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Research Paper

Application of GIS Techniques in Watershed Analysis for Flood Control Injambutu Area of Jimeta Town Adamawa State, Nigeria

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ABSTRACT
Geographic Information Systems (GIS) Techniques has been applied in various fields of surveying in recent times, one of them is watershed analysis for floods control. However the techniques was applied in watershed analysis with a view to finding a lasting solution to the menace of flood in jambutu area. To achieve that, the Differential Global Positioning Systems (DGPS) equipment was used to obtain the X,Y,Z coordinates of some selected points along the perimeter and within of the study area. Those points were downloaded in to a computer through the GNSS solution software and were processed using DGPS data module. Layout/map of the area was created and hence the position of the GPS fixes were displayed by plotting the coordinates of the points obtained from the field using Arc View software. The displayed points were exported to surfer 8 software and contour lines were generated at 1m interval. The contour map generated was then exported to ILWIS 3.3 academic software and the Digital Elevation Model (DEM) of the area was created. Various watershed maps/analysis were made using the parameters aspect, slope and height differences derived from the DEM. The results show that Jambutu is centrally located at the lowest altitude in the mid – southern zone of the area with irregular nature of terrain and ¾ of the area is vulnerable to flooding. It is recommended that a large drainage be constructed from Lake Gerio to by-pass the entire Jambutu area along side with streets and side drainages and also buildings should be removed on water ways to allow free flow of water out of the area during rainy seasons.

Keywords: ***Watershed Analysis, Floods, Altitude, Contour Lines, Vulnerability***

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I. INTRODUCTION

GIS is an information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a data base system with specific capabilities for spatially referenced data, as well as set of operations for working with the data (Star and Estes, 1990). This definition stresses that a GIS is a system for delivering answers to questions or queries what might be called an information system definition. This means that a GIS collects data, sifts and sorts them, and selects and rebuilds them to create precisely the right organization of the information to answer a specific question. The reference to geographic coordinates is an important one, because the coordinates are literally how we are able to link data with the Map (Keith, 2011). An information system is designed to re-organize information in such a way as to make it useful, i.e. to convert raw data into more valuable pure information. Dueker (1979) defined a GIS as a special case of information systems where the data base consist of observations on spatially distributed features, activities or events, which are definable in spaces as points, lines or areas. A geographical information system manipulates data about these points, line and areas to retrieve data for adhoc queries and analysis.

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Powell (2009) said that a watershed is "that area of land, abounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as human settled, simple logic demanded that they become part of a community". Watersheds come in all shapes and sizes. They cross country, state and national boundaries.

Jambutu is an area in Jimeta town of Yola North local government area of Adamawa State. Historically, Jambutu was located on the suburb of the main town of Jimeta. As of the year 1983, the area (Jambutu) was inhabitable due to the swampy nature of the area. The area was mainly used for rice farming and

