and Ibadan. In Lagos State, Kosofe has experienced highest number of flood in recent time. These occur after a heavy and prolong downpour of rain and consequently damage is usually enormous. In addition, thousands of people are displaced, buildings, farmlands, social infrastructure are destroyed and economic activities disrupted.

Etuenovbe (2011) identified the forms of flooding in Nigeria as coastal flooding, river flooding, flash floods, urban flooding, dam burst levee failures and dam spills among others. Coastal flooding occurs in the low-lying belt of mangrove and fresh water swamps along the coast. River flooding occurs in the flood plains of the larger rivers Flash floods are associated with rivers in the inland areas where sudden heavy rains can change them into destructive torrents within a short period. Urban flooding occur in towns located on flat or low lying terrain especially where little or no provision has been made for surface drainage, or where existing drainage has been blocked with municipal waste, refuse and eroded soil sediments. Extensive urban flooding is a phenomenon of every rainy session in Lagos, Maiduguri, Aba, Warri, Benin and Ibadan.

The study area suffers incessantly from unmitigated flooding, often resulting in: disruption of communication, structural damages to buildings and loss of lives and properties. The high rate of urbanization in the area also means a high rate of housing construction and encroachment on open spaces and wetlands. The generally low lying terrain, coastal influences on its micro-climate, heavy precipitation, blockage of drainage and occasional release of water from the Oyan dam, all coalesce to exacerbate flood problems in Kosofe LGA. This contributes immensely to the flood situation in the area as water level rise and is further sustained in the Ogun River catchment areas.

Furthermore, unapproved development of marginal land, massive reclamation of swampy areas (for industrial operational bases and high class residential developments without adequate provision for drainage canals), outright blockage of drainage channels and discharge outfalls and other characteristics of urban organic growth have ineluctably aggravated the flood situation in the study area. This study is therefore designed to assess the environmental impact of flooding in Kosofe Local Government Area of Lagos State, using remotely sensed data, with a view to ensuring sustainable living environment. The objectives are therefore to:

i. identify factors responsible for flooding in the study area;
ii. examine the effect of flooding on the physical, social and economic status of Kosofe Local Government Area; and
iii. assess the environmental impact of flooding in the study area using remotely sensed data;

2.0 The Study Area:

Kosofe is one of the twenty (20) Local Government Areas (LGAs) in Lagos state. It was created on the 27th of November, 1980. It is located at the northern part of the state; it is bounded by 3 local governments namely: Ikeja, Ikorodu and Shomolu. It also shares a boundary with Ogun state. Its area of jurisdiction comprises of ten wards and encompasses an area of 178.85sq/km with its headquarters at Ogudu. NPC (2006) puts the population of Kosofe at 682,772 people with 358,935 males and 323,887 females. Using the 3.18% growth rate (NPC, 2006), the projected population to year 2012 is 1,126,574.

The vegetation of Kosofe is the swamp forest which had been encroached by construction of houses, market and other infrastructure. However the climatic condition of the area is influenced by the climatic seasons, dry

between November to March, and wet between April to October. The major water body in the local government is the Ogun River.

The indigenous dwellers of Kosofe LGA are mainly the 'Aworis' whose major occupation was mat-weaving, farming and fishing. However, due to its location as the gateway to Lagos State and the hospitality of the indigenes, Kosofe houses people from the northern and eastern part of Nigeria who engage in commercial activities in the various markets such as Mile 12 and Ketu markets. Another emergent class of dwellers in Kosofe area is top civil servant and officials who live in government residential areas of Magodo and Ogudu.

Kosofe is a bustling commercial centre being the terminal for all food items and fruits from all part of the nation. This is understandable as Lagos state still remain the major market for all agricultural products from the hinterland. As a result, Kosofe is mainly occupied by traders, civil servants and elites. There are over 35 communities in Kosofe LGA and these include: Oworosoki., Ifako, Sholuyi., Anthony village, Ajao estate, Ogudu, Ojota; Alapere, Orisigun, Kosofe, Ajelogo and Akanimodo; Ikosi, Ketu, Mile 12, Ayedere, Maiden; Isheri, Olowora, Shangisha, Magodo phase 1 & 2; Agboyi-1; Agboyi-2; Owode-Onirin, Ajegunle and Odo-Ogun among others. For the purpose of this research areas mostly affected by flood will be considered, these include: Mile 12, Maiden, Agboyi-1, Agboyi-2, Owode-Onirin, Ajegunle and Odo-Ogun.

