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Floodplain Mapping of River Ogun Lower Basin Using GIS Model

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Abstract: Floods are the most common natural phenomenon due to relatively higher flows and that temporarily submerges land and habitation endangering both life and properties. River Ogun flood annually with paucity of information on the extent and mitigation approach. In this study, floodplains mapping within River Ogun Lower Basin was done to reduce flooding menance in the area. Catchment delineation of River Ogun requires the imagery of the whole river Ogun catchment and elevation data obtained from Goggle earth. This data were remote sensed and taken to GIS environment. The river was characterized into three basins based using GIS hydrological tool (Upper Basin, Mid-Basin and Lower Basin). The hydrographical delineation entails the flow region of River Ogun, its tributaries and tributaries flow network and pattern. The input for the hydrographical delineation are the Google earth remote sensed elevation data. The Lower basin of River Ogun was identified as the region with highest flow influx. Different maps were derived from the delineation of the lower basin catchment area. The summary of the data were used to generate the following maps which includes contour map, topography map, drainage pattern map, elevation collection points map, land-use map, digital elevation measurement (DEM) and floodplain map. The maps generated can be used as a drainage master plan, Land use monitoring, Channel Improvement and Floodplain zoning to reduce the development-induced impact along the area.

Keywords: *Floodplain, Mapping, GIS, River Ogun Basin and Model.*

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I. INTRODUCTION

Floods are the most common natural phenomenon due to relatively higher flows and unwanted higher stages of a river that temporarily submerges the land and habitation endangering both life and properties. The devastating floods not only result in loss of precious human lives, cattle and damage to public and private property resulting in huge economic losses, but also create a sense of insecurity and fear in the minds of people living in the flood plains. Emergency Events Database (EM-DAT) maintained by the Centre of Research on the Epidemiology of Disasters at Brussels (CRED) reported that in the last decade of the twentieth century floods have taken the lives of about 1 lakhand affected over 1.4 billion people (Djokic, 2012).

For minimizing the losses due to floods, proper sustainable scientific flood management strategy needs to be adopted. It is again important to mention that the return period of major floods which was 100 years earlier, may now start to happen in every 20–30 years due to changed climatic scenario. The flood season may become longer and there will be flooding in the places where there were no floods earlier. So, risk of flooding looks greater than ever all over the world (Adeyokunnu, 2024).

Flood inundation models play a central role in both real time flood forecasting and in flood plain mapping. All flood inundation model work with discharge and water level as upstream, downstream or as internal boundary conditions. Large numbers of works have been reported in literature to model flood in Mahanadi River (Mays, 2005) which helps flood management experts and water resources engineers to develop suitable flood management strategy to reduce the havoc of flood in the deltaic regions. However, suitable structural measures in the form of embankment heightening and channel modification to reduce losses due to floods by way of flood mitigation are not available in literature.

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In Nigeria, flood is one of the most common disasters. The Riverine areas are hugely affected by flood. The country suffers many damages and losses every year due to flood. Advanced computing facilities gives easy way to forecasting and mapping of flood. This gives flood warning. Rivers Niger and Benue are among the largest rivers in Nigeria.

A Geographic Information System (GIS Software) is designed to store, retrieve, manage, display, and analyze all types of geographic and spatial data. GIS software lets you produce maps and other graphic displays of geographic information for analysis and presentation. GIS software lets you produce maps and other graphic displays of geographic information for analysis and presentation. With these capabilities a GIS is a valuable tool to visualize spatial data or to build decision support systems for use in your organization.

A GIS stores data on geographical features and their characteristics. The features are typically classified as points, lines, or areas, or as raster images. On a map city data could be stored as points, road data could be stored as lines, and boundaries could be stored as areas, while aerial photos or scanned maps could be stored as raster images.

Geographic Information Systems store information using spatial indices that make it possible to identify the features located in any arbitrary region of a map. For example, a GIS can quickly identify and map all of the locations within a specified radius of a point, or all of the streets that run through a territory.

In addition to the above capabilities, Maptitude implements a professional-strength relational database, a feature critical for GIS software. Attribute data may be freely joined to and detached from geographic layers and tables. Relational data manipulation is integrated with robust and powerful geoprocessing for spatial queries, polygon overlay, and other location-based analyzes. This is supported seamlessly so that data are moved easily to and from relational tables and geographic databases. In addition, the Maptitude fixed-format binary table supports 32,767 fields and 1 billion records, and has unlimited character field widths.

II. MATERIALS AND METHODS

➢ *Brief Description of Study Area*

The study area is River Ogun which rises in Oyo state near Shaki at coordinates 8º41′0″N, 3º28′0″E and flows through Ogun state into Lagos state. The river is crossed by the Ikere Gorge Dam in the Iseyin local government area of Oyo state. The reservoir capacity is 690 million cubic metres (560,000 acre-ft). The reservoir abuts the Old Oyo National Park, providing recreational facilities for tourists and the river flows through the park. The Ofiki River, which also rises near Shaki, is the Ogun River's chief tributary. The Oyan River, another tributary, is crossed by the Oyan River Dam which supplies water to Abeokuta and Lagos.

