

FLOOD RISK ASSESSMENT IN IKERE LOCAL GOVERNMENT AREA OF EKITI STATE, NIGERIA USING GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

Seasonal flood is a major problem in Nigeria and the world at large claiming lives and properties and also causing displacement of people. The rapid rates of urbanization and population growth led to uncoordinated development in the swamps and floodplains of Ikere-Ekiti thereby aggravating the risk of flood hazards. The study assessed the flood risk in Ikere-Ekiti using Geographic Information System (GIS). Both primary and secondary data were used, the coordinates of the river and buildings affected during flood were taken as primary data; these were used in generating hydrologic analysis such as stream network, flow accumulation map, flow direction map, flow length map and surface analysis of the study area such as contour and slope maps of the study area. The digital elevation model (DEM) of the study area was generated (3D DEM), Color black and white void-filled DEM which shows the proportion of the study area at risk during flooding. Flood risk map of the study area was developed and the result shows that over 80% of the study area are at risks during flooding even the peak region that are safe because they are elevated zones are still flood zone. The risk of flood is bound to increase in the future with increasing urbanization hence the need to demarcate the flooded areas for effective flood mitigation, also good drainages and water channels should be put in place within Ikere Ekiti for effective discharge of surface water during heavy rainfall.

Introduction

Flooding is a situation that occurs when part of the earth surface which are usually dry are inundated and covered with water due to high amount of rainfall or the overflowing of a water body Musa et al., (2014) . It is an extreme weather events naturally caused by rising global temperature which results in heavy rainfall, thermal expansion of the ocean and glacier melt, which in turn lead to rise in sea level, thereby causing salt water to inundate coastal lands (Angela, 2011). Previous studies also reported that

communication and traffic are interrupted while many land areas are inundated and industrial plants and commercial establishment are paralyzed during flood (Oluduro, 1988, Durotoye 1999; Folorunsho and Awosika, 2001).

Flood is a yearly occurrence especially along the flood plain of Osun River. The risk or damage experienced during flooding is enormous. The year 2001 was the first time the river overflowed its bank causing a lot of damages to people living around the flood

plain. The flood episode of 2001 killed two children of the same parent and also caused damages to properties worth of thousands of naira. In 2004 the Osun river over flowed its bank again and inundated the surrounding areas especially road network, thereby preventing workers and student from going to work that particular day. In 2005, the flood plain of Osun River in Adun Ogbon Street and Igbalaye Street in Ikere-Ekiti experienced flooding as usual; this incident greatly affected the dwellers, thereby causing loss of properties, stress and resettlement of affected people. This has been occurring every year. Recently in 2014, Ikere-Ekiti experienced severe flooding as it does not only damage properties but also carried along dangerous and harmful animals like snakes, scorpions were found in the flood entering affected areas. This is due to increasing rate of urbanization and increase population which lead to increase need of land and housing; therefore people started building in flood plain areas. Also there is absence of well-articulated and comprehensive physical planning control. Refuse dumped over the years has led to the filling up of rivers and the blockages of other natural aides to drainage so that when there is high intensity rainfall; there will be no room for water to drain away hence, excessive flooding. In Ikere-Ekiti, there is no proper documentation of flooding events and a research on flooding has not been given so much attention. Therefore, this present study will attempt the assessment of flood risk in Ikere-Ekiti.

Study area

Ikere-Ekiti lies between latitude $5^{\circ} 11'.5''$ E and $5^{\circ} 15'.5''$ E and between longitude $7^{\circ} 35'N$ and $7^{\circ} 39'.5''N$, with a population of 59,257 but more current estimates put it at more than 100,000 people. The town enjoys tropical climate with two distinct seasons, these are

the rainy season (April to October) and the dry season (November to March). Temperature ranges between $21^{\circ}C$ and $28^{\circ}C$ with high humidity, the mean relative humidity is over 75%. The south westerly wind and the northeast trade winds blow in the rainy and dry seasons respectively. The mean annual rainfall is about 1800mm, and the altitude of the area varies between 300m-600m. Ikere-Ekiti is mainly an upland zone, rising over 250meters above sea level. It lies on an area underlain by metamorphic rocks of the Precambrian basement complex. These basement complex rocks show great variations in grain size and in mineral composition. Relief is rugged with undulating areas and granitic outcrops in several areas, the notable ones are Orole hill and Olosunta hill. The major river in Ikere-Ekiti is Osun River; it flows into the Atlantic Ocean.