3.0 Data Acquisition and Preparation

This study was interested in the analysis of the causes of flooding in the study area. It also seeks to determine the environmental impact of flooding on the social, economic and physical status of the study area. To achieve these, data were collected using structured questionnaire which were administered on political ward basis in the study area as shown in Table 1 below:

Table 1: Questionnaire Administration

Wards	Location	No of Buildings	Total Number of Questionnaire Administered (30% of buildings)
Ward 6	Mile 12	80	24
	Maidan	150	45
	Agility 1& 2	200	60
Ward 7	Isheri North	25	7
Ward 8	Agboyi 1	100	30
Ward 9	Agboyi 2	100	30
	Owode Elede	200	60
	Owode Onirin	60	18
	Ajegunle/Laniyan	250	75
Ward 10	Odo Ogun	50	15
	Owulade Bako	120	36
	Idera/Irawo	50	15
	Itowulo	30	9
Grand Total		**1415**	**425**

Source: Field survey 2011

The questionnaire was administered on household heads in the study area. The questionnaire addresses income of respondents, distance of building from floodplain, building plan approval, causes, benefits and effects of the flood among others. The questionnaires were administered by trained field assistants. Also, photographs of interested scenes were taken to complement the questionnaires administered.

The geographic data of the study area was captured from IKONOS satellite imagery of 80m resolution and Land-SAT Thematic Mapper showing 70% coverage of Lagos state including the study area. The aerial photograph of the study area collected from Lagos State Ministry of Physical Planning and Urban Development also form part of the geographic data. These data and their characteristics are as shown in the Table 2.

Table 2: Remotely Sensed Data for the Study

SN	Imagery/Aerial Photograph	Spatial Resolution	Date Acquired	Source
1	IKONOS	5m	2010	LASPPDA
2	LANDSAT	30m	2010	LASPPDA
3	AERIAL PHOTOGRAPH	not available	2010	MPPUD

Source: Authors Field Survey, 2011.

4.0 Results and Discussion

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

4.1 Socio-economic Traits of the Respondents:

The age structure of the respondents show that 5% of the sampled population is under 20years of age, 17% are between 21-30 years, 23% are between 31-40years while 30% accounted for 41-50 years, the remaining 25% are above 50 years of age.. This age structure shows majority of the respondents are adults between the age of 21 and 50. These set of people are the active proportion of the population who are likely to bear the burden of the flooding menace. It also shows that over 70% of the population is agile and economically vibrant. They constitute the working population and as such their views cannot be jettisoned as far as the issue of flooding is concerned in the study area. The children and the aged rely on these set of people for their livelihood. Any adverse impact of flooding on this set of people will surely have backwash effects on the social and economic life of the general populace.

Majority of the respondents are low income earners. Figure 2 shows the income structure of the respondents. The study revealed that over 54.4% of the respondent earn less than ₦18,000 per month, 25.4% earn between ₦18,000 – ₦36,000, 12.9% earn between ₦36, 001 - ₦44,000, while only 7.3% of the respondents earn above ₦44,000. This implies that majority of the respondents are low income earners who cannot afford accommodation in a standard environment, especially in Lagos state where the cost of accommodation is high and housing supply does not match its supply. This set of people can only afford accommodation in the flood prone area where accommodation is cheaper because of the low quality of the environment.

The level of education of majority of the inhabitants in the study area is low. About 52% of the respondents are secondary school certificate holders. Secondary school graduates in Nigeria are not usually considered for good job opportunities as such graduates are only good for labour job in the industries. This set of people earn very low income and are therefore ready to reside in any environment as bad as flood prone areas where accommodation is cheapest. A negligible 8.7% of the respondents have post secondary school education.

4.2 Environmental Impact of Flood on Buildings:

Most of the buildings in the study area were constructed before 1980. Over 68% of the buildings were constructed between 1960 and 1980, while only 32% of the buildings were constructed between 1980 and 2010. Majority of the buildings are over 30 years of age. The implication of this is that the existing buildings have been over utilized and are now dilapidated due to obsolescence. The age of buildings also affects its value, hence, the prevalence of low income earners in the study area. The use to which these buildings were put is majorly residential (92.2%). Table 2 shows the building use analysis in the study area.