➢ *Lower Basin Catchment Delineation*

Catchment delineation of River Ogun requires the imagery of the whole river Ogun catchment and elevation data. This data were remote sensed and taken to GIS environment. River Ogun was characterized into three basins based using GIS hydrological tool (Upper Basin, Mid-Basin and Lower Basin). The hydrographical delineation entails the flow region of River Ogun, its tributaries and tributaries flow network and pattern. The input for the hydrographical delineation are the Google earth remote sensed elevation data. The input maps was imported in to Arc GIS environment through a process known Adding of Data. The maps was geo-referenced, that is, the map would be given its correct coordinates through the process of geo-referencing within the Arc GIS environments. The flow direction and flow basin tools were then used to classify River Ogun into different basins. The area with highest flow influx was identified as the lower basin catchment.

The extraction of the lower basin catchment involved other processes such as; Rectifying, Digitizing, Laying-out and exporting. Rectifying implies correcting the input map with the exact geo-referenced values of the map. Digitizing implies extracting or carving out the necessary features needed in the input map which are the River Ogun, its catchment and tributaries, settlements and roads within the catchment. The Lower basin of River Ogun was identified as the region with highest flow influx. Laying-out is the act of given necessary attributes of a map to our newly produced map. Those attributes include; Size of paper, North Arrow, Scale, Title and Legend. After laying out the map, the land-use map was exported from the ArcGIS environment in a TIF format.

➢ *Land Use Map*

The input maps required for generating the land use map was gotten Goggle earth remote satellite. The inputs are best obtained online from Goggle map sophisticated technology as they contain recent data which are always updated. The maps were obtained in many magnified bits to ensure accurate details. The accuracy/resolution of acquire data was to nearest 25m an equivalent of 0.000225^0. The input maps would be imported in to ArcGIS environment through a process known Adding of Data. ArcGIS interface has a cross '+' sign which help in adding this input map. The maps would be geo-referenced, that is, the map would be given its correct coordinates through the process of geo-referencing within the ArcGIS environments.

The extraction of the land use data from the input maps would involve other processes such as; Rectifying, Digitizing, Laying-out and Exporting. Rectifying implies correcting the input map with the exact geo-referenced values of the map. Digitizing implies extracting or carving out the necessary features needed in the input map which are the River Ogun, its catchment and tributaries, settlements and roads within the catchment and the land use pattern of the catchment (such as riverine, swamps, semi-paved and paved areas). Laying-out is the act of given necessary attributes of a map to our newly produced map. Those

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attributes include; Size of paper, North Arrow, Scale, Title and Legend. After laying out the map, the land-use map would then be exported from the ArcGIS environment in a TIF format.

➢ *Digital Elevation Measurement (DEM)*

Elevation data of stations within the catchment were obtained using remote sensing. Data collection stations were at 25m interval. These elevation data were gotten by placing the mouse cursor at specified stations. The coordinates and elevation values of station were taken and recorded. The elevation data was taken to GIS environment to generate the DEM. The elevation data were digitized to point features using Arcmap digitizing tool. Attribute table was created by ArcGIS where the elevation stations were assigned height values. The point features were then interpolated to produce a spatial variation of elevation with the catchment. The spatially varying elevation is our required DEM. Natural Neighbor method of interpolation would be employed as it is the most appropriate method for generating DEM. The interpolation icon is found under the ArcGIS Toolbox.

➢ *Floodplain Map*

The Floodplain mapping of River Ogun down reach was based on two parameters - Land use pattern and Digital Elevation Model. Topography and land property of the area are major factors used in identifying floodplains. Other factors include, geomorphic, rainfall and temperature. This other factors have no spatial variability within the catchment. The Ogun down-reach catchment is generally a gently sloped lowland with unified rainfall and temperature values. The combine effect of topography and land cover were used for floodplain classification. Semi-paved elevated areas are less prone to flood unlike riverine lowland. Flood zones are classified within the GIS environment by using Spatial Plus tool. The land cover patterns map of the study area were assigned weight and re-classed. The semi-paved, paved, swamps and riverine areas were numerically re-classed from weight 1 to weight 5. The DEM of the study area was also weighted at definite interval and re-classed. The DEM was also numerically weighted. Elevated areas were assigned lower weight. Whereas, depressed areas were assigned higher weights as they are assumed to have more flood tendency. The re-classed Land-cover and DEM were then combined using Spatial Plus tool to produce the flood susceptible zones and satisfactory zones. Zones with high spatial pus function are susceptible to flood.

III. RESULTS AND DISCUSSION

This chapter shows the results of various information gather from Goggle earth remote satellite in orders to investigate the extraction of the lower basin catchment involved other processes such as; Rectifying, Digitizing, Laying-out and Exporting. The summary of the data were used to generate the following maps which includes contour map, topography map, drainage pattern map, elevation collection points map, land-use map, digital elevation measurement and floodplain map.

➢ *Lower Basin Catchment Delineation*

Different maps were derived from the delineation of the lower basin catchment area. The maps were the contour, topography, drainage pattern and the elevation collection points.

Contour is a line drawn on a map connecting points of equal elevation on a map. Figure 1 is the contour map of the study area, which is indicating the contour lines, the roads, rivers and the settlements within the study areas. From the map, the movement of the river flowing can be seen from the upstream or downstream along different elevations. Settlements can also be seen at different elevations as well.

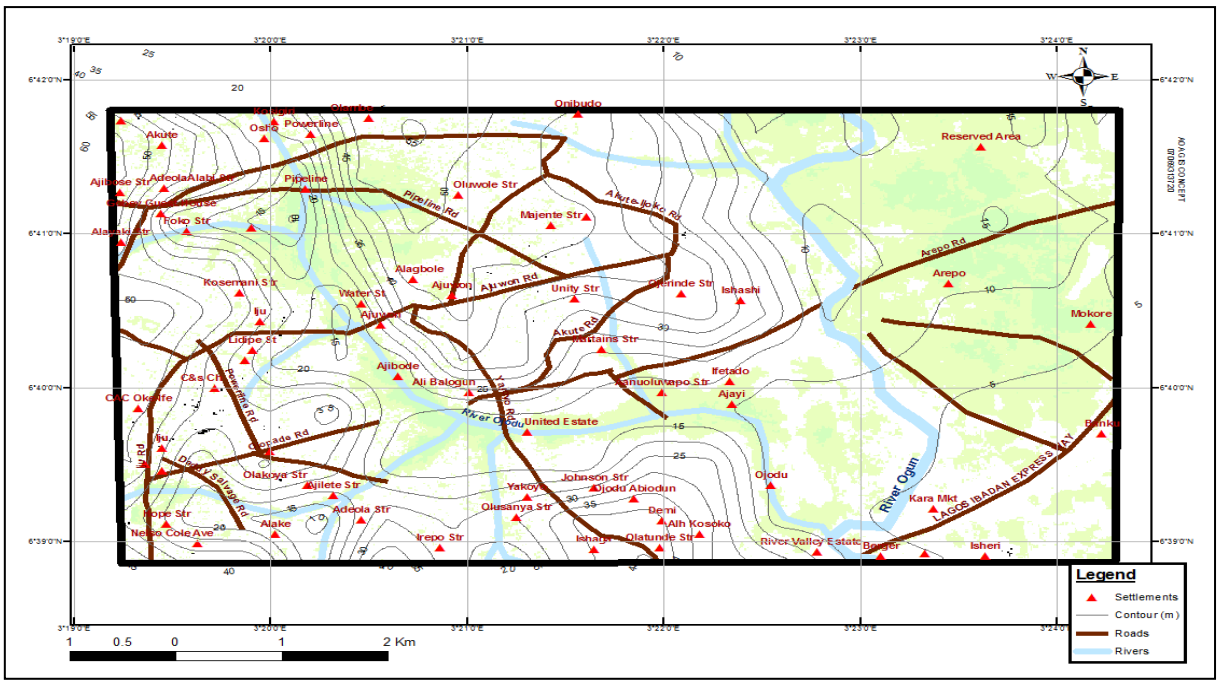


Fig 1 Contour Map of the Study Area.

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Topography is the configuration of a surface and the relations among its man-made and natural features. Elevation and slope play an important role in governing the stability of a terrain. Generally, slope influences the direction of and amount of surface runoff or subsurface drainage reaching a site. In addition, slope has a dominant effect on the contribution of rainfall to stream flow. It also controls the duration of overland flow, infiltration and subsurface flow. The combination of the slope angles basically defines the form of the slope and its relationship with the lithology, structure, soil type, and drainage.

Therefore, smooth/flat surface that allows water to flow quickly is a disadvantage and generally results to flooding, whereas a higher surface roughness can slow down the flood response. Steeper slopes are more susceptible to surface runoff, while flat terrains are susceptible to water logging. Low gradient slopes are highly vulnerable to flood occurrences compared to high gradient slopes. Rain or excessive water from the river always gathers in an area where the slope gradient is usually low. Areas with high slope gradients therefore do not permit the water to accumulate and most often results to flooding.

Figure 2 is the topography map of the study area, which indicate the features in the contour map and their elevations. The greenish coloured area with elevation ranging between 2.01-5m around Isheri and Kara market shows lowest elevation and represents alluvium deposits of the riverine areas. The olive green and lemon areas around Mokore and Arepo values between 5.01-10m and 10-20m. Finally, the relatively higher elevations vary within elevation ranges between 50.01-60m and 60.01-67m respectively corresponds to areas around Akute and Olambe areas. Topography has important influence on flood formation and re-distribution. The areas with lower elevations in the study area have a higher risk of flooding because it is easier to be inundated by flood.

