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Application of GIS in Water Management of Eleyele Catchment, South-Western Nigeria

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Abstract
Eleyele dam has drastically reduced in capacity since its inception in 1942. There are frequent flood incidences within the dam catchment area- noteworthy of them is the August, 2011 flood incidence. This research studies the hydrological condition of Eleyele catchment through the use of Geographic Information System. The topographical maps, digital elevation measurement maps (DEM) and hydrological maps of the Eleyele catchment were produced through GIS watershed delineation process for the year 1967 and year 2014.The results show that there is an average lowering of elevation of about 14.63m within the catchment which has greatly affected the hydrological pattern of the catchment. The Triangulated Irregular Network (TIN) of the catchment was used to produce flood risk map. The map showed that 25.24% of the catchment is prone to flooding. The study showed that there is a change in topography of Eleyele Catchment within the period studied. This is due to the urbanization of the area.
Keywords: Eleyele Dam, Flood Incidences, Hydrological Condition, GIS, Watershed Delineation Process, Triangulated Irregular Network

1. Introduction

In 1942, the quest to create a modern water supply system to meet the challenge of water scarcity for the emerging Ibadan metropolis led to the construction of Eleyele Dam on the main River Ona with a reservoir storage capacity of 29.5 million litres (Tijani *et al*, 2011). However, Eleyele dam capacity has reduced in capacity from 29.5 million liters to below 11million liters in 2014 (Olaniyan, 2013). Eleyele catchment located in Iddo local government has also witnessed incidences of flooding during the rainy season over the years. A noteworthy of them is the August, 2011 Ibadan floods incidence whereby many communities in Iddo local government lost lives and properties (Alayande *et al*. 2012*)*. The study utilizes GIS to study the hydrological condition of Eleyele Catchment to effective water management of the dam.

Geographic information system (GIS) is designed to visualize, store and analyze the information about the locations, topology and attributes of spatial features. GIS also has the ability to be used as watershed delineation tool. Watershed delineation as carried out in this study involves delineating the study based on its flow direction, flow length, flow accumulation and flow basin through the use of the Digital Elevation Measurement Model (DEMs) of the area. Similar study by Djokic and Maidment (1991) used watershed delineation tool to extract stream networks from DEMs in GIS. This helped to determine the internal distribution of water flow and describes the connectivity of the links in the watershed flow network.

2.Study Area

Eleyele dam is located in North-Eastern part of Ibadan, southwestern Nigeria within longitude $E03^051^l0^{ll}$ and $E03^052^l37^{ll}$ and latitude $N07^025^l14^{ll}$ and $N07^026^l40^{ll}$. The study area (Eleyele catