Identification and mapping of flood prone zones and drainage blocked areas in Owerri municipal

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Abstract– **Flood is one of the most serious environmental disaster influencing the developing countries of the world. It is a body of water which rises and overflow the land surface. The aim of the study is to identify and map for prone areas in Owerri owing block drainage routes by using remote sensing and GIS. The study was also designed to predict the flow of runoff in the study area using digital elevation model (DEM). Ground information was also observed during field visit to ascertain the accuracy of the study. The primary and secondary dataset were utilized in the study to achieve the aim of the study. The ArcGIS 10.4 software was the major software adopted for the study, for geospatial analysis and for map preparation. The topographic map adopted for the study was from SRTM digital elevation model, which was acquired from the USGS Earth Explorer website. The spatial analyst tool in the ArcGIS software was utilized for extracting the study area surface contours within the SRTW digital elevation model (DEM). The hydrological spatial analysis was observed with the DEM of Owerri municipal, for generating the drainage routes in the study area. The DEM of the study area was analyzed for the prediction of the flow of the runoff. The results of the study shows that GIS and Remote Sensing can be used for the identification of obstacles which can hinder the drainage system that exist within the study area.**

Keywords– **disaster, Flood, Owerri, Remote Sensing**

1. INTRODUCTION

Flood is one of the most serious environmental disaster influencing the developing countries of the world. It is a body of water which rises and overflow the land surface ( ). Paul (2008) highlight that flooding is a secondary hazard which associates with debris, especially when the runoff zone impedes the flow of a river. In their own view, Tanvir(2003) express that flood takes place when runoff exceeds the discharge flowing capacity of a river which over flows along its channel. Flooding is said to be a natural flow of water and flooding conditions take places, when river discharge is not accommodated within the marginal extent of water channel. Flooding action is related to the amount and intensity of existing precipitation. Flooding often destroy wetlands, farmlands and flood plains. Increase in the width of river channel and destruction of associated floodplain by flooding actions are extremely common and have been reported repeatedly in semi – arid regions of the world. Flooding are often associated with excessive rainfall,vandalized and overflow dams and river banks, coastal storms, snow, storm surges and other water systems. In most developing countries, flooding are often caused by blockage of drainage ditches, drains and sewers, heavy rainfall and high infiltration which increases the level of ground water. Flooding can often displace local inhabitants, destroy economic crops, degrade land value, and also lead to loss of lives and properties (Ugonna, 2016). Several studies have been done on flood mapping in different parts of the world. Researchers such as Vahdettin and Ozgur (2015) did a study on flood mapping using GIS and hydraulic model, relating to Mert River Basin in Turkey. Their research had involved the use of topographic data for the preparation of the digital elevation model (DEM), with which the final results had involved the integration ArcGIS and HEC – RAS software. Nwachukwu et al. (2018) did a study on flooding in Owerri urban. Their study expound that the major causes of flooding in Owerri is blockage of drainage system. GIS and Remote Sensing can be extensively used for monitoring and mapping flood prone area (Iyinyon and Ehiiorobo (2011). The technique permits and provide a coverage of estimate of the affected land area and infrastructure by flood. GIS and Remote Sensing permits digital mapping at a rapid time period and at a cheap rate when compared to the existing transitional means (Chukwuocha, 2018). The aim of the study is to map the existing flood pone zones owing to blocked drainage routes in Owerri municipal and then predict the possible runoff flow in the area with the digital elevation model (DEM). Figure 1 is a picture, which was acquired during field visit to depict the runoff flowing along a drainage channel within the study area.

Figure 1. Runoff flowing along a drainage channel within the study area (Field work).

2. AREA OF THE STUDY

The area of study is Owerri. Owerri urban is located in Imo State, within the South – Eastern geopolitical zone of Nigeria. The region is found between Latitude $5^0$24′N and $5^0$33′N and Longitude $6^0$58′E and $7^0$06′E (Figure 2). Owerri is drained by two important rivers. The river Nworie and river Otamiri respectively. The geology of the study area indicate that the zones is located within the coastal plain sand of the Benin Formation, with a major part of the Imo River Basin, covered with the Benin Formation, made of clay and sand. The sand deposits are fine to medium and seldom coarse grain, which appears to be poorly sorted (Uma andEgboka, 1985).

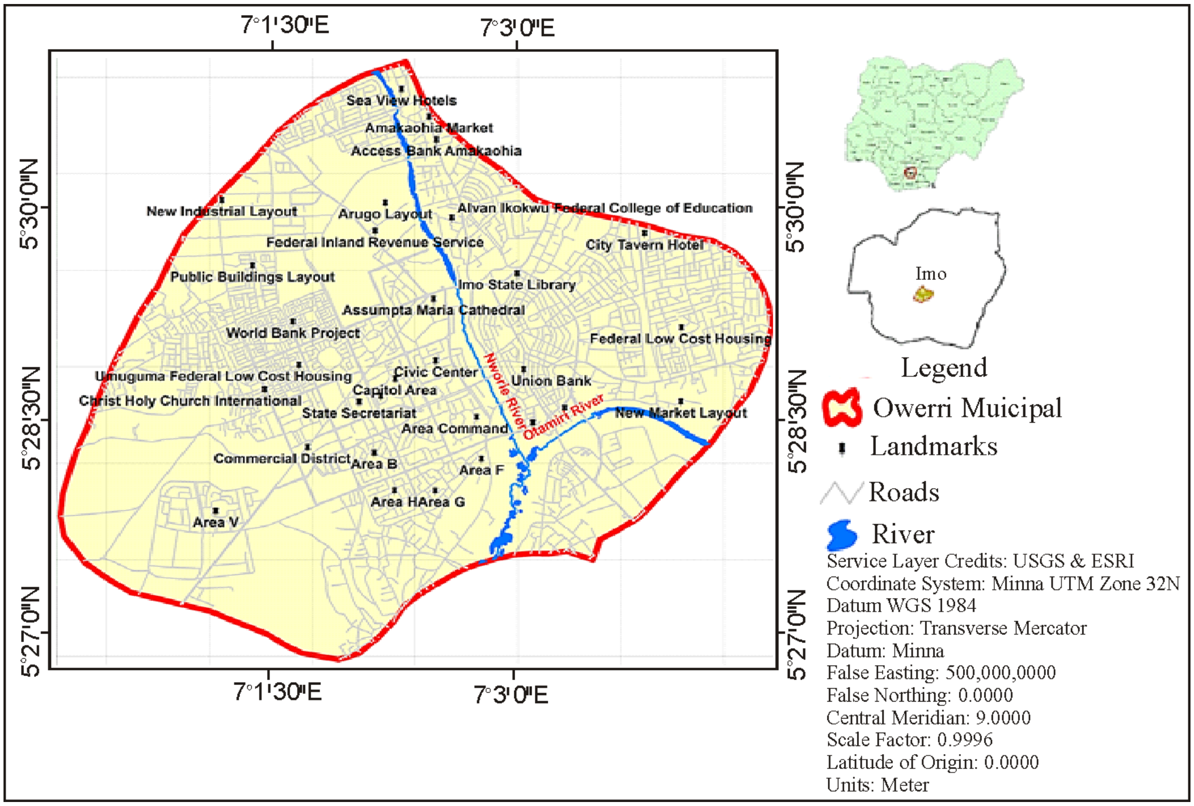


Figure 2. Location map of Nigeria and Imo State showing the study area

3. RESEARCH METHODOLOGY

For the study, the primary and secondary data were utilized. The primary dataset had include the satellite imagery, which was downloaded from Google Earth pro. The shuttle Radar Topographic Mission (SRTM) was downloaded from the USGS Earth explorer website. GPS was utilized during field visit to assess the overall accuracy of the study. The secondary data acquired for the study is the Environmental Systems Research Institute (ESRI) shape file, which its source is from the Google Earth pro, through a screen digitization located in the ArcGIS software. The ArcGIS 10.4 software was the major software adopted for the study, for geospatial analysis and for map preparation.

The topographic map adopted for the study was from SRTM, which was acquired from the USGS Earth Explorer website. The spatial analyst tool in the ArcGIS software was utilized for the extraction of the study area surface contours within the SRTM digital elevation model (DEM). The contours were characterized with symbols with the map embellished.

The methodology flow diagram for the study is shown in Figure 3.

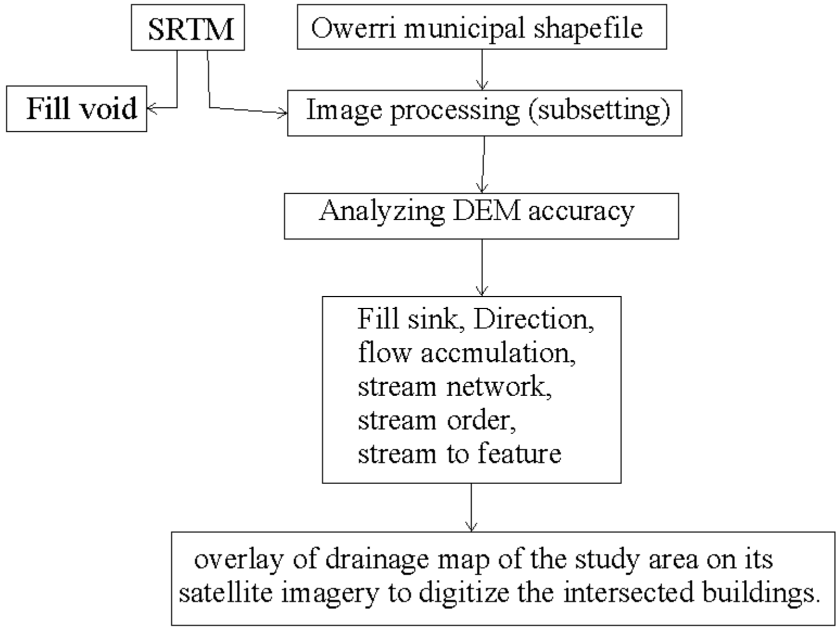


Figure 3. Methodology flowchart of the study

3.2. Analysis of DEM accuracy

Digital elevation model (DEM) is a continuous surface data, which requires the root mean square error (RMSE) as a measure of accuracy. The root mean square error is defined as the square root of the mean of the squares for all errors contained in a set of data or observations. These errors are categorized as random and systematic, and are often introduced into the results during data generation. RMSE is used to assess DEM elevations by comparing them with the elevation of points which reflects the probable elevations at specific locations within the study area. For vertical accuracy of elevation values, the USGS defines RMSE as (I)

$$\text{RMSE} = \sqrt{\frac{\sum_{i=}^{n}(Z_i - Z_t)^2}{n}} \quad - \quad - \quad - \quad - \quad (\text{I})$$

Where Z is denoted as interpolated elevation of DEM at test point and Z_t is highlight as the true or accepted value of elevation of the test point. *n* is depicted as the number of test points with RMSE quantifying the validity of predictive models (USGS, 1998).

3.3. Digital Basin model

For the study, the drainage basin model was produced with the hydrology tools for surface creation within the ArcGIS software. To create the drainage basin, a terrain pre-processing steps is observed, with basis on the stream network and watershed boundaries delineation. The flowchart depicting DEM hydrological spatial analysis is shown in Figure 4.

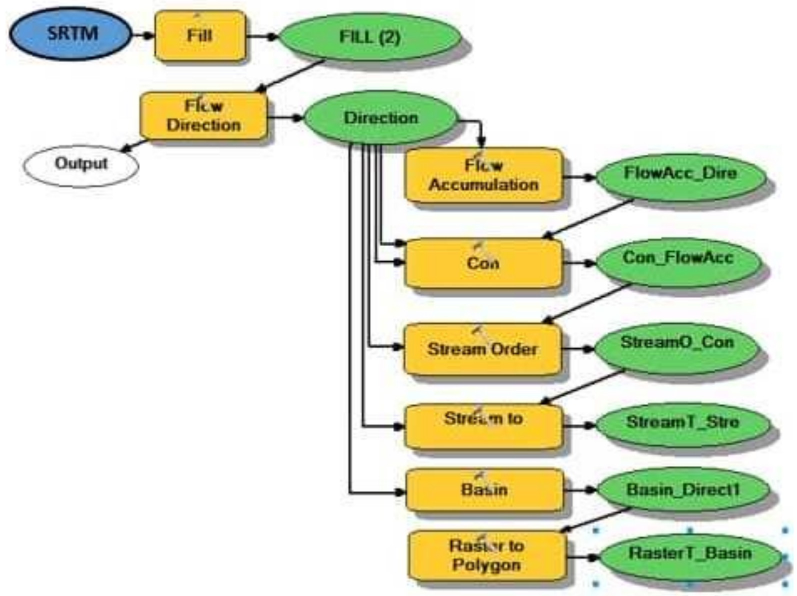


Figure 4. Flowchart of DEM hydrological spatial analysis

By adopting a step by step approach, the following grid files were derived from the SRTM DEM in the ArcGIS software.

(a) Fill – Sink Grid

A digital elevation model (DEM) was prepared by utilizing the fill tool for filling the sinks associated with the DEM. The fill tool uses a variety of spatial analyst tools. Figure 5 (a) is a map showing the DEM fill – sink of the study area.

(b) Flow Direction Grid

The flow direction tool was adopted for processing the fill – sink grid so as to generate the flow direction grid. While processing the grid file linked to the fill – sink, the respective direction of the steepest descent to a neighboring cell was highlight for each cell. Figure 5 (b) is a map depicting the DEM flow direction grid of the study area.

(c) Flow Accumulation Grid

The flow direction grid is often utilized to delineate the flow accumulation grid. The flow accumulation grid is defined as the number of upstream cells which drains into cells in the grid. In this study, the flow accumulation grid file was prepared by using the flow accumulation tool. Cells exhibiting high flow accumulation represent areas where the flow is concentrated and are often used to identify stream channels. Figure 5 (c) is a map showing the DEM flow accumulation grid of the study area.

(d) Stream Network Grid

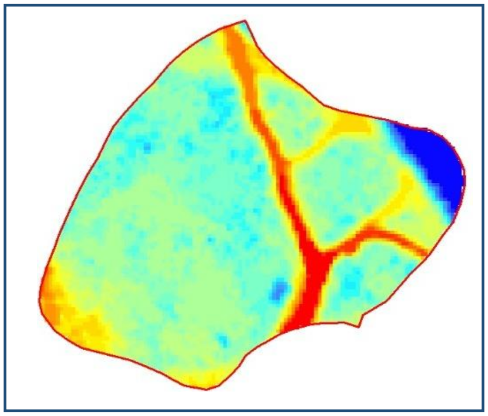
The flow accumulation grid was utilized for preparing the stream network grid by considering a threshold value. Figure 5 (d) is the DEM stream network grid map of the study area.

(e) Stream Ordering Grid

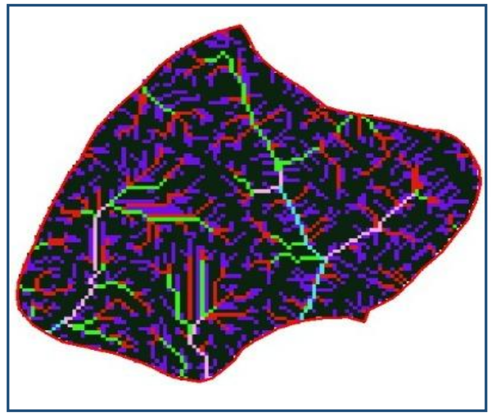
The stream order tool was adopted for assigning numeric orders to the links in the stream network.

(f) Stream to Feature

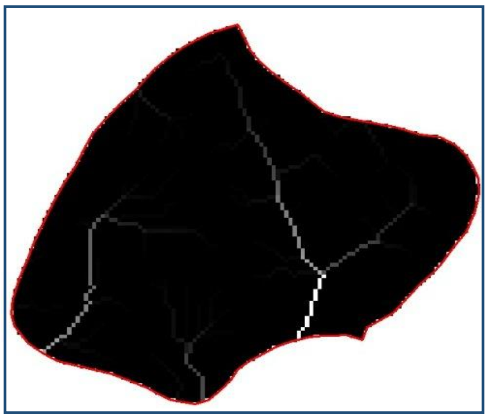
The stream to feature tool was adopted for converting raster stream network to polyline feature class. This is known as vectorization of raster stream network. Figure 5 (e) is the DEM stream to feature map for the study.