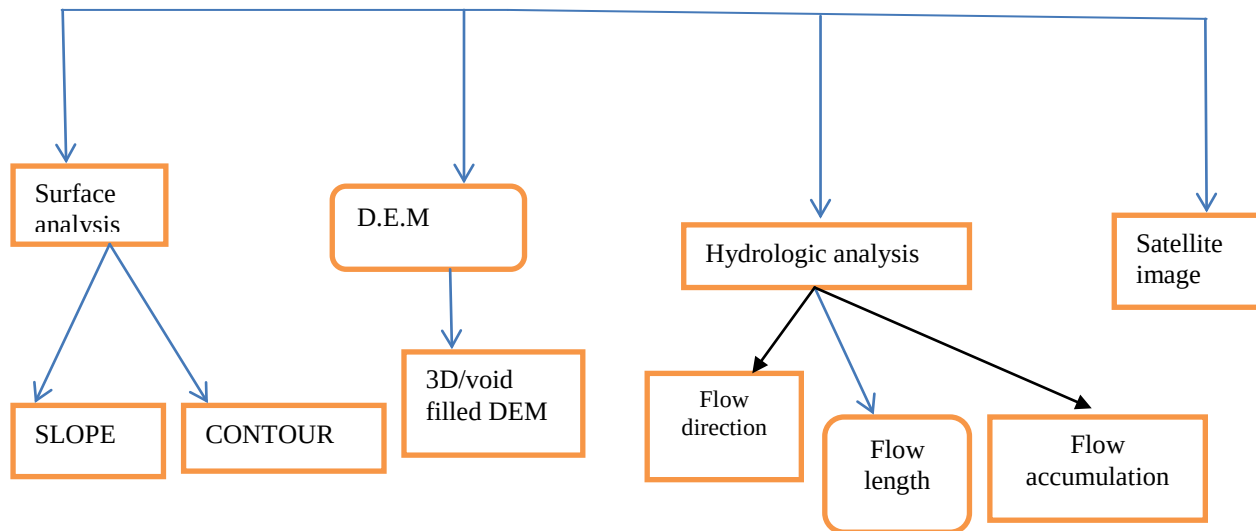
The natural vegetation is hardly present now but relics are observable, especially in the area where some forest reserves are established by the government. Also an important aspect of the vegetation of Ikere-Ekiti is the prevalence of tree crops such as cocoa, kola, coffee, oil palm and citrus. As a result of degradation of the natural forest, exotic trees have been introduced as forest plantations. For example, *Tectona Grandis* (teak) and *Gmelina Arborea*. *Terminalia Superba*, native species is also cultivated. All these cultivated trees now replace the natural vegetation of the forest reserve.

Methodology

Two types of data are required in this study. Primary such as the elevation of the river basin and coordinate of the river basin, the second type of data is secondary data which includes: Topographic map of the study area, satellite image of the study area and Generation of digital elevation model of the study area.

