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APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING IN MAPPING SURFACE WATER IN EKITI CENTRAL SENATORIAL DISTRICT, NIGERIA

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ABSTRACT

The demands on surface water for agricultural, industrial and domestic activities has been on the increase while the quality and quantity of freshwater supply is decreasing geometrically as a result of rapid population growth in Ekiti Central Senatorial District, Nigeria. The supply of surface water to every nock and crannies of the studied area must be met. To achieve this, the application of Geographic Information System (GIS) and remote sensing was used to map out surface water for effective and efficient water distribution at the required quantity and quality to the studied area. Surface water mapping provides accessible, accurate, readable and reliable information about the location, quantity, availability and distribution of surface water in Ekiti Central Senatorial District. The LANDSAT ETM+ was used to acquire the satellite imageries of surface water in the studied area. The surfer 8 and Arc GIS 10 softwares were used to generate the digital elevation model, flow direction, flow length, flow accumulation, land use and drainage maps of the studied area, respectively. The results revealed that the studied area has a steady flow of water which can be evenly distributed throughout the senatorial district. Water flows from the areas of high elevation to the areas of low elevation, while accumulates at the downstream of the water flow. Geographic Information Systems (GIS) and remote sensing technologies provides easily read and rapidly accessible maps that can be used to monitor the surface water to enhance water distribution for domestic, industrial and agricultural purposes and the system can also be used to manage water resources correctly and effectively.

Keywords: Geographic information system, remote sensing, mapping & surface water.

1. INTRODUCTION

The Ekiti Central Senatorial District is experiencing drastic population growth with its high pressure on the natural resources including both land and potable water supply. Development of reliable water resources represents a challenge for planners and decision-makers in Ekiti Central Senatorial District, Nigeria with high population growth and water scarcity. Occurrence of inadequate surface water supply for agricultural, domestic and industrial usages has remained on the increase over the years. Even though some occurrences of inadequate water supply were foretold, the data available for planning effective mitigation against their occurrence were always inadequate. Water as one of the natural resources required for the survival of man, animals, and plants are unevenly distributed in the senatorial district. There are a lot of variations in terms of both quantity and quality of surface water.

As water is connected to every forms of life on earth; an adequate, reliable, accessible and acceptable water supply has to be available for various users to carry out different purposes. This study will help in finding lasting solution to the growing need of water resources among users by

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bringing attention to the quantity of water that can also be distributed from surface water. The increasing demands placed on the global water supply threaten biodiversity and the supply of water for food production and other vital human needs. Water shortages already exist in many regions, with more than one billion people without adequate drinking water. The research aimed at using Remote Sensing and Geographic Information System (GIS) to map out surface water in Ekiti Central Senatorial District.

Water is the most important natural resource and valuable natural asset which forms the major constituent of the ecosystem. Water plays a vital role in the existence of life and various sector of the economy such as agriculture, livestock production, forestry, industrial power generation, fisheries and other creative activities (Tyagi *et al.,* 2013). Water can be sourced from rain, surface and ground water. Surface water should be well planned, developed, conserved, distributed and managed and its infrastructure should be properly maintained to avoid future water problems according to Audu and Anyata, 2010. Mapping is a vital components for appropriate surface water distribution in the study area. It creates easily read and accessible maps which will prioritize the mitigation efforts, responses and solution to surface water distribution system in Ekiti State (Pekel *et al.,* 2016).

Remote sensing provides useful data for water resource mapping and it is suitable for monitoring changes in surface water bodies (Chen *et al.,* 2004). It is key to understanding surface water resources and how they are responding to intensified appropriation and modification by humans (Alsdorf *et al.,* 2007; Turpie *et al.,* 2015). Geographical Information System (GIS) and Remote Sensing (RS) techniques were used to map out the water distribution system in Ekiti State. Google Earth and Land Satellite (LANDSAT) 7 sensor of Enhanced Thematic Mapper Plus (ETM+), path 191 and row 55 were used to acquire the satellite imageries of the study area (Yu *et al.,* 2005). Using high resolution imageries, a Digital Elevation Model (DEM) was developed with Surfer 8 and ArcGIS 10.0 softwares to identify surface water in the areas (Du *et al.,* 2014). The slope, contour, watershed, drainage and aspect maps of the study area were generated by using the DEM. Watershed analysis was also carried out by using DEM to determine the flow direction, flow length and flow accumulation. The slope, elevation, flow accumulation and flow length maps were combined with land use map to produce surface water maps with the use of map algebra in ArcGIS 10.0.