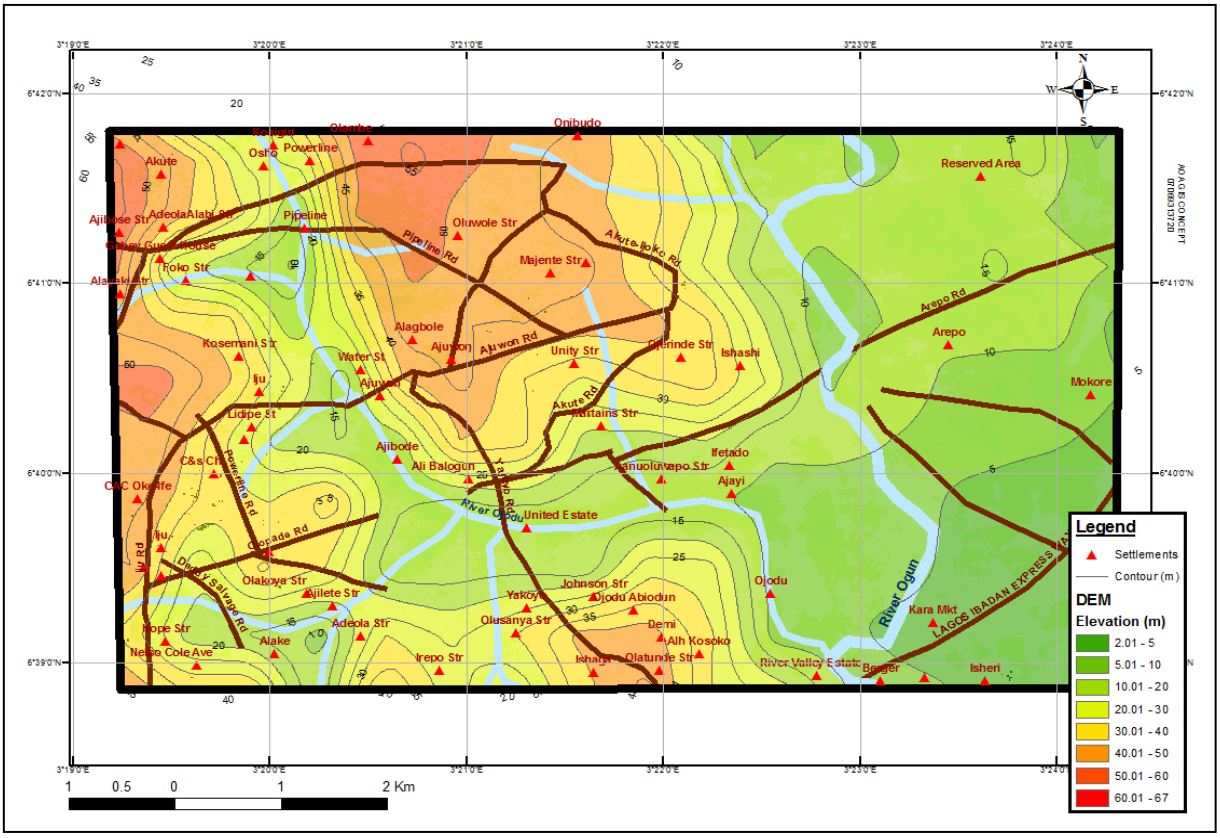


Fig 2 Topography Map of the Study Area.

Drainage is the way of allowing flow off excess water gradually to join watercourses.

Generally, regions or areas with high relief will have a higher drainage density than other drainage basins if the other characteristics of the basin are the same. Flooding is influenced by how much water is stored in the soil from previous flooding and local rainfall, described as antecedent conditions. Prolonged, severe drought depletes stores of water in soil, which means that larger flows are then required for inundation to occur.

Figure 3 is the drainage pattern map of the study area, which indicate the settlements, downstream and tributaries of the River Ogun. Downstream is the main flow way of the lower basin and no major settlement along the flow but the closest settlement to flow is the Kara market. Majority of the settlements fall most around the tributary flow but the settlements that fall along the tributary flow lines are Pipeline, Foko and Ajibode and they are at different sections along the flow line.

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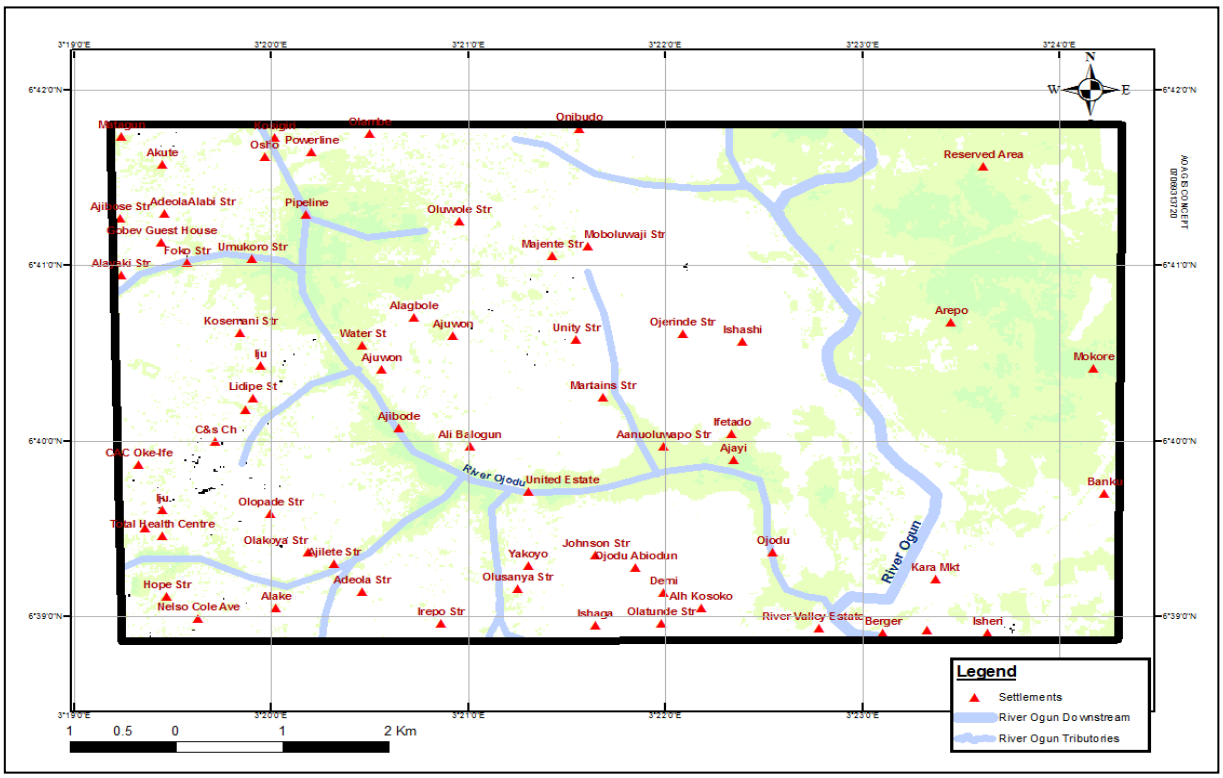