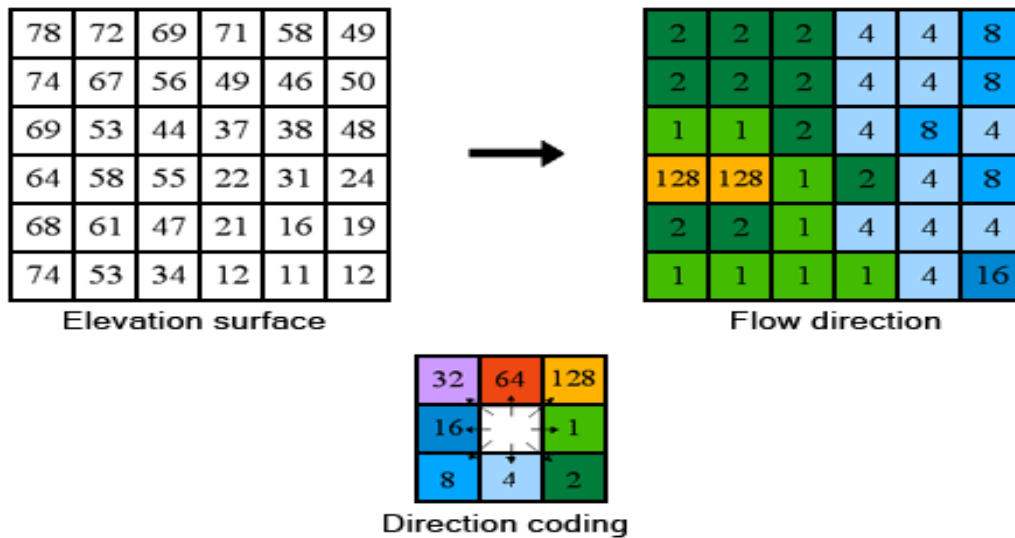
Table 1: Sources and Year of Data Sets

	Data sets	Source	Year
1	Satellite image of the study area	Google earth	2013
2	Digital elevation system/shuttle radar thematic map (3-arc seconds)	USGS	2012
3	Topographic map (1:50000)	Local government area office	
4	Elevation, longitude and latitude of the study area	Global Positioning System (GPS)	2013

**Fig 1: Flow Chart of Data Analysis****Source: Authors' Survey****Figure 1 demonstrates the procedure of data analysis for this study.**

- a. **Hydrologic Analysis:** Stream networks were delineated from a digital elevation model (DEM) using the output from the flow accumulation tool.
- b. **Flow direction:** this is done with flow direction tool. There are eight valid output directions relating to the eight adjacent cells into which flow could travel. This

approach is commonly referred to as an eight direction (D8) flow model and follows an approach presented in Jenson and Domingue (1988). The output of the flow direction tool is an integral raster whose value range from 1 to 255. The values for each direction from the center are



- c. **Flow accumulation:** The flow accumulation tool calculates accumulated flow as the accumulated weight of all cells flowing into each down slope cell in the output raster. If no weight raster is provided, a weight of 1 is applied to each cell, and the value of cells in the output raster is the number of the cells that flow into each cell. Cell with a high flow accumulation are area of concentrated flow and maybe used to identify stream channels, this is discussed in identifying stream networks. Cells with a flow accumulation of 0 are local topographic highs and maybe use to identify ridges.
- d. **Flow length:** The flow length is the distance from any point in the watershed to the watershed outlet. This distance is measured along the direction of flow. When it rains, a drop of water landing somewhere in the basin must first travel some distance before reaching, assuming there is constant flow velocities the pixel with the greatest flow length to the outlet represents the hydrologically most remote

pixel, its flow length divided by the flow velocity represents representative lag time for the basin. The lag time quantifies how long before the entire basin is contributing to flow at the outlet and is a representative scale of the basin.

- e. **Contour line:** The contours lines are in an area are drawn keeping difference in elevation between two consecutive lines constant. Widely space contour indicate surface while closely spaced contour indicate steep ground.
- f. **Slope:** The word slope is use to describe the measurement of the steepness of a straight line, the higher the slope, the steeper the line.

Results and Discussion

Nature of Attribute Data in Parts of Osun River Basin in Ikere-Ekiti

Table 2 shows the elevation, longitude, latitude and different points of river basin and buildings affected by flood in the study area.

Table 2: Attribute Data of Ikere River Basin

S/N	Points	Latitude	Longitude	Elevation
1	River Osun	005°12'45.6"	07°28'47.2"	377m
2	River Osun	005°13'32.11"	07°28'58.3"	364m
3	River Osun	005°13'33.8"	07°28'55.4"	355m
4	River Osun	005°13'33.4"	07°28'56.4"	358m
5	River Osun	005°13'45.7"	07°29'05.0"	357m
6	River Osun	005°13'45.7"	07°29'04.9"	359m
7	River Osun	005°13'45.7"	07°29'05.1"	352m
8	River Osun	005°13'46.8"	07°29'04.9"	356m
9	River Osun	005°13'46.8"	07°29'05.1"	355m
10	Building	005°13'45.1"	07°29'04.0"	356m
11	Petrol Station	005°13'46.8"	07°29'08.6"	356m
12	Building	005°13'45.7"	07°29'09.0"	358m
13	River Osun	005°13'14.5"	07°28'54.9"	357m
14	River Osun	005°13'14.5"	07°28'55.1"	358m
15	River Osun	005°13'14.0"	07°28'55.4"	356m
16	Building	005°13'13.7"	07°28'56.9"	358m
17	Building	005°13'12.9"	07°28'58.4"	355m
18	Rock Type	005°13'25.39"	07°29'47.04"	389m
19	Mosque	005°13'51.80"	07°29'53.95"	378m
20	Building	005°13'31.57"	07°29'37.47"	368m
21	Building	005°13'46.55"	07°28'45.97"	370m
22	Building	005°13'24.46"	07°28'31.74"	366m
23	Building	005°15'5.32"	07°28'44.75"	363m
24	Building	005°12'30.32"	07°28'55.97"	367m