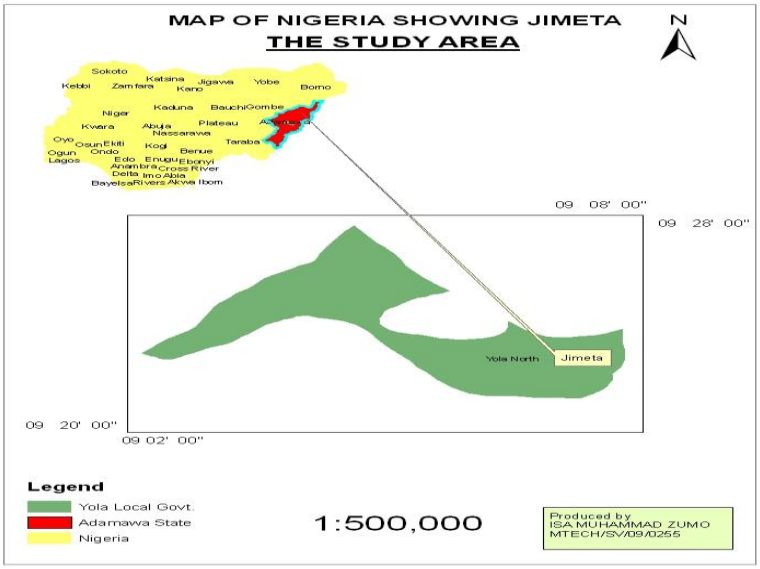
grazing in some parts. Not, until the year 1984 when Jambutu started becoming a settlement as a result of the measures taken by the defunct Gongola state government to relocate the displaced persons as a result of "Maitatsine" uprising and to decongest the main town of Jimeta. In its efforts to achieve that, the state government constructed some feeder roads linking Jambutu with the main town of Jimeta. Government also constructed some roads and drainages locally within the area to cushion the effect of flooding in the area. Social amenities such as water, electricity, health centers, schools etc. were also provided. Among the schools provided was works training school presently occupied by the Jambutu Campus of Adamawa State Polytechnic. Since the provision of those amenities there has been an influx of people to Jambutu and as at now, Jambutu is well developed and constitute the main town of Jimeta.

However, despite the efforts made by the state government in providing the necessity of life to the inhabitants of this area (Jambutu) is over the years facing serious problems of flooding, especially during rainy season and this may not be unconnected with the poor roads and drainages in the area, the general nature of the terrain and above all the location of lake Gerio just on the North - East of the area. Individuals had been making efforts in constructing local drainages to subdue the effects of flooding but efforts always fall in vain and lot of damage are always recorded especially on locally built houses.

II. STUDY AREA

The study area, Jambutu is historically a suburb of Jimeta town which is located between latitude $9^0 10^{'}$ N to $9^0 15^{'}$N and longitudes 12^0 11$^{'}$ E to 12^0 17$^{'}$E (Britannica, 2011). Jimeta, a twin city to Yola town, is the seat of Yola North local Government Headquarters and Adamawa State capital of Nigeria (fig. 1). Like any other Nigerian city, Jimeta comprises of so many land use types ranging from institutional, commercial, and residential. The city is clearly stratified in terms of population densities. These are low, medium and high density areas. The low density areas are well planned units where government officials reside while medium and high density areas are made up of common people with little or unplanned buildings. In recent times, Jimeta has risen as the premier commercial, industrial and transportation urban area of the Northeastern Nigeria. The rapid growth of Jimeta, particularly within the past 30 years, has made it one of the fastest growing metropolitan areas in Nigeria. The population of Jimeta was 73,080 as of 1991, the population increased significantly by 69% between 1973 and 1991 and 58% between 1991 and 2006 (NPC 2006).

The current city jurisdiction came into effect in 1996 as a result of the creation of Yola North Local government Area with eleven Political wards. These wards are Yelwa, Limawa, Ajiya, Alkalawa, Gwadabawa, Lugere, Demsawo, Jambutu, Nasarawo, Doubeli, and Karewa. It was discovered that Jimeta started growing faster as an urban centre from the middle of 1970s when Yola was made the headquarters of the defunct Gongola State in 1976. Even though Yola has been the nominal headquarters of Gongola and later Adamawa State, but virtually all the government offices and other official buildings are found in Jimeta. That is to say the actual seat of Adamawa State is in JImeta. The city expanded from 33, 133 hectares in 1986 to 51,578 hectares in 2008 (Zemba et al, 2010). Most of the new developments took place in the suburbs as organized clusters for accommodating especially residential expansions, academic institutions, emerging settlements, warehouses, or external transportation facilities, in addition to rapid developments on the outskirts of the old city core. Karewa and parts of Gwadabawa were designated as Government Residential Areas (GRA) in the 1980s. This led to massive construction of offices and government quarters in these areas. New residential buildings quickly swelled up to reach these areas. By this time, new developments were mostly directed to the suburbs in order to contain the growth of the inner city. Jimeta, being a state capital, it is a major transport hub with buses and taxis heading north to Mubi and Maiduguri, West to Numan, Gombe and Bauchi and South to Makurdi and Katsina. The location of Adamawa, and Jimeta town is hereby shown on the map of Nigeria in figure 1 below.