Fig 3 Drainage Pattern Map of the Study Area.

Also, Figure 4 is the elevation collection point's map of the study area, which indicate the roads, rivers, settlements and the collection points within the area indicated with numbers.

Elevation collection points is the points located within the study area either along the tributaries, downstream or closest to the paved roads within the area. Some numbers like 8, 9, 7 are located along the downstream of the river channel at different points while numbers like 14, 12, 10, 11, 15, etc are some of the numbers located along the tributaries at different points within the study area. Some numbers are closest to the already paved roads like 46, 51, 30 etc.

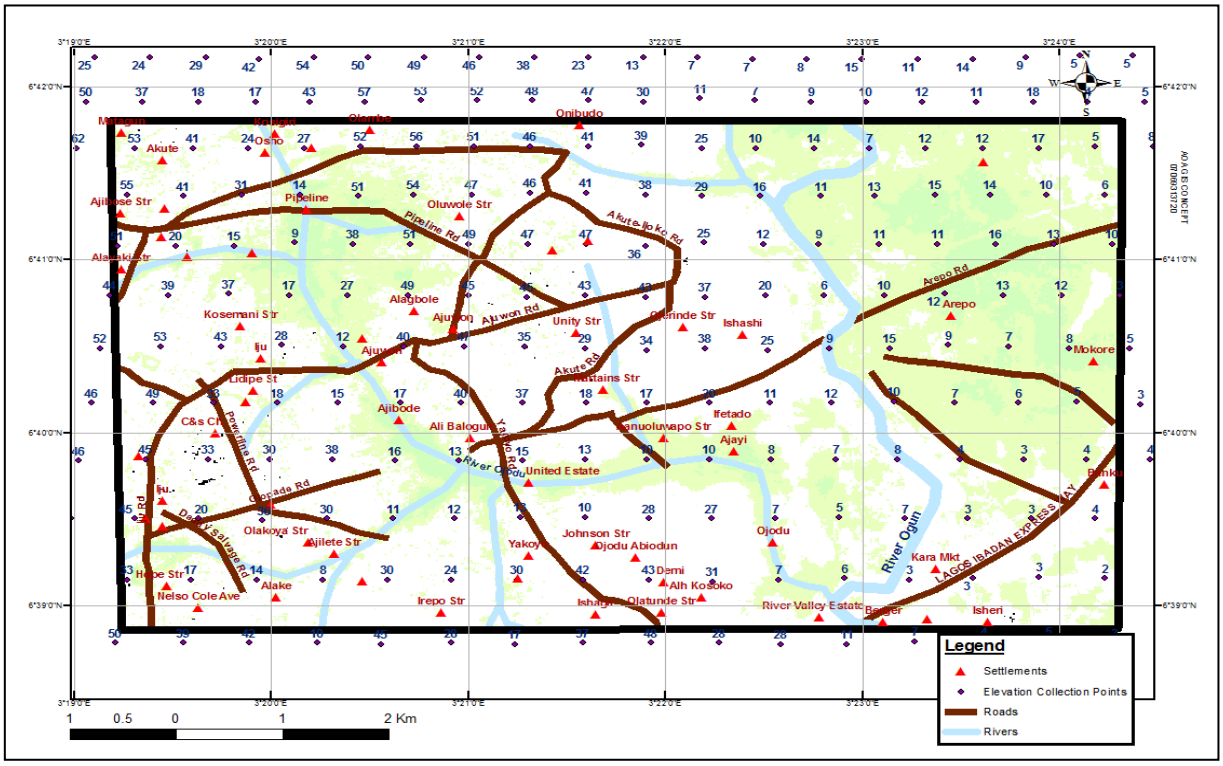


Fig 4 Elevation Collection Points Map of the Study Area

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➢ *Land Use Map*

The land-use map of an area is of primary concern in flood hazard/risk mapping because it is one factor which not only reflects the current use of the land, pattern and type of its use but also the importance of its use in relation to soil stability and infiltration. Land-cover like vegetation cover of soils has an important impact on the ability of the soil to act as a water store. Runoff of rainwater is much more likely on bare fields than those with a good crop cover. The presence of thick vegetative cover slows the journey of water from the sky to the soil and reduces the amount of runoff. On the other hand, impermeable surfaces such as concrete, absorbs almost no water at all. Land-use like buildings, roads, slum areas, decreases penetration capacity of the soil and increases the water runoff.