Source: Authors Field Survey

According to Table 2, the area seems to be riverine as 60% of the attributes are rivers. The study area is located on latitude 5°11'.5"E and 5°15'.5"E and between longitude 7°35'N and 7°29', this therefore represents tropical environments. Further, elevation of the area ranges from 352m to 389m.

Surface Analysis of Parts of Osun River Basin in Ikere-Ekiti

This section shows the result of surface analysis using the contour map and slope map of the study area.

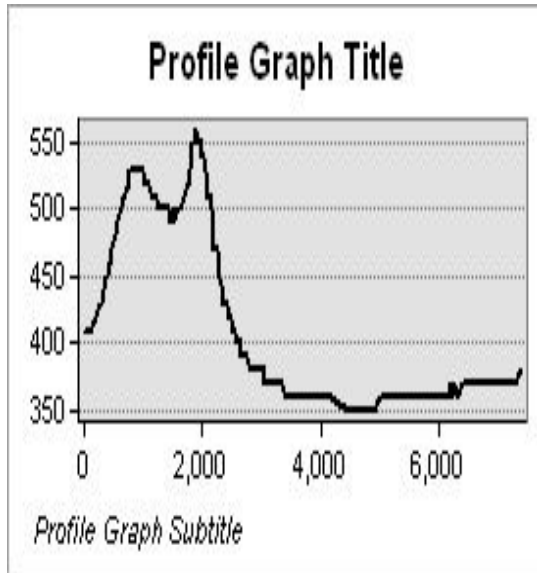


Fig. 2: Profile Graph of Undulation of the Contour Map

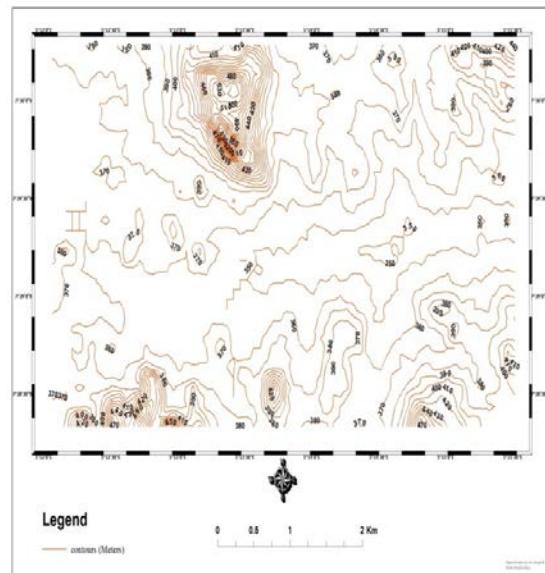


Fig. 3: Contour map of the study area

Contours which are placed in close proximity to each other signify a hill while contour which are widely spaced signifies lowland. According to figure 2 and 3 above, the northwestern part of the study area is the Orole hill which is about 380m to 600m and the southern part is generally hilly comprising of Olosunta hill, ilemimo hill among others, these are the highest

points on the map while the middle (eastern and western) part is generally gentle which is lesser than 380m. River Osun in the study area and most of the buildings are located in the gentle parts, this implies that when the river flood almost all the buildings will be flooded excluding only the hilly parts. The study area is a high flood risk zone in this analysis.