MAP OF NIGERIA

Figure 1. Map of Nigeria Showing Adamawa state and Jimeta town

III. MATERIALS AND METHOD

There are two types of data used in this project, these are: Spatial data and non-spatial data, the spatial data are data that can be linked to locations geographic space usually via features on a map otherwise known as map information. The non-spatial data are oral services and social survey conducted through interviews on the residents of Jambutu to ascertain the most severe and water logged areas during rainy seasons which served as a proof to the result of the analysis carried out using GIS techniques.

There are two types of data source. Primary sources and Secondary source, the primary source is the source of spatial data which include the analog map of the study area, topographical map covering Jimeta town and administrative map of Nigeria, Adamawa State and Yola North Local Government Area which were acquired from the ministry of Lands and Survey, Yola. The Secondary sources is direct acquisition of X,Y,Z coordinates of some selected points along the perimeter and within of the study area which were acquired using the Differential Global Positioning System (DGPS) equipment. The DGPS is an enhancement to the Global Positioning System (GPS) which provides improved location accuracy in the range of operations of each system, from the 15meter nominal GPS accuracy to about 1-3cm for best implementations. The DGPS works by placing a GPS receiver that is a reference station at a known location. The station measures the ranges to each satellite. Then it uses the measured ranges and the actual ranges calculated from its known position. Measured ranges contained errors such as ephemeris data errors or internal receiver noise. The difference between measured and calculated ranges becomes a "differential correction" is then transmitted to the DGPS receivers.

IV. DATA PROCESSING

The raw data from the field obtained using DGPS was downloaded into a computer, the data was post processed using DGPS data module. Plotting of the field data was carried out in Arc view 3.2a environment to create the map of the study area with the elevation of the points displayed. The map created was exported to surfer 8.0 environment and a contour map was generated and exported to ILWIS environment where a Digital Elevation Model (DEM) of the study area was generated. From the DEM, watershed analysis was carried out using the parameters aspect, slope and heights derived from the DEM. Several maps/analysis were generated these include: Perimeter map of Jambutu, sport height fixes, contour map, DEM of the study area, fill sink, flow direction, flow accumulation, drainage extraction, drainage network ordering map, catchment extraction, flow direction and vulnerability maps. The cartographic frame work of the methodology is here by presented in figure 2 below.