2.MATERIALS AND METHODS

Description of the Study Area

The research was conducted at Ekiti Central Senatorial District, Ekiti-State, Nigeria. Ekiti Central Senatorial District has five geographical areas of: Ado Ekiti Local government Area, Efon Local Government Area, Ekiti West Local Government Area, Ijero Local Government Area and Irepodun/ Ifelodun Local Government Area. The map of Ekiti State showing the studied area as shown in Figure 1.

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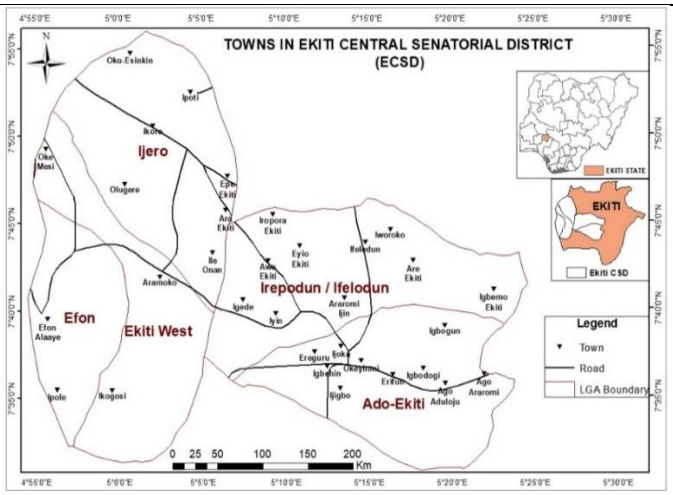

Figure 1: Map of Ekiti Central Senatorial District

Land Use/Land Cover Map

LANDSAT was used to acquire the satellite imageries and Arc GIS 10 was used to map and analyse the land use/land cover of the study area. Land use/cover classification was conducted using a cloud – free Landsat image. The images classification into thematic maps was done by using supervised classification approach. Band combination colour composite images was prepared for visual interpretation and delineation of the study areas (Shalaby and Tateishi, 2007).

Drainage pattern generation: Hydrological analysis was carried out on Digital Elevation Model (DEM) of the study area using ArcGIS software.

Digital Elevation Model (DEM)

The Ado-Ekiti was delineated in Google Earth and several points within the study area were marked within Google Earth and their coordinates and elevations were recorded in a Microsoft Excel spreadsheet. The X, Y and Z point data was exported to Surfer 8 software where the data were re-sampled to a grid interval of 10 m. The re-sampled data was blanked from the blank file and then the digital elevation model of the study area was generated. High resolution imagery was required for a clear depiction of the extent of vulnerability (Muhammad, 2013).

Flow length: The flow length of the study area was generated from the digital elevation model of the area using hydrology tools in ArcGIS software. Sinks were filled before performing the flow direction and a flow direction map was produced.

Flow direction: The flow direction of the study area was generated from the digital elevation model of the area using hydrology tools in ArcGIS software.

Flow accumulation: The flow accumulation of the study area was analysed using the flow direction generated as input flow data, this analysis was performed with the ArcGIS software and a flow accumulation map was produced.

Stream order: Stream order of the basin was generated with ArcGIS 10.0 software. This was done using the flow accumulation raster as the input stream raster. The drainage pattern of the study area was created using the stream order tool. While the stream to feature tool was used to convert the drainage pattern into vector format.

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Ekiti Central river body and flow: Drainage patterns and the vectorized water body from satellite imagery of the study area were imported into Google earth pro-environment and this was used in aiding water body detection and confirmation. Additional water body detected were digitized and exported into a working folder. The exported file from Google Earth was imported into the Arc GIS environment to update the water body of the study area.

Determination of Surface Water Elevation: The elevation of surface water of the studied area was determined by first determining the location (Latitude and Longitude) of the detected surface water bodies. The points were overlaid on the digital elevation model (DEM) of the state. Using the Extract to Points tool in the Arc Map, the elevations of the surface water bodies were extracted and determined.