Table 2: Building Use in the Study Area

Land Use	Frequency	Percent	Cumulative Percent
Residential	392	92.2	92.2
Commercial	18	4.2	96.5
Industrial	6	1.4	97.9
Educational	9	2.1	100.0
Total	**425**	**100.0**	

Source: Field Survey, 2011

About 4% of buildings in the study area were for commercial use while 1.4% are for industrial use and 2.1% of the buildings are for educational purposes. This phenomenon implies that the study area does not offer employment opportunities to the people. It is a residential suburb where people reside and go to work elsewhere. The planning implication of this is that, the per capital income of the people will be low; investors will not be attracted; and government presence will be minimal and as such development of roads, drainages, bridges and other facilities that protects the environment from flooding will be at very low ebb.

In addition, the manner by which the people acquire land in the study area is of great concern. The study shows that only 1.6% of the respondents acquire their plots of land from government. About 96% of the respondents

got their plots from private individuals, while just 2.4% of the respondents got their landed properties through inheritance. This phenomenon implies that the study area is at the mercy of private individuals who buy land cheaply, sub-divide them into substandard plots and sell to the public. In Nigeria, areas of this kind are not under the control of government as far as physical development is concerned. Individuals develop their lands to the detriment of the larger society. In such an environment, there is every tendency for micromanagement tendencies in the management of land. This is a situation where an individual assumes control in the provision of landed amenities as opposed to entrusting public authorities to do the same (Fasakin, 2009). It may be done by one who is a professional or not, the notion here is that individuals rather than collectives (designated authorities, CBO's, NGO's etc.) take initial decision on facility provision and maintenance and execute them in the study area. For instance this form of land acquisition encourages individuals to determine the fence-line, extend drainage and electricity lines to suit themselves rather than collective decision at the detriment of the general environment (Olamiju, 2012). In this way drainages could be blocked; roads not properly aligned or totally blocked, hence aggravating flooding in such areas.

The distance of building to floodplain is an important area examined in the course of this study. Table 3 provides information on the distance of buildings to the river floodplains. From the table, it is evident that over 68% of the buildings do not maintain the statutory 30m set back to the river floodplain. In a low-lying terrain such as the study area, a distance of 100m is not out of place for safety purposes. In this case, less than 2% of the inhabitants of the study area are safe from the menace of flooding, while the remaining 98% are susceptible to flooding hazard.

Table 3: Distance of Buildings to Floodplain

Distance	Frequency	Percent	Cumulative Percent
0 - 29m	290	68.2	68.2
30 - 59m	102	24.0	92.2
60 - 99m	25	5.9	98.1
100 - 150m	8	1.9	100.0
Total	**425**	**100.0**	

Source: Author's Field Survey, 2011.

Plate 1 shows a cross-section of buildings in the study area that are built on stream channels. Plate 2 also shows an aerial view of buildings submerged by flood in the study area.

Plate 1: Aerial Photograph Showing Buildings Built Close to River Channels

Source: Field Survey, 2011

It is evident from plate 1 that buildings are built without respect to distance from the rivers and streams. .This phenomenon explains why damage to lives and properties during flooding hazard is very enormous.

Plate 2: Aerial Photography of the Study Area Showing Buildings Submerged by Flood
Source: Field Survey, 2011

The study also shows that about 54% of the respondents suffer loss of properties in any event of flooding hazard. 11% accounted for loss of lives, while 35% accounted for damage to infrastructure. This phenomenon explains why there are no tarred roads, good drainage and parking facilities in the study area (see Plates 2, 3, and 4).

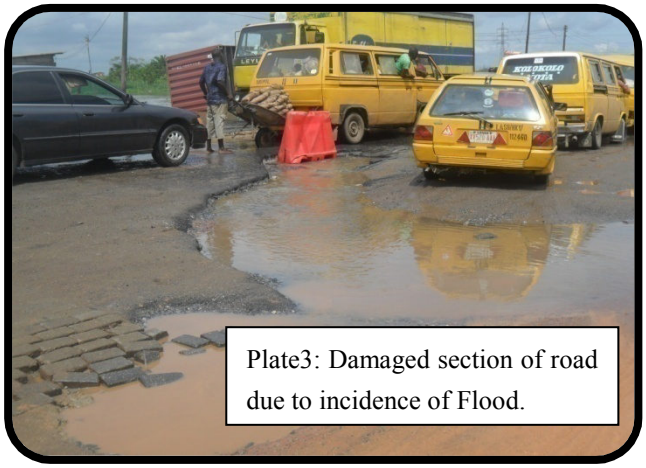

Plate3: Damaged section of road due to incidence of Flood.