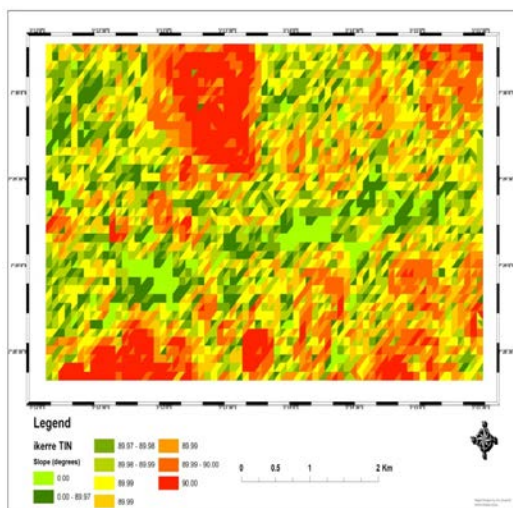


Fig 3: Slope Analysis
Source: USGS Abuja

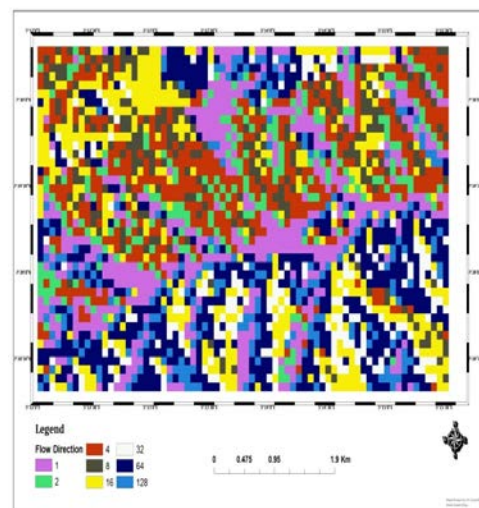


Fig.4: Flow Direction Analysis

In figure 3 above, using the legend to analyze the map, the higher the slope degree the steeper the area and the area with lesser slope degree shows low terrain. The middle part of the map with slope degree ranging from 0.00 to 89.9 shows area with low terrain such areas include Oke-Osun, Igbalaye street, Adun-ogbon street among others and some northern and southern part of the map with slope degree ranging from 89.9 to 90.00 shows area with higher steep this areas include Okeruku street, Agbado street among others. This means that area found around the low terrain are at high risk to flooding and this area cover about 70% of the study area while area with higher steep are about 30%. The major parts of this study area are prone to flood from this analysis.

Hydrologic analysis of Parts of Osun River Basin Ikere-Ekiti

The figure 4 shows the map of direction of flow of Osun River in the study area. There are eight valid output directions relating to the eight adjacent cells into which flow could travel. This approach is commonly referred to as an eight direction (D8) flow model and follows an approach presented in Jenson and Domingue (1988). Using the legend in the map and the direction coding, the river is flowing from 1 to 2 from 2 to 4 from 4 to 8 from 8 to 16 from 16 to 32 from 32 to 64 from 64 to 128. This implies that the river direction is from 1 (purple color area), when the river flood it is severe in this area and over 60% of study area is found in this place.

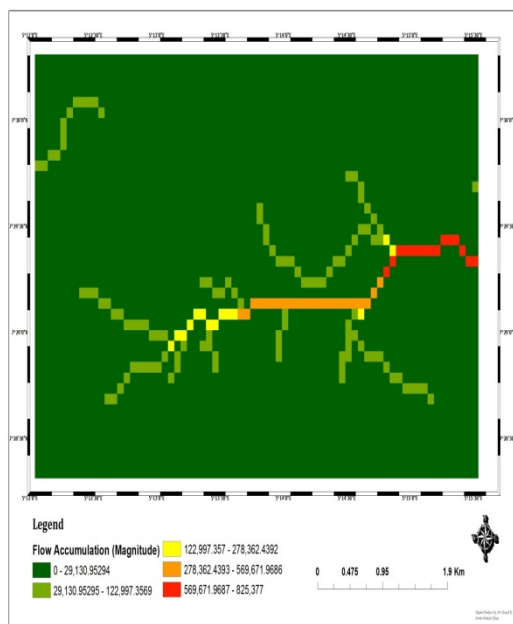


Fig.5: Flow Accumulation Analysis

Figure 5 shows the flow accumulation map of the river. Using strahler's method of stream ordering, areas with green and lemon color are first order stream, area with yellow color are second order stream, areas with orange color are third order stream and area with red