In other words, Land-use types work as resistant covers and decrease the water hold up time; and typically, it increases the peak discharge of water that enhances a sudden flooding. This implies that land-use and land-cover are crucial factors in determining the probabilities of flood happenings. Land use and other human activities also influence the peak discharge of floods by modifying how rainfall are stored on and run off the land surface into streams. In undeveloped areas such as forests and grasslands, rainfall collects and is stored on vegetation, in the soil column, or in surface depressions. When this storage capacity is filled, runoff flows slowly through soil as subsurface flow. Increasing frequency and magnitude of flooding is perceived to be partly caused by changes in rural land use management, for example deforestation, land drainage and intensification of crop cycles, animal stocking, etc. Similarly, areas where much of the land surface is covered by roads and buildings, have less capacity to store rainfall. Construction of roads and buildings often involves the removal of vegetation, soil, and depressions from the land surface. The permeable soil is replaced by impermeable surfaces such as roads, and sidewalks that store little water, reduce infiltration of water into the ground, and accelerate runoff to ditches and streams.

The land use map of the study area is presented in Figure 5. From the land use map, different areas were able to be specified from each other like the riverine areas were able to be separated from the swamp areas. Also, the already paved areas were able to be separated from semi-paved areas by using different colour to indicate them even though there are some settlement areas within those areas. From the map, settlement like Arepo and Mokore are situated within the riverine area likewise Ajibode which means these settlements will be more prone to extreme flood anytime there is rainfall or overflow from the river. Anuoluwapo and Ifetado are part of the few settlement that fall within the swampy area, which means they too will be experiencing flood when there is excess rainfall or when the river is overflowing with too much water. Ishashi and Ojerinde are some of the place that falls on the semi-paved area, which means the areas around these place are covered with slight firm surface and they may not witness flood in those area as compared to those that fall within the flood zone whether slight or extreme flood. Paved areas are the area that have firm surface. It can be seen from the map that paved areas are the road that connect different places to each other like moving from one end to the other end within or outside the river area.

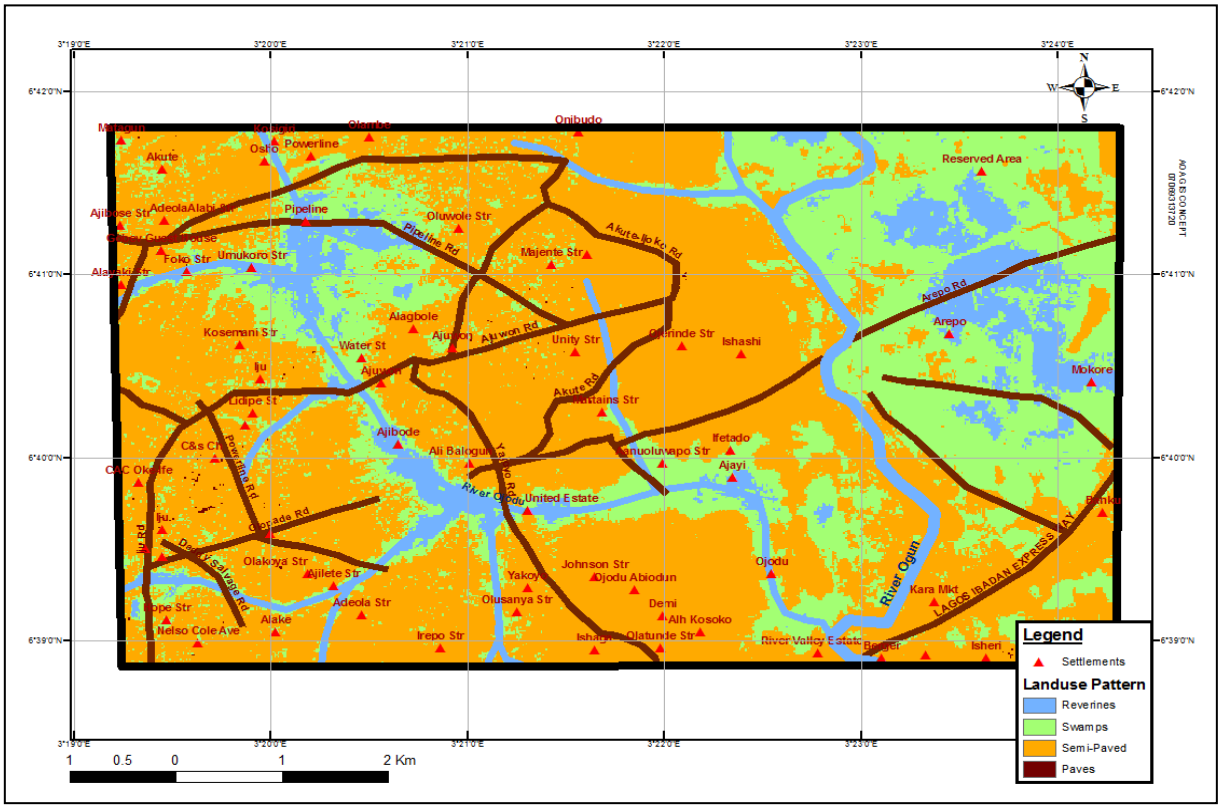


Fig 5 Land Use Map of the Study Area.