3.RESULTS AND DISCUSSION

Drainage Patterns Map of Ekiti Central Senatorial District

The drainage pattern of the Ekiti state surface water body in Figure 2 is dendritic in nature, which develops in regions underlain by homogeneous material. That is, the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take. Tributaries are seen joining larger streams at acute angle (less than 90 degrees) and it drains from water from the north to Ekiti senatorial district.

This map shows how water drains in and out of rivers and large water bodies (reservoirs) in Ekiti state. Water drains majorly from dams and rivers upstream, moves with even distribution across the state into reservoirs and rivers downstream. Rivers and reservoir in Ekiti central district reserves the larger portion of the water that comes from the upstream because they have the highest number of tributaries emptying into them. Figure 2 reveals the largest tributaries water contribution. Its landform is relatively low in elevation compared to its surrounding environment, making majority of the water draining form the upstream to the downstream. Having some lands higher than other areas of Ado Ekiti accounts for the formation of a river and capability of being damned and also good water retention and stability of water velocity.

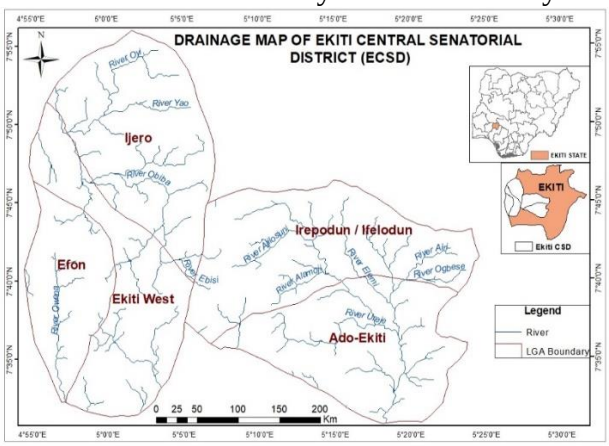

Figure 2: Drainage Map of Ekiti Central Senatorial District

Surface Water Map

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The surface map in Figure 3 shows large water bodies that are damned and flowing rivers in Ekiti Central District with their respective elevations. Dams and prominent surface water are found in Ado-Ekiti, Efon, and Ijero.

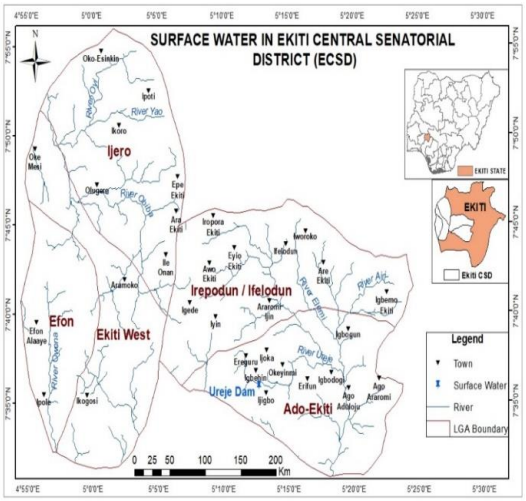

Figure 3: Map of Surface Water

Elevation Map of Ekiti Central District

The elevation map in Figure 4 shows clearly the reason for the drainage pattern of Ekiti. It shows that at the North- east part of Ekiti state the land elevation is lowest and increases gently across the study area towards South-west but also decreasing gently towards the Eastern, South-eastern, South and South-western part of the study area. The gradual slope of the study area supports good water accumulation, retention and even distribution of water. Therefore we can see that larger portion of the water in Ekiti drains out of Ekiti majorly in the South-eastern part of Ekiti.