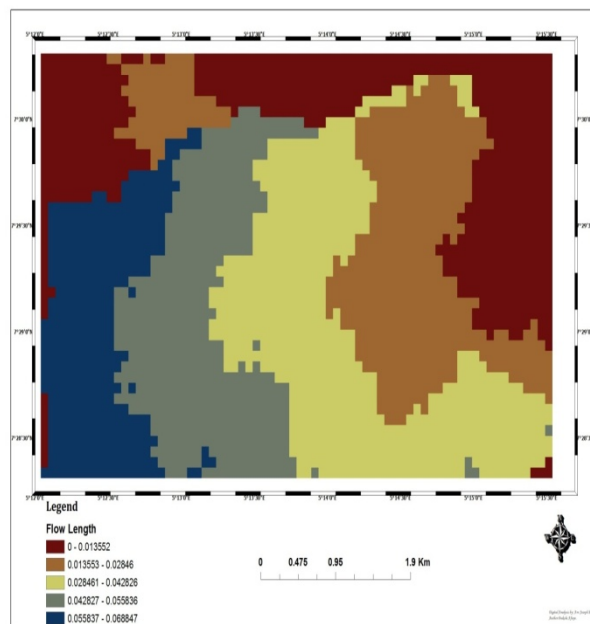


Fig.6: Flow Length Analysis

color are fourth order stream. All the tributaries that is 1st to 3rd order stream take their source from 4th order stream which shows that the force and the magnitude of flow is strongest in the 4th order and the river is flowing from 4th order to the other stream

orders. This insinuate that when the river flood, the flood magnitude will be higher in the 4th order zone, next in the 3rd order zone than other zones and buildings that fall within this region will be more affected than other region.

According to figure 6, the flow length of a river is the basin area per stream number,

when rain falls it drops directly on the 4th order stream with the highest speed and length of 0-0.013552, the flow speed reduces to the 3rd stream order (brown), 2nd stream order (cream and ash color) down to the 1st order stream (blue). As the speed of flow reduces down the stream order, the flow length also reduces.

4.4. Digital Elevation Modeling of Parts of Osun River Basin Ikere-Ekiti

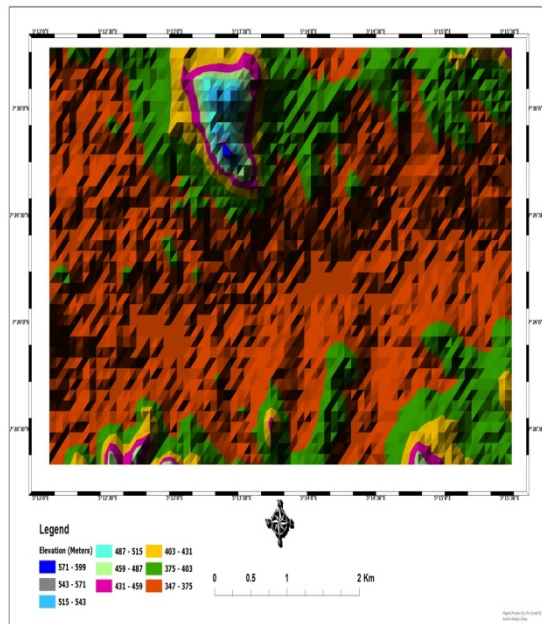


Fig. 7: The 3D DEM.

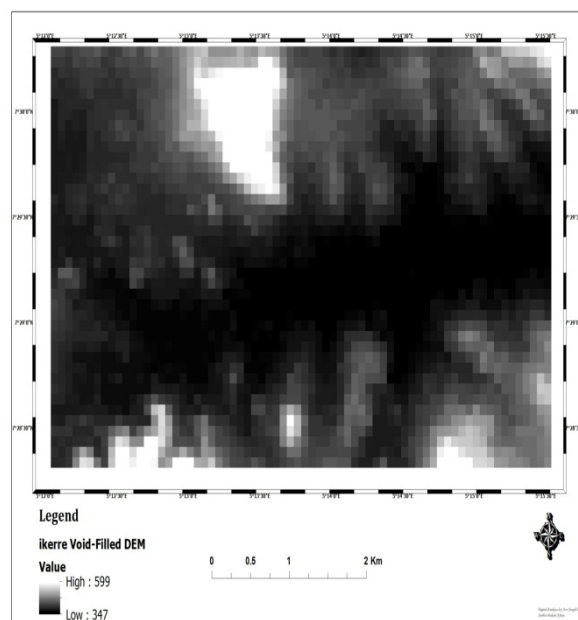


Fig. 8: The Black and White Void-Filled DEM

DEMs are derived from hypsographic data (contour lines) or photogrammetric methods using USGS 7.5minute, 15minute, 2-arc second (30 by 60minute) and 1 degree (1:250,000) scale topographic quadrangle maps. According to the legend, the map is showing elevation in meters, the highest point on the map is 599m which are the peaks is found in the northwestern part of the area include Olosunta hill, Orole hill among others and the middle part is the lowest point on the map between 347m-375m which comprises of the