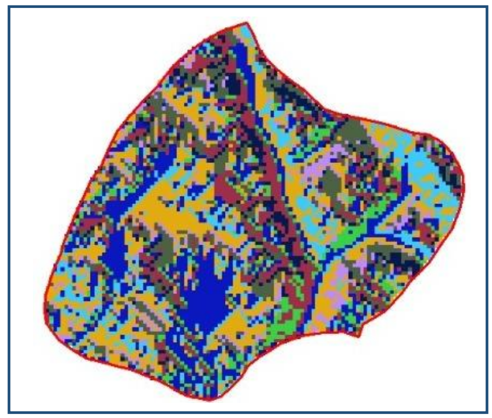
(a) Fill – sink Arc map



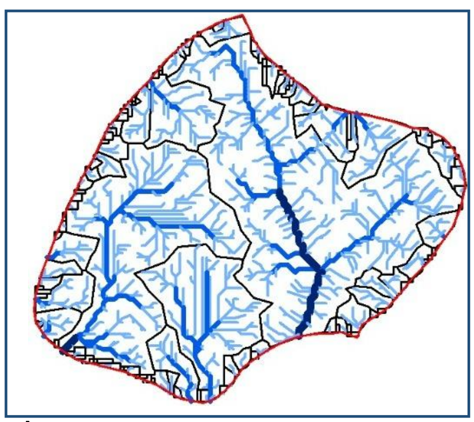
(b)Flow direction Arc map



(c) Flow accumulation map



(d) Stream network order map



(e) Stream to Feature Arc map

Figure 5. Approach to derive the SRTM DEM

3.4. Creation of Digital Elevation Model (DEM)

The digital elevation model (DEM) of the study area, prepared from SRTM is shown in Figure 6. The SRTM DEM of the study area is found between 44–95 m elevations values with the lowest elevation value (44 m) represented with the darkest color.

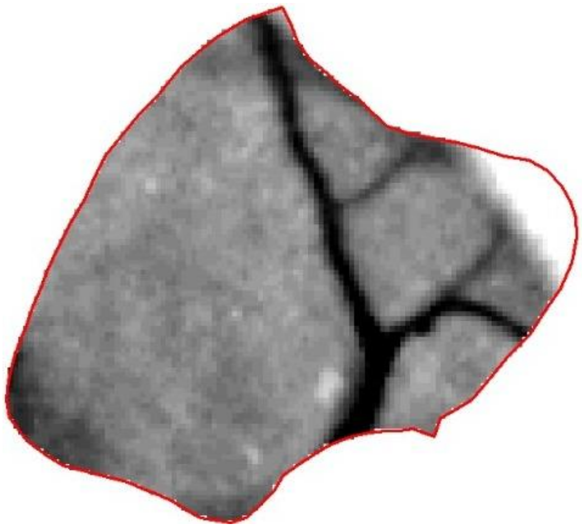


Figure 6. DEM of the study area

4.1. Drainage map of the study area

The final drainage map is produced by overlapping the drainage network constituting the study area. Here, we see that two important rivers, the Nwaorie and the Otamiri Rivers which drains the study area flows to the corresponding stream orders within the drainage network. If we zoom, we easily identify and extract the necessary coordinates of the intersected buildings. Table 1 depicts the selected extracted coordinates of the intersected buildings within the study area.

Table 1.
Selected coordinates of intersected buildings

4. Results and Analysis

Name	Area (m^2)	X	Y	Long.	Lat.
Residential building behind assumpta cathedral Owerri	781.802	281424	604764	7.02718	5.46808
Residential building behind assumpta cathedral Owerri	824.549	281099	604616	7.02425	5.46673
Residential building behind assumpta cathedral Owerri	346.344	281250	605119	7.0256	5.47128
Residential building behind assumpta cathedral Owerri	965.538	280444	606644	7.01828	5.48504
Residential building behind assumpta cathedral Owerri	927.99	280332	606690	7.01727	5.48546
Residential building behind assumpta cathedral Owerri	795.01	280286	606726	7.04554	5.48578
Residential building at KanuNwankwo Avenue Egbu road	4175.07	283462	605542	7.04693	5.47517
Residential building at KanuNwankwo Avenue Egbu road	1845.21	283617	605712	7.04774	5.47671
Residential building at KanuNwankwo Avenue Egbu road	3359.56	283706	605816	7.04774	5.47766
Federal Housing Estate Egbu road	2471.2	284071	606177	7.05102	5.48093

Figure 7 is the drainage map of the study area. Here, the intersected buildings are highlight with green color.