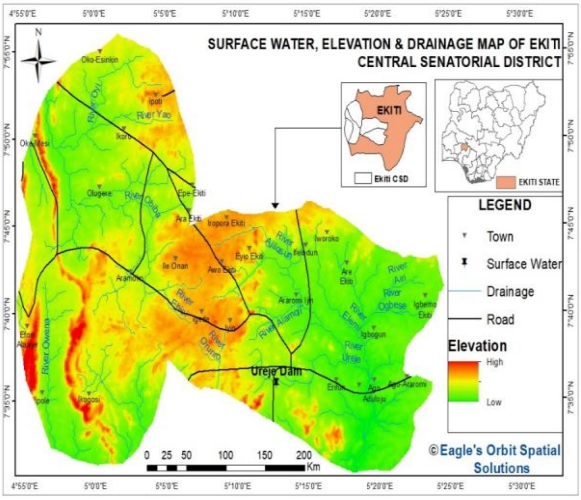

Figure 4: Elevation Map of the Study Area

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Digital Elevation Model (DEM)

The Digital Elevation Model in Figure 5 reveals that Ado-Ekiti consists of areas with high, medium and low elevation within the terrain. Figure 5 represents the DEM of the study area which ranges between 5.215 – 7.603 m. The values within 5.215 m indicate the lowest point on the map while the areas with values within 7.603 m represent the peak of the study area. Values from 7.603 – 7.60 m, 7.599 – 7.597 m and 5.209 – 5.215 m show areas of high, medium and low elevation which are less, moderately and highly vulnerable.

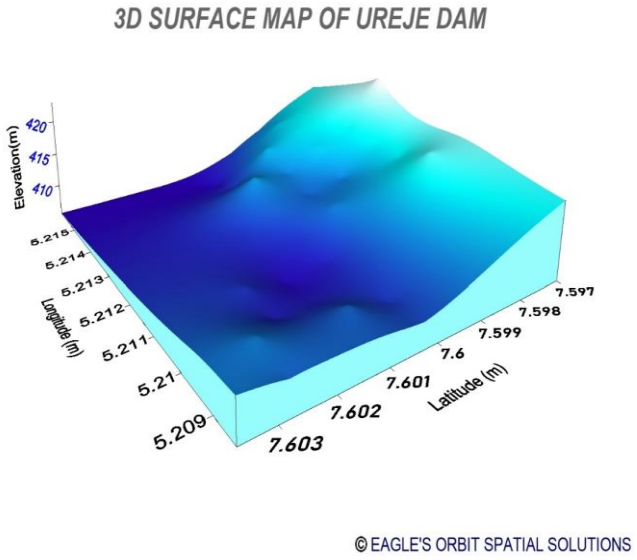

Figure 5: Digital elevation map model of Ureje Dam

Flow length

The flow length which represents the distance at which water flows in the catchment is an essential factors in surface water mapping as shown in Figure 6. The shorter the length, the faster the flow and the longer the length, the slower the flow.

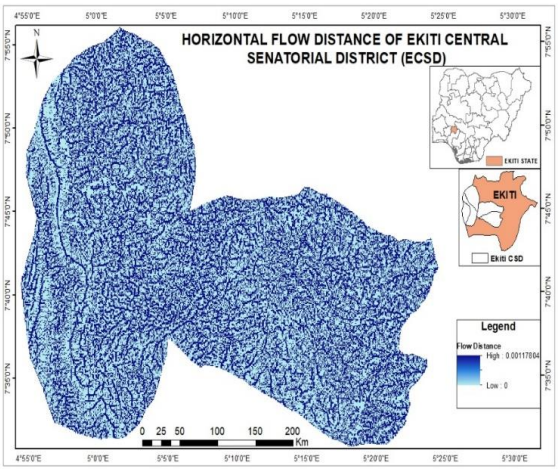

Figure 6: Flow Length

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Flow Direction of the Study Area

The direction of flow of the study area drainage in Figure 7 is dominantly to the South-east and South-west. This means that the water from the upstream and mid-stream part of the study area flows downward to the downstream part of the area. All other flow directions merges into the dominant direction to contribute their water and this makes the water flowing in this direction larger than those flowing other directions.