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➢ *Digital Elevation Measurement (DEM)*

DEM is used to determine the attributes of terrain, such as elevation at any point, slope and aspect. DEM is also used to find features on the terrain, such as drainage basins and watersheds, drainage networks and channels, peaks and pits and other landforms. Terrain stability which are the areas prone to avalanches are high slope areas with sparse vegetation, which is useful when planning a highway or residential subdivision.

The digital elevation measurement map of the study area is presented in Figure 6. The DEM figures revealed the topographic roughness and geomorphologic structure of the study area. The DEM of the study area was used to show the elevation differences and for a quick estimation of the morphology of the area.

Geomorphologically, the area has a nearly flat/smooth topography with elevations varying between 2-67m. The area is classified into eight geomorphological units: the greenish coloured area with elevation ranging between 2.01-5m around Isheri and Kara market shows lowest elevation and represents alluvium deposits of the riverine areas. The olive green and lemon areas around Mokore and Arepo DEM values between 5.01-10m and 10-20m. Finally, the relatively higher elevations with DEM elevation ranges of 50.01-60m and 60.01-67m respectively corresponds to areas around Akute and Olambe areas.

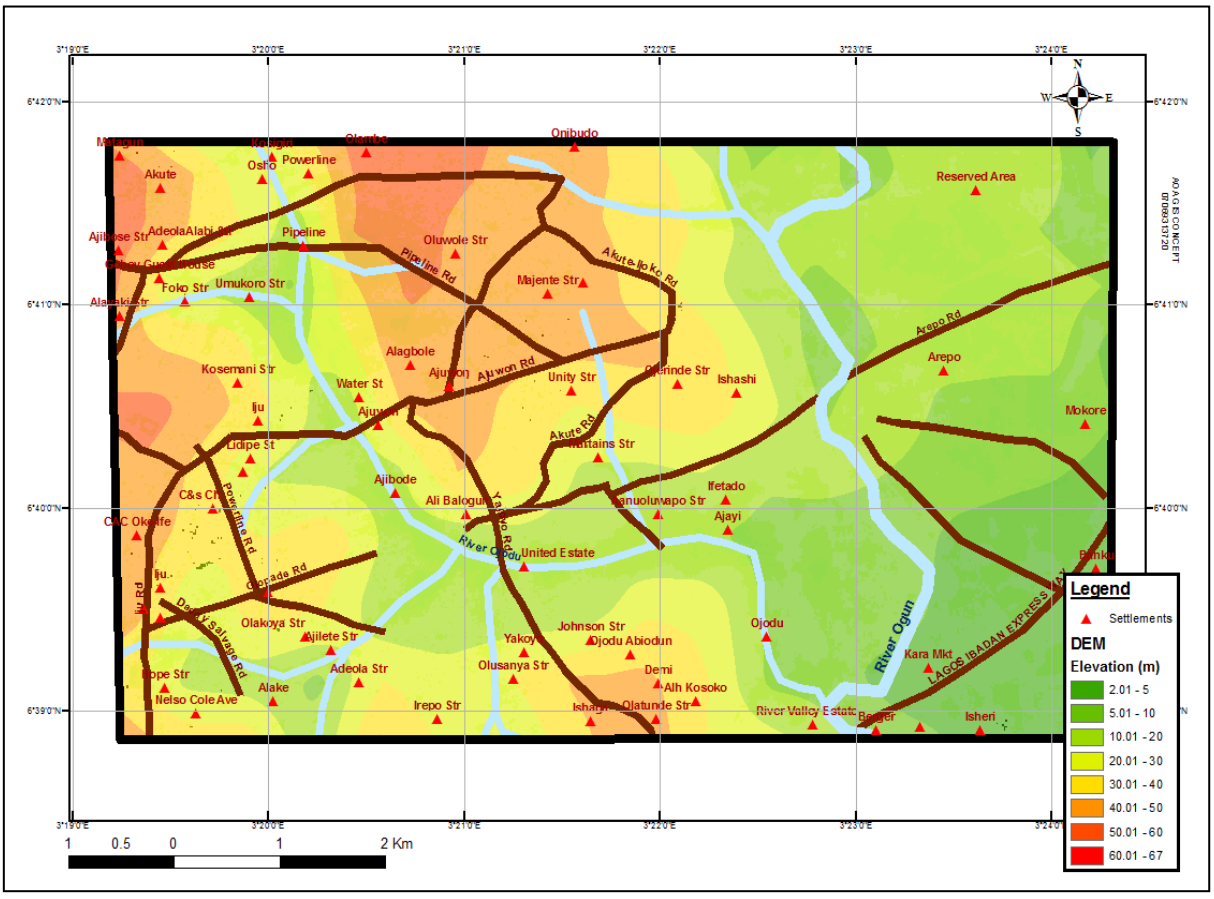


Fig 6 Digital Elevation Measurement Map of the Study Area.

➢ *Floodplain*

Floodplain is a low plain adjacent to a river that is formed chiefly of river sediment and is subject to flooding. It may be the area that could be subject to inundation by the maximum possible flood event (i.e., the largest flood that theoretically can occur at a given site during the present geologic and climatic era.). To a lesser degree, it may be based on an estimate of the area required to carry the runoff resulting from precipitation of a particular magnitude (in terms of intensity and duration) and frequency. The natural and human environments in the floodplain constantly interact, and often adversely affect, their respective uses. Human activities frequently interfere with the natural floodplain processes, suffering inconvenience or catastrophe as a consequence.