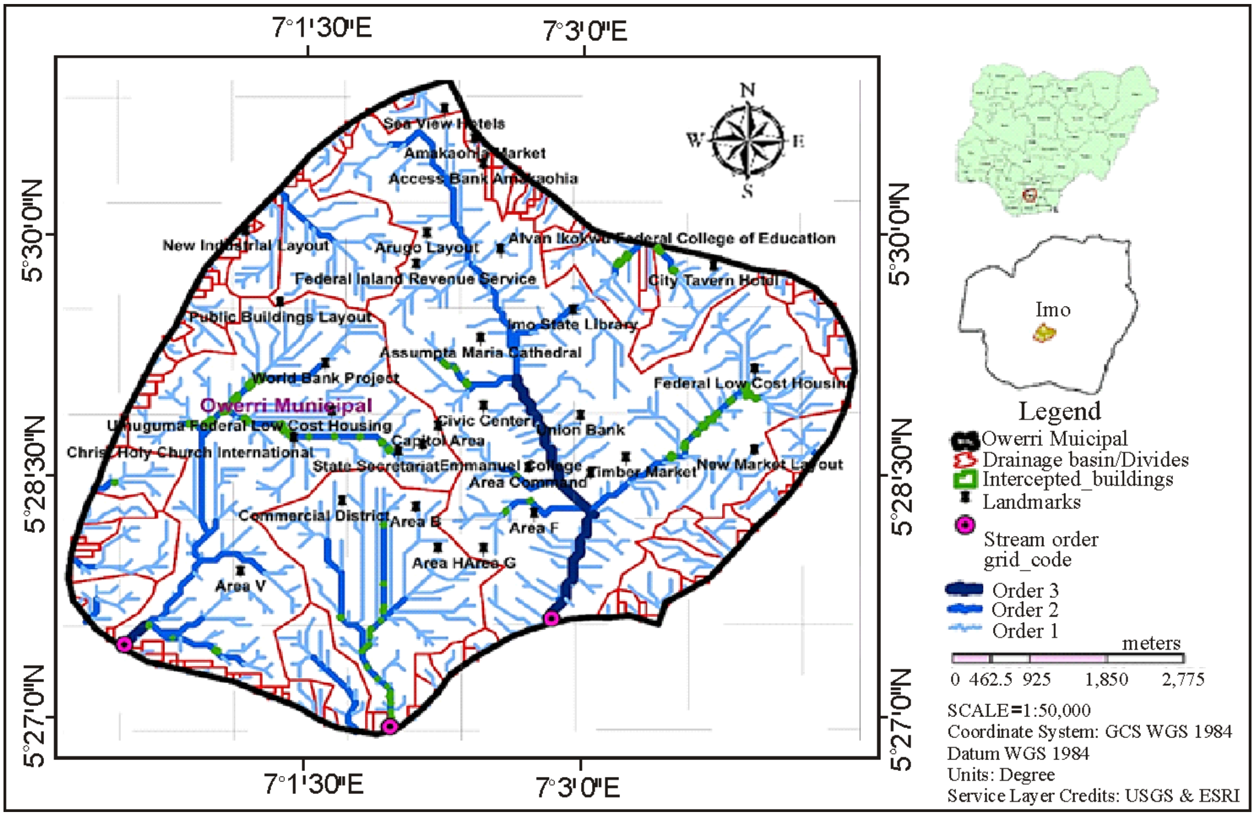


Figure 7. Drainage map of the study area.

4.2. Validation of intersected buildings

The coordinates of the intersected buildings and those observed by ground information were validated at selected points. Areas where ground teething was observed in the study area had include: world bank housing estate, federal housing estate Umuguma, works layout, federal housing estate, Trans – Egbu, KanuNwankwo avenue, off Egbu road, Assumpat cathedral area, Federal and State secretariats Port Harcourt road and Naze timber market layout. The validation observed was based on random sampling.

4.3. Runoff prediction and analysis

In the study, the digital elevation model (DEM) shows that runoff flows from areas of higher elevation to areas of low elevation. For a grid cell, the eight direction rule [D8 rule] which is bounded by seven neighboring cells characterized with high elevation values highlight that the runoff flows from the neighboring cells to the cell located at the center with lower elevation. In the study, the river runoff took place in areas of the cells location described with lower elevation value of 44 m, which corresponds to where rivers Nworie and Otamiri drains. This proves that the river runoff often take place owing to gravity and towards the direction of steep slope. Figure 8 shows that the flood vulnerability map of the study area.