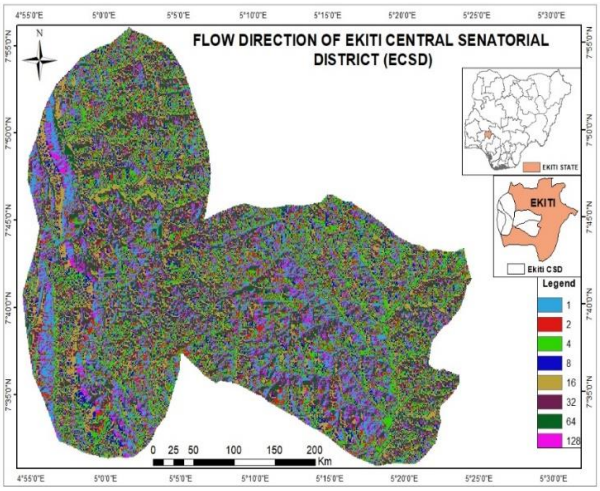

Figure 7: Flow Direction

Flow Accumulation of Surface Water

The flow accumulation of the study area in Figure 8 gives the pattern and position where water gathers within the study area. From the map, it is seen that the upstream is the major source of water accumulating in the basin, though there are other tributaries feeding the main accumulation flow. The accumulation of water increases as it travels down the drainage basin from the upstream to the downstream.

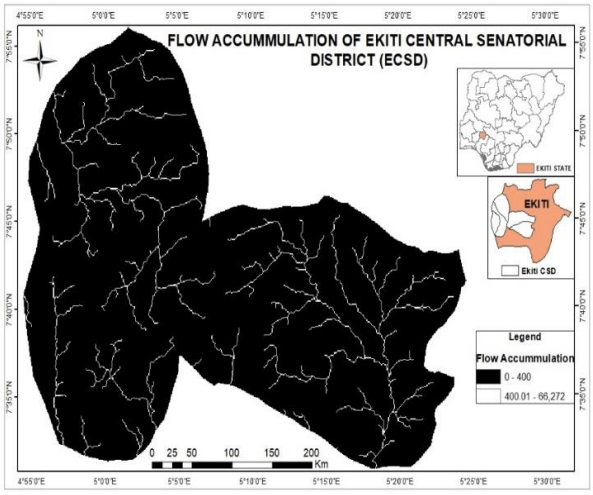

Figure 8: Flow Accumulation

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Land Use and Land Use Cover

The geographical information system (GIS) was used to estimate the total area of the Ekiti Central Senatorial District. The GIS used was to identify prospective locations of the land uses/land cover of the study area. The data obtained through the analysis of multi-temporal satellite imageries are diagrammatically illustrated in Figure 9. Accuracy assessment was conducted to assess the practicality of classified data in change analysis. For accuracy assessment, the producer's accuracy, user's accuracy, overall accuracy and kappa statistics were calculated generating error matrices. This level of accuracy conforms to the standard accuracy of >90% for LULC mapping. (Lea and Curtis, 2010).

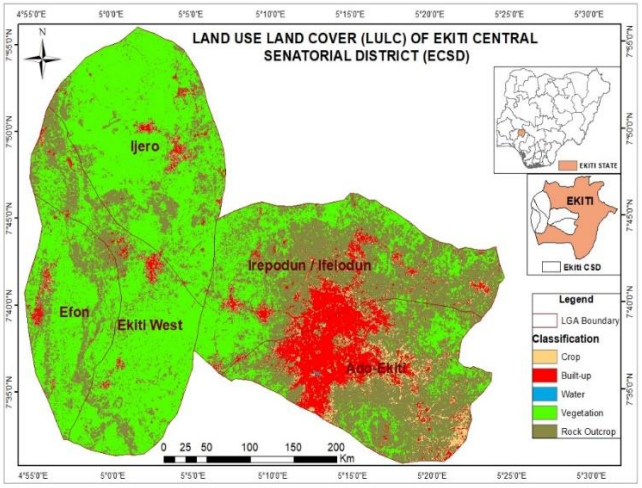

Figure 9: Map of Land Use/Land Use Cover

4.CONCLUSION AND RECOMMENDATIONS

A well planned and properly mapped water distribution network plays an immense role in the provision of drinking water supply. A good water distribution system is essential for environmentally sustainable development in any country and is also important in the control of waterborne diseases.

The river in Ekiti Central Senatorial District flows downstream from areas of higher elevations to lower elevations. The River Elemi flows into River Ureje and emptied into Ogbese river basin. Reservoirs are created on rivers with large volumes of water and good flow rate. Geographic Information System (GIS) and remote sensing can be used for monitoring of surface water for better water distribution for domestic, industrial and agricultural purposes. Geographic Information System can be used for proper and effective management of water resources.

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