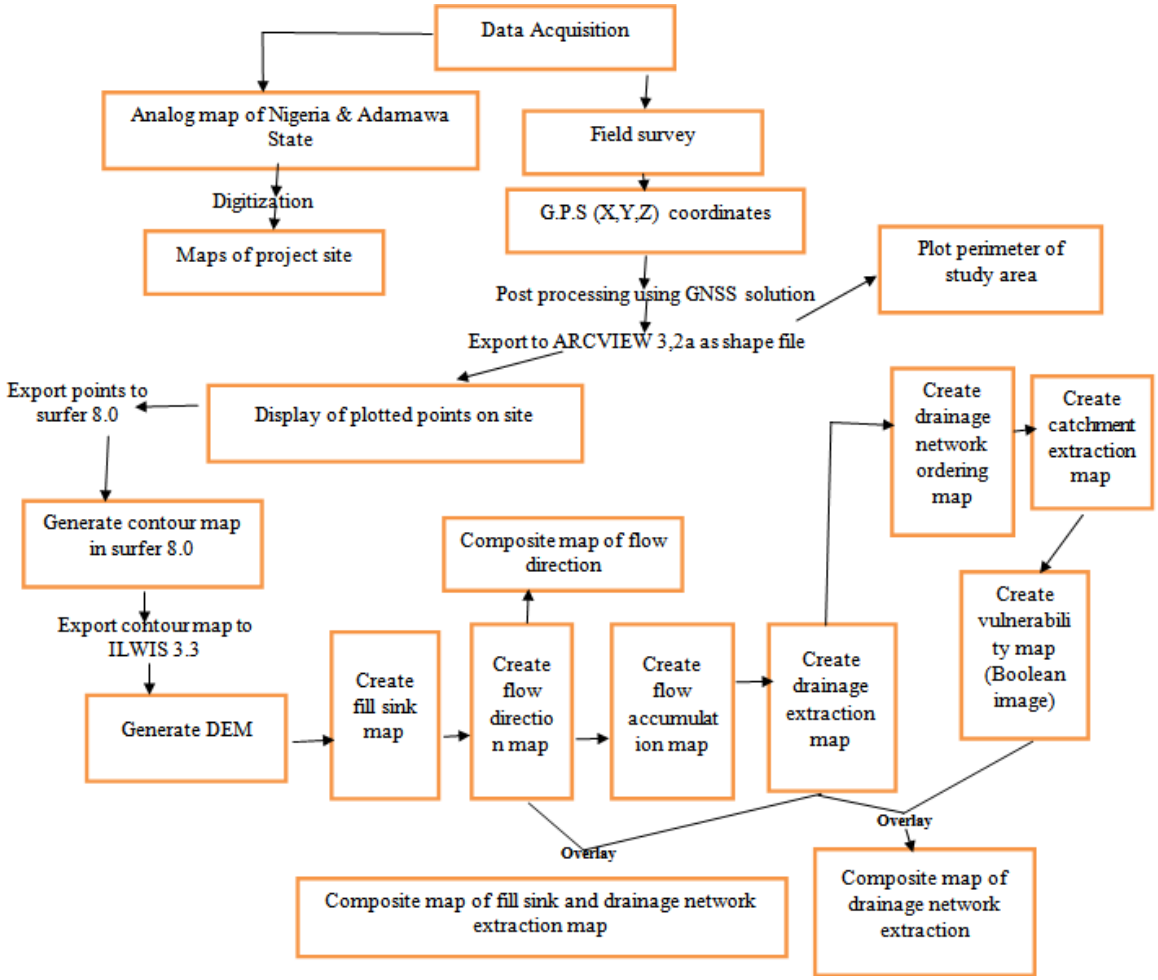


Fig.2 Cartographic framework of Methodology

V. RESULTS PRESENTATION AND DISCUSSION:

The processing and computer manipulation of the field data has yielded results which are basically in graphics as presented in the figures below. Figures 3 and 4 show the extent of Jambutu area covered during the field work and the positions of the GPS fixes across the area respectively. Figure 5 shows the contour map of the area interpolated from the GPS fixes and hence the creation of the Digital Elevation Model (DEM) as shown in figure 6. Figure 7 is a map of fill sink, figure 8 is a map of flow accumulation, figure 9 is a drainage network extraction, Figure 10 is the flow direction pattern of the area, figure 11 is the overlay of the basic drainage network on the DEM and figure 12 shows the vulnerability map and drainage network showing the vulnerable and non – vulnerable areas. Out of the various watershed maps produced the final outputs of the whole process are figures 10, 11 and 12 as composite maps.

From the maps produced, one could notice from the contour map in figure 5, the area has higher elevations on its boundaries on the South and South - West which entails that all waters from those boundaries would naturally flow towards the settlement. However the area has the lowest elevation on the North – East, one would expect that the waters within the settlement would naturally get its way out through that direction but this could not be possible due to the presence of lake gerio on the North - Eastern part of the settlement which portrait a valley – like depression that pushes the water back to the settlement especially when the lake is over flooded. A critical look at the flow direction map in figure 10 leaves one in no doubt that most of the basic drainage network of Jambutu settlement have their flow direction pointing towards the settlement. And judging by the over view of the whole area it is clear that the settlement has lots of higher lands and depressions all over the area where the water is collected and has no access to flow out of the settlement there by causing flood. The results of the data processing also show that Jambutu settlement is centrally located at the lowest altitude in the mid southern zone and is constantly under serious thread of flood disaster and over ¾ of the entire Jambutu settlement is vulnerable to flooding and only ¼ of the area is non vulnerable as shown in the vulnerability map Figure 12.