Plate4: Service road Submerged by Flood

Plates 3 & 4: Condition of Road in the Study Area
Source: Field Survey, 2011

4.3 Test of Hypothesis Using Chi-Squared (X^2) Analysis

The hypotheses for this study are as stated in the null form below:
H_{o1}: There is no significant relationship between flooding incidence and refuse disposal
$H_{A1:}$ there is significant relationship between flooding incidence and refuse disposal
H_{o2}: There is no significant relationship between flooding incidence and building setback from river.
$H_{A2:}$ there is significant relationship between flooding incidence and building setback from river.
H_{o3}: There is no significant relationship between flooding incidence and building plan approval before construction
$H_{A3:}$ there is significant relationship between flooding incidence and building plan approval before construction
Table 6 shows the result of Chi-Squared test carried out on three dependent variables.
The Chi-Squared (X^2) test shows that method of refuse disposal practice, setback of building to river and building plan approval before construction are all significant at 0.000.

Table 6: Chi-Squared Analysis on Flooding Incidence in the Study area

Variables	Chi-Squared (X^2) Value	Asymptotic Significance	Remark
REFUSE	5.670	.000*	Reject H_o
SETBACK	16.167	.000*	Reject H_o
APPROVE	19.391	.000*	Reject H_o

*Significant at 0.05 level
Source: Field Survey, 2011.

The Chi-Squared test shows that there is significant relationship between flood incidence on one hand and refuse disposal practice, setback of buildings to river bank and building plan approval before construction at significant levels of 0.05 on the other hand. The asymptotic significance is .000 and a Chi-Squared value of

5.670, 16.167 and 19.391 respectively. This shows that 95% of flooding incidence in Kosofe is as a result of the combinational effect of all the three variables. All the null hypotheses (H_o) were rejected and the alternate hypotheses (H_1) were accepted.

5.0 GIS Analysis

GIS analysis was carried out on the Landsat TM Band 4 & 5 imagery. The bands were combined using ER-Mapper software. The imagery was classified using the same software before importing to ArcGIS environment. The IKONOS imagery was overlaid on the classified Landsat TM data to compare the various spectral reflectances. In this way the land-cover map of the study area was generated. Figure 7 shows the resultant flood map of the study area showing floodable and swampy land covers.

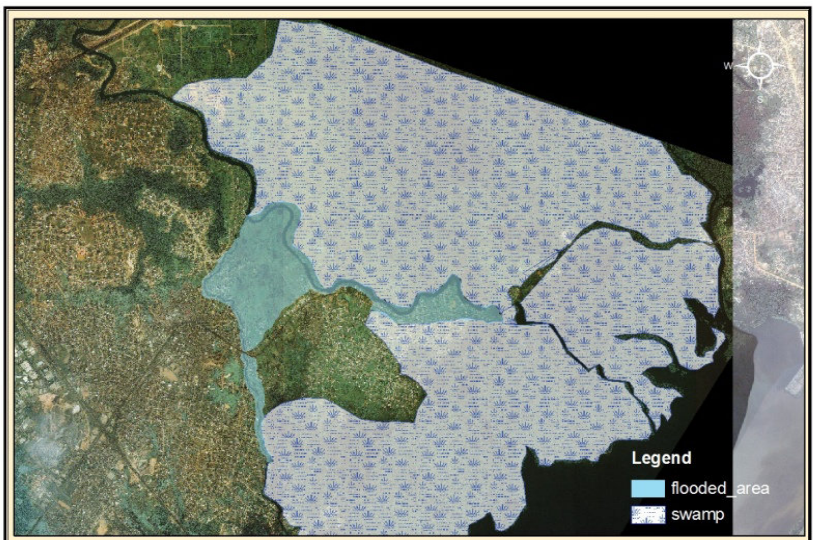

Figure 7: Classified IKONOS Imagery Showing Flood Prone Parts of the Study Area
Source: Field Work (2010)

The IKONOS imagery was also damped with the aerial photograph of the study area to show clearly the encroachment of buildings along river banks in the area. Figure 8 shows the imagery and the aerial photographs.

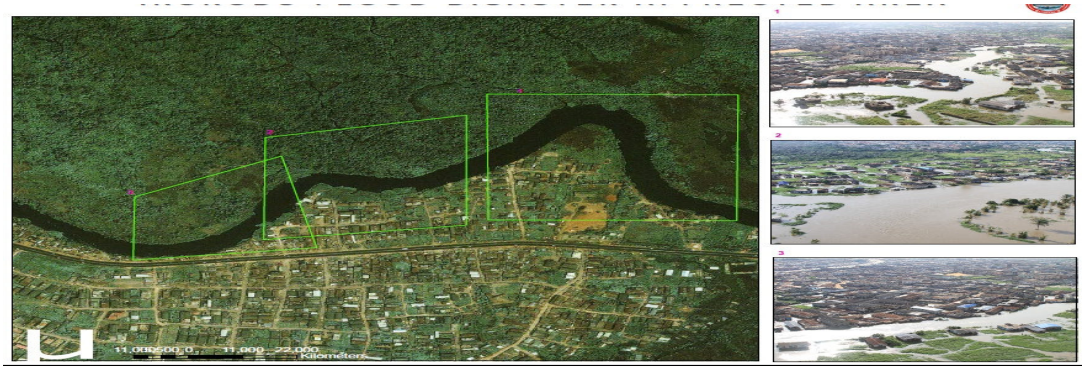

Figure 8: Damped IKONOS Imagery and Aerial Photographs Showing Encroachment on the River Banks in the Study Area.
Source: Field Work (2010)

From figure 8, it is manifest that buildings are right inside a meander that would soon develop into an ox-bow lake. The river channel is becoming narrower due to encroachment along the river banks. If this trend continues, a greater loss of lives and properties is imminent.

5.1 Digital Elevation Model Generation

A digital representation of relief over space is known as Digital Elevation Model (DEM). The co-ordinates of the points which spread across the study area were entered into Microsoft notepad; it was converted into a vector file on IDRIS for windows. The vector file was converted back into a document file which was a point map. The point map was converted into a DXF file and imported to ILWIS. In ILWIS, Moving Average Method (MAM) of point interpolation was used to convert the point map into a raster map.. The output is a DEM, also called a height map. Relating the map with the corresponding terrain surface in a 3D model, it helps to discover and

understand relations between spatial data sets. For example, by draping a land use map over the height values of a 3D model, areas of interest could be seen and are located: on slopes, on flat areas, in the lower areas or in the mountains. The red and green part of the map generated in Figure 9 shows the height of the study area above sea level. The DEM shows that area under study is at high risk; this is because the height of the region is low. The red colour indicates the areas at high risk (low terrain), and the green colour indicates low risk (high terrain).

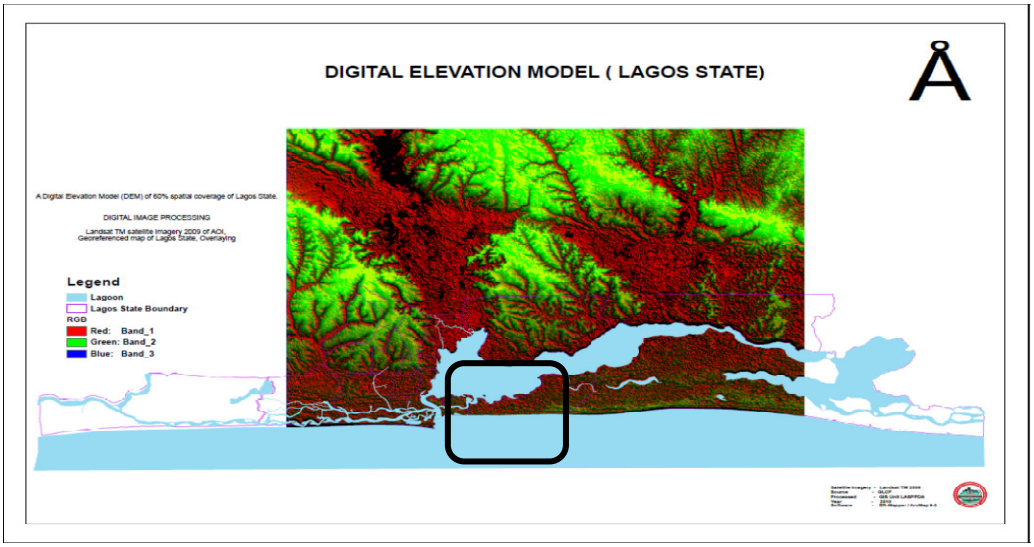

Figure 9: Digital Elevation Model of the Study Area
Source: G.I.S Unit of Lagos State Physical Planning and Development Authority (LASPPDA), 2010.

6.0 Conclusion

This study has highlighted the problem of flooding in Kosofe Local Government Area of Lagos state and its implication on the environment and the people of the area. Flooding in the study area revolves around poor refuse disposal practice, encroachment on floodplains and lack of adequate setback from rivers among others. The occasional release of the Oyan dam and heavy rainfall associated with the study area is also an issue of great concern. The Ogun river floodplain has been encroached due to uncontrolled influx of people into the area. The municipal services such as waste disposal machineries are lacking and therefore forcing residents in the study area to dump wastes in drainage channels. Most of the inhabitants of the study area have stayed there for a considerable length of time and have witnessed many flooding incidents. The people have also suffered from various afflictions and diseases arising from a degraded urban environment due to flooding. Their businesses and education have also been adversely affected due to the poor state of the environment.

From the on-going, it is safe to advise that individualistic effort at fighting flood is not always efficacious. A concerted effort at the community level to tackle flooding problem in the study area is lacking. The community must therefore come together and effect plans on how to keep the drains clear of rubbish. Individualistic approaches to flood mitigation and abatement must give way to a holistic and result-oriented approach. All stake holders such as Lagos State Government, Kosofe Local Government Authority, landlords, property owners, tenants, public and semi-public service providers such as Power Holding Company of Nigeria, Lagos State Water Corporation and Ministry of Physical Planning and Development Authority must be involved in flood prevention and management in the study area. If all the recommendations are put in place with the cooperation of all stakeholders the inhabitants of the study area will surely enjoy a new lease of life in a sustainable environment.

7.0 Recommendations

This study has established that there is a high correlation between flooding and building setback form river, building plan approval before construction and refuse disposal. The GIS analysis has also revealed that the topography of the study area has a role to play in the areas that are susceptible to flooding. The land-cover map of the study area also shows floodable and swampy areas. Based on these findings, this study offers the following recommendations:

It has been pointed out that the major factor responsible for flooding in the study area is the inundation of the Ogun River. The study area occupies the lower course of the Ogun River, at this course, the river channel is

shallow; the deepening, widening and cutting off of meanders are therefore imperative. The channel capacity must be increased so as to ensure efficient flow velocity downstream. In other words, Ogun River is being impeded by the deposition of solid wastes by the inhabitants of the study area; the velocity can be increased by cleaning out the water course and eliminating sharp meanders. The provision of adequate drainage facility in the study area cannot be over-emphasized. Lack of good drainage system is one of the major causes of flooding in the study area. Covered drainages should be provided where lacking to prevent people dumping refuse in them, while existing ones should be renovated as an essential part of anti-flood construction.

Lack of waste disposal facility in the study area is one major factor responsible for blocked drains and consequent flooding of the environment; the state government is therefore enjoined to put in place an enduring waste disposal facility in the study area. Laws against indiscriminate disposal of refuse should be promulgated and enforced in the study area.

The statutory 30m setback from Ogun River should be maintained no matter whose horse is gored. It is the responsibility of the Local Planning Authority to ensure development control in its area of jurisdiction, and this can be done by enforcing development control instruments such as demolition of structures that violates the 30m setback. In addition the nature of ground and height above sea level should be considered before building plans are approved in the study area. Abatement notice and consequent demolition should be enforced in the study area so as to permanently relocate occupants of illegal structures. The interval between openings of dam should be reduced. The study revealed that it is common practice to open the dam every 2-3 years, this could be reduced to about 3-6 months period as stipulated in part II, Sections 27 and 60 of the Nigerian Urban and Regional Planning Decree 88 of 1992 (FGN, 1992). This practice would ensure that excess water which could have resulted into flooding is discharged on time to avert flooding disaster.

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