The floodplain map of the study area is presented in Figure 7. From the floodplain map, different flood zones were indicated based on their categories. Different flood zones are indicated from the least affected areas to the worst affected areas with different colour. Settlements are also indicated which means those living within the satisfactory area are still in the area but are covered with little flood even when the intensity of rainfall is high or the river flow is excess. Some of the settlements along these area are the people staying in Akute, Ishaga and Mejenle area of Ogun state.

The slightly satisfactory area are also within the flood area but there situation is more worse in times of flooding compare to the satisfactory area because the more the

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intensity of the rainfall increase or the overflowing of the river increase, the more the area is more prone to flooding. Some parts of Ojodu fall in these area, Powerline, Irepo, Ishashi etc are some of the place that fall within the area.

The floodzone area is surely to be affected with little or no rainfall or when the river is overflowing with water because the area is already mark as floodzone and these maybe of its closer to river channel or river flow or because of the soil in the area cannot hold much water whether there is rainfall or overflow of the river. Ifetedo, Kara market, Isheri are some of the places that is within the floodzone and people living in these area do experience flood.

The extreme floodzone is completely flood area. It may be the main channel of the river, downstream, tributary or the closest area along the flowing river which is either water-logged every time or the area is already submerged with water. Settlements along these is very dangerous which will continue to cause lots of damage to both property and lives anytime and anyday. People living in these vicinity like Pipeline, Arepo, part of Ojodu, Ajibode usually most of the time experience flooding because they are staying within the place classified as extreme floodzone areas.

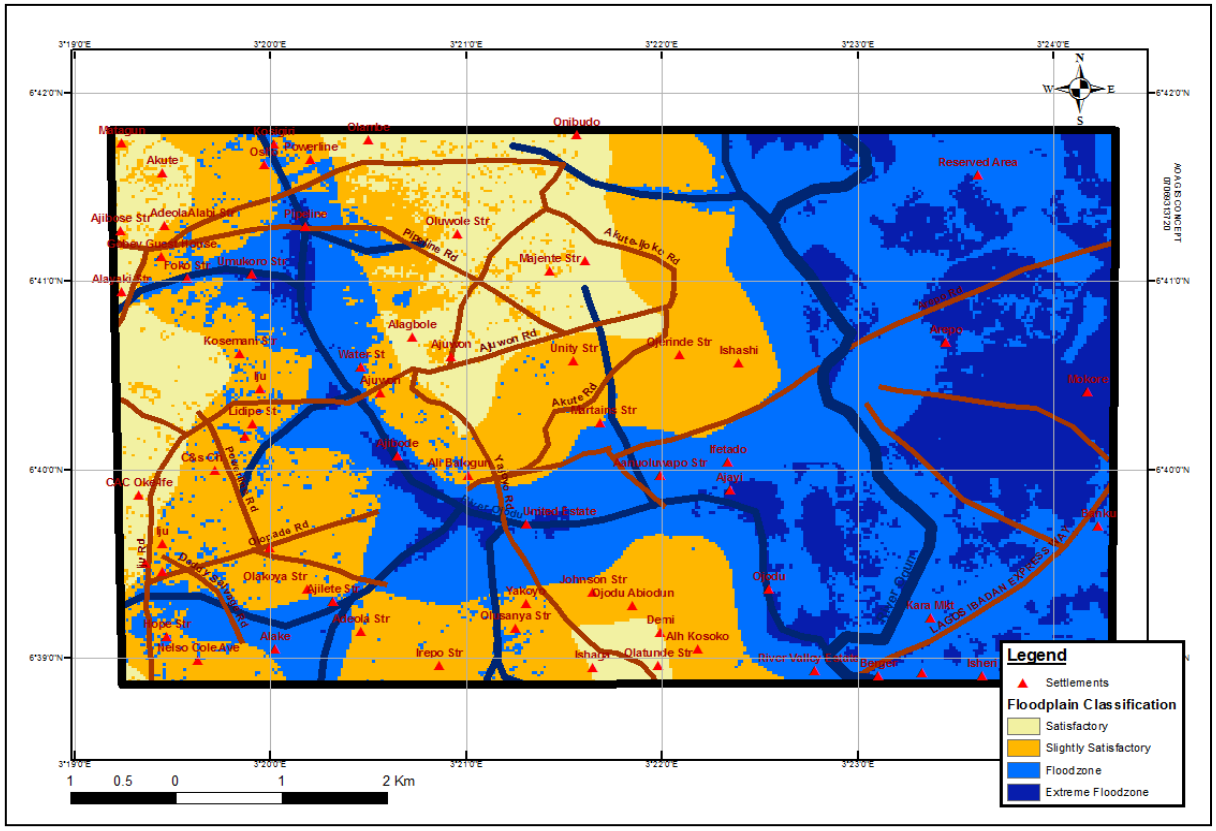


Fig 7 Floodplain Map of the Study Area.

IV. CONCLUSIONS

The following conclusions were made: Delineation map of River Ogun Lower Basin were generated, Land Use map was generated, Digital Elevation Measurements map is generated, Floodplain map is also generated. Therefore it is recommended that there should be a drainage master plan, Land use monitoring, Channel Improvement and Floodplain zoning to reduce the development-induced impact along the area.

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