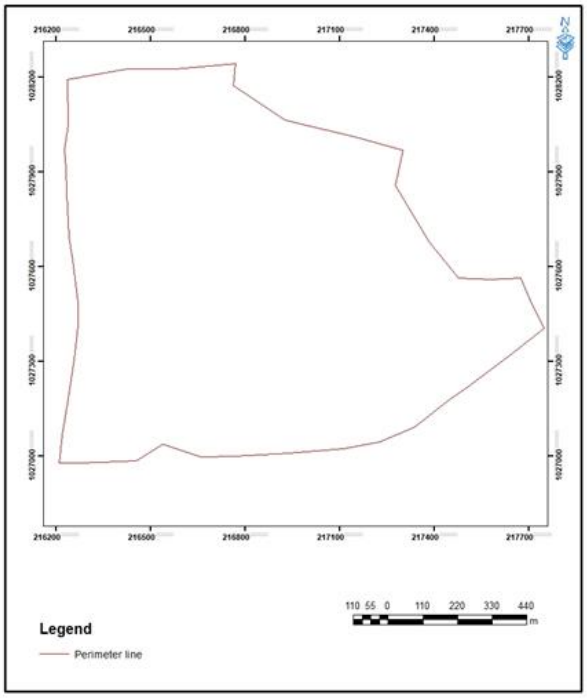


Figure 3 Perimeter Map of Jambutu

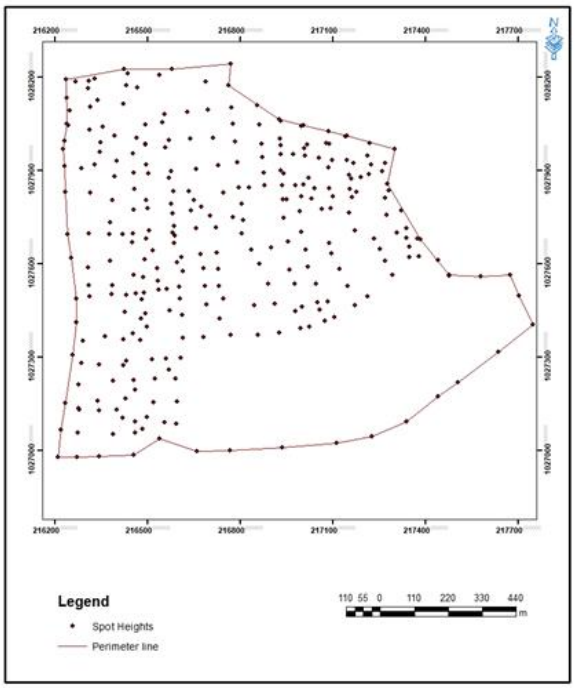


Figure 4 Displaying Spot Height fixes across Jambutu

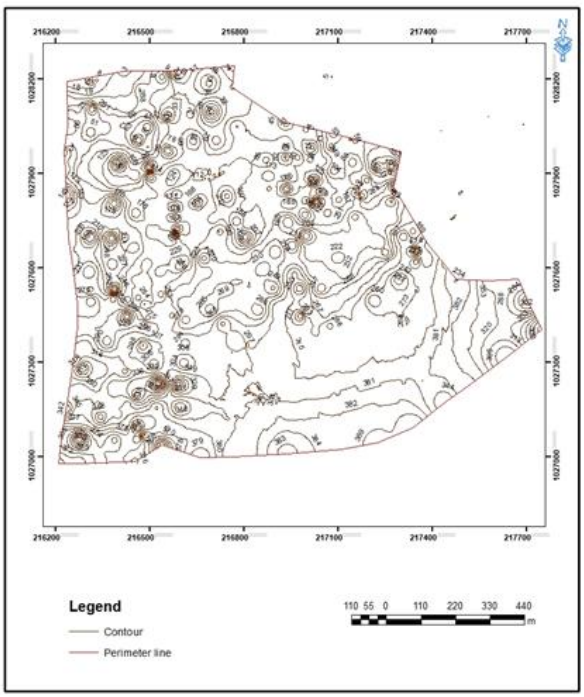


Figure 5 Contour Map of Jambutu

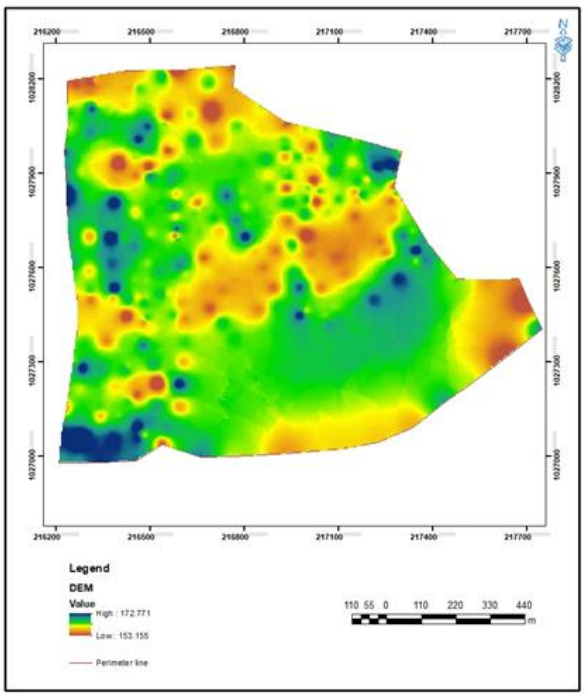


Figure 6 Digital Elevation Model

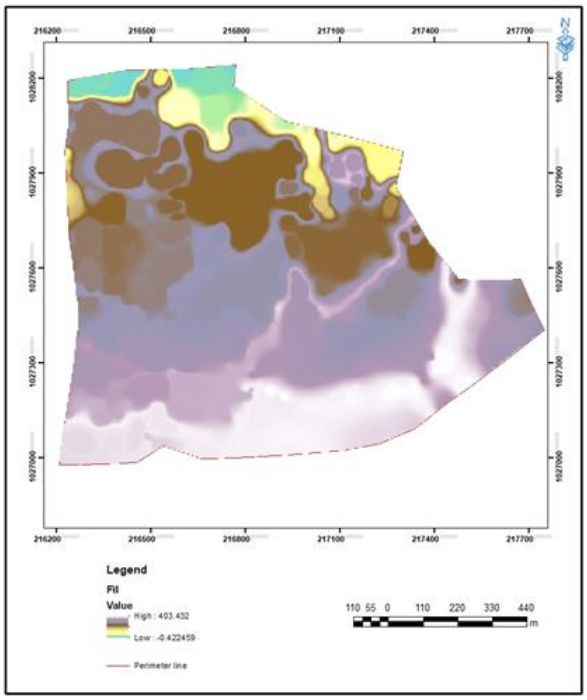


Figure 7 Map of Fill Sink

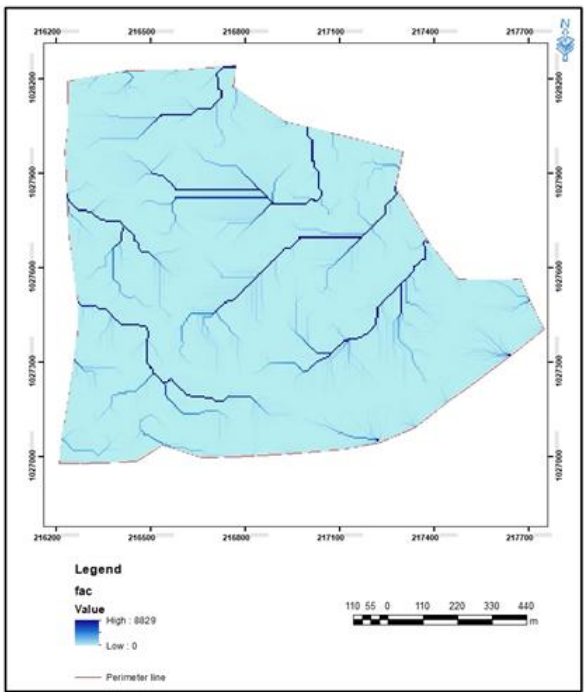


Figure 8 Map of flow accumulation

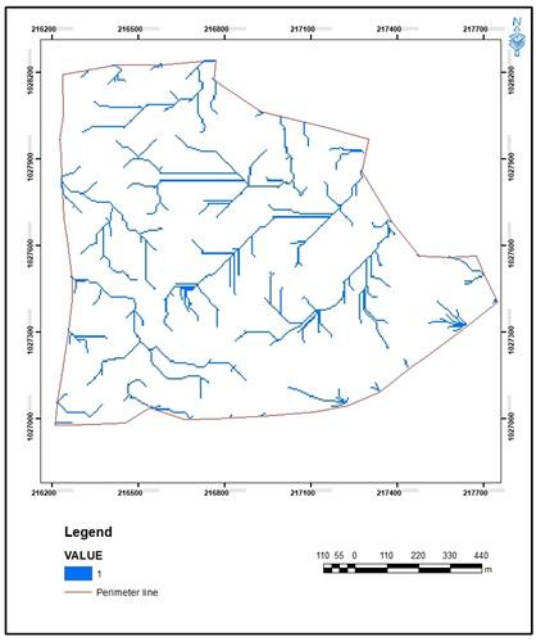


Figure 9 Drainage network Extraction

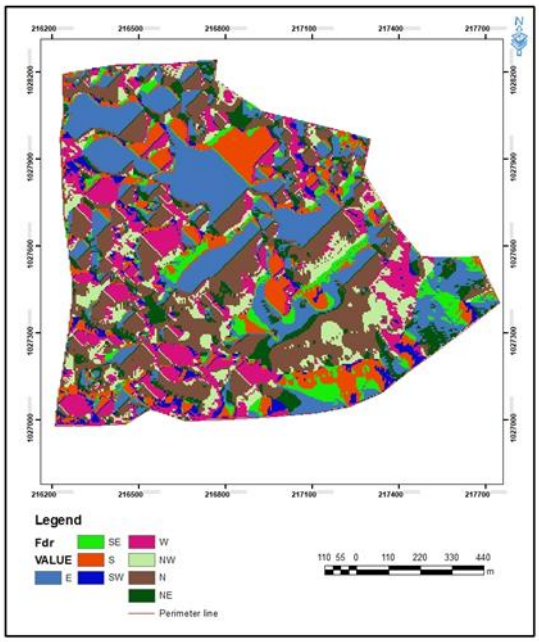


Figure 10 Map of Flow Direction

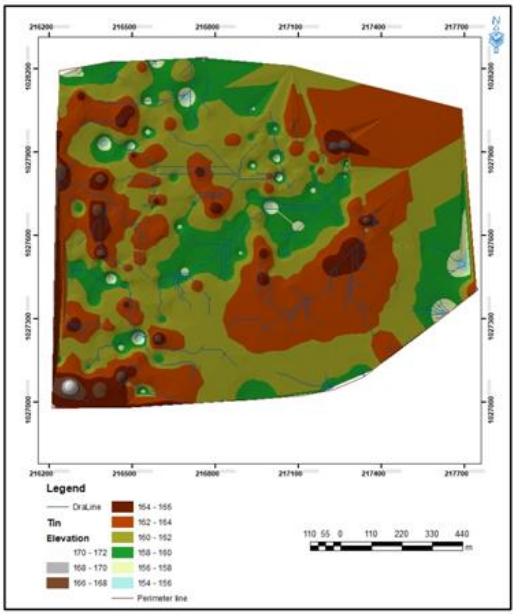


Figure 11 Digital Terrain Model and Drainage Network

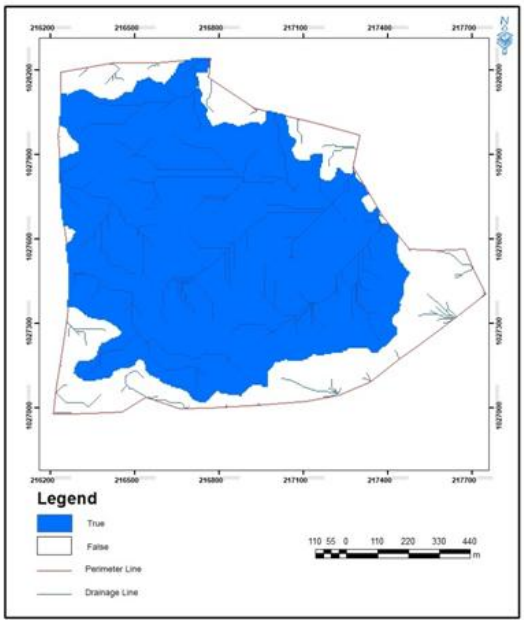


Figure 12 Vulnerability map and Drainage Network

VI. SUMMARY:

Jambutu was an area located on the outskirt of Jimeta town curved out by the government of the defunct Gongola state to settle down those displaced by "maitastine" uprising which took place in the year, 1984 with the view to decongesting the town. The settlement is located precisely on the South-West of lake Gerio and has been facing serious floods and watersheds over the years. This is due to its close proximity to the lake Gerio couple with the swampy and irregular nature of its terrain. The floods and watershed menace bring to a standstill of all socio economic activities in the area, collapse of buildings and sometimes loss of lives and property. However, scientific means has been used to analyze the watershed and determined the channels of water and the most vulnerable areas to flood in the area. In this method the basic requirement is the DEM which was derived from the spot heights obtained from the field. The DEM of the study area was used as an input for terrain pre-processing. GIS which is an important tool in watershed analysis, was used in this project to integrate four GIS layer, slope, aspect, elevation and watershed. Analysis show that Jambutu settlement is centrally located at the lowest altitude in the mid southern zone and ¾ of the area is vulnerable to flooding.

VII. CONCLUSION:

It is concluded that the watershed analysis for flood control in Jambutu Area was successful. Various watershed maps has been produced and physical analysis was done as well. The study shows that Jambutu is located at a very low altitude with irregular nature of terrain and it is also located close to Lake Gerio which when over flooded during raining season, pushes its water contents towards the settlement. The physical approach of the area revealed that the area lacks a good drainage system and there were a lot of blockages on water ways due to indiscriminant buildings in the area. These problems pose serious flood threat to the area unless measures are taken by government and non- governmental agencies alike, Jambutu would continue experiencing floods that will lead to collapse of buildings, loss of lives and property year in year out.

VIII. RECOMMENDATIONS:

Having successfully completed the study I hereby made the recommendations thus: 1. Large drainage should be constructed from Lake Gerio in such a way that waters from the lake would by- pass the entire Jambutu settlement when it is over flooded 2. The street networks in Jambutu should be constructed with side drainages all through, 3. Buildings on water ways should be removed to allow free flow of water outof the Settlement and 4. Adamawa State government and non – governmental organizations should intervene promptly by constructing roads and drainages within the area.

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