river path and buildings, the DEM is dividing the study area based on elevation. The river cut across the lowest part, 80% of the study area fall within the height range of the river, when the river flood it is sure that area around 347m will be flooded and the next level (around 375m-403). Areas around 403-431m are slightly elevated region and are also liable to flood risk, the only safe zone in the study area are between 459-599m and these are only 5% of the study area.

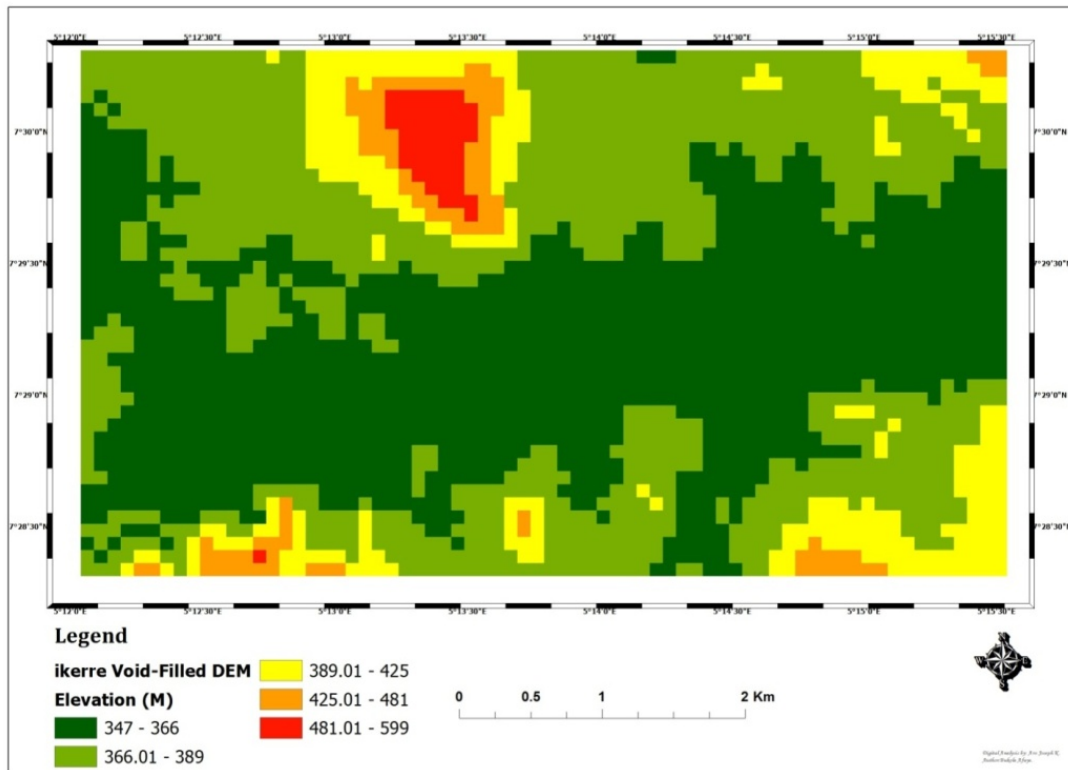


Fig. 9: The colored Void-Filled DEM

A void- filled Digital Elevation Model is a digital elevation model which sink have been corrected using the spatial analyst tool in the arc GIS. The sinks are cleaned so that all the area will be assumed to have equal elevation this is known as the predicted. The legends have the same explanation with 3D DEM legend explained above, the red region are the highest point of the area, the yellow and orange region are slightly elevated zone and the deep green and light green regions are the lowland. Areas found in the peak zone are safe

from flood while other regions are liable to flood risk.

Ikere-Ekiti is located in a trough, and is surrounded by hills such as Olosunta, Orole hill among others. These hills serve as watershed, therefore at instance of flash floods which is triggered by convectional rainfall, high flow is generated. The run-off is further affected by reducing infiltration capacity of the soil. As a result of increasing urbanization in this area has led to incidence of floods.