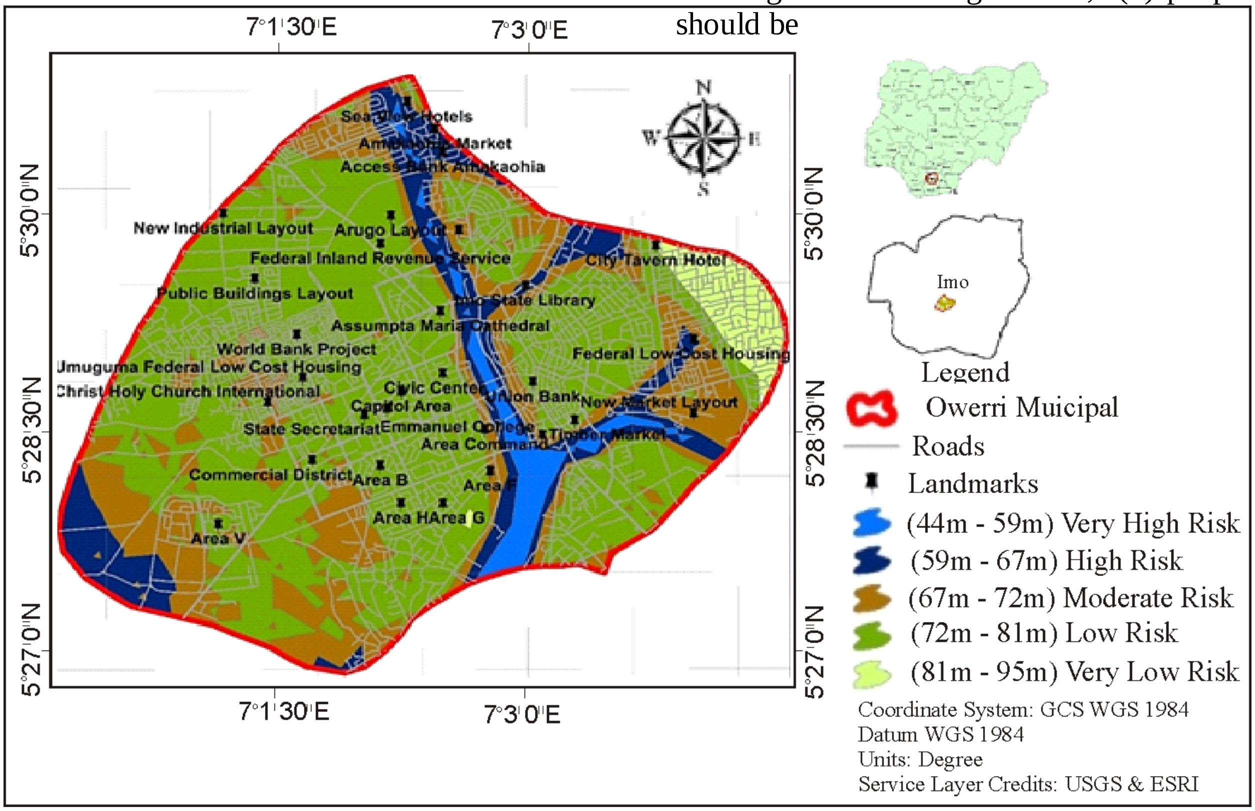


Figure 8. Flood vulnerability map of the study area.

5. SUMMARY AND CONCLUSION

The study was observed in order to identify obstacles which hinder the free flow of water in the drainage systems that exist within the study area. Owing to these obstacles, flood was noted to be a common hazard in the study area. The study focus on the use of GIS and ground information techniques to validate the results of the study. The study shows that areas where volume of water are obstructed, are zones liable to flooding.

5.1. Recommendation

Owing to the numerous problems associated with flooding within the study area, the study recommend the following points as possible solutions. (1) policies should be made, prohibiting people from erecting building within drainage routes; (2) people should be enlighten on the consequences of blocking drainage routes; (3) mitigation measures should be adopted against impending flooding.

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