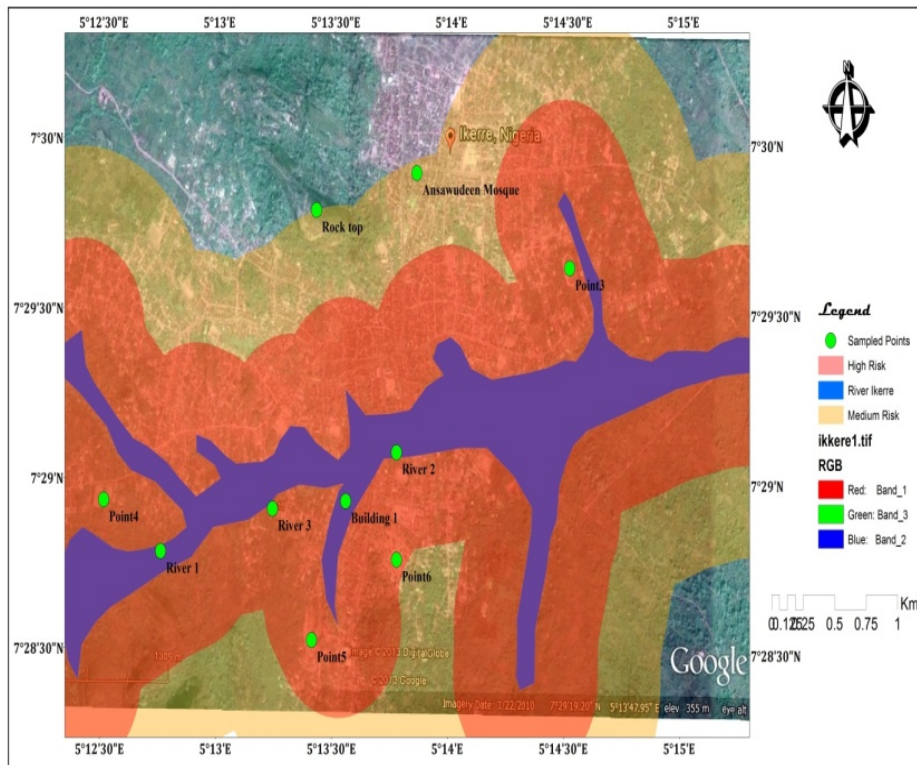


Fig.10: The Flood Risk Assessment Map of Ikere-Ekiti.

Figure 10 shows the super imposed flood risk map of Ikere-Ekiti, the blue area on the map is showing the river path cutting across the town, when the river flood during rainfall, the orange color area on the map which is next to the river path shows the region of great impact to flooding that is, high risk zone this area include Oke-Osun, Adunogbon street, Igbalaye street among others. The next region on the map which is indicated with yellow color are the areas of medium risk zone these

areas include Atiba street, Odo-oja, Oke-Aodu area in Ikere-Ekiti. Other areas that are not covered with flood on the map are the safe zone, these area include Afao, Agbado-Oyo, Okeruku in Ikere-Ekiti among others. This shows that more than 80% of the study area is at risk during flooding and if proper management and adaptation measures are not taken into place quickly, as urbanization and population increases flood risk will extend to the safe zone.



Plate 1: Flood Incident Damaging properties in Igbalaye Ikere-Ekiti



Plate 2: Flood Displaced Dwellers of Adunogbon street in Ikere-Ekiti



Plate 3: Flood incident in Adunogbon Street Oke-Osun Ikere-Ekiti

Plate 1, 2 and 3 indicate recent incidence of flood in the study area, it is therefore recommended that good drainages and water channels should be put in place within Ikere Ekiti for effective discharge of surface water during heavy rainfall; Constant monitoring system of the area should always take place for effective management.

In conclusion, there is an urgent need for a collaborative effort of both government and dwellers to support town planning, engineering and other professional agencies

to combat flooding in this area to avoid its long-range consequences. For every individual, develop your plot with deep or wide drainage system, and don't dump wastes in the waterways (it's perilous to you in your living domain. The media should also assist in educating the public on flood consequences. The environment remains our most valued possession and legacy which we must all strive to protect'. Let us all join hands in protecting our common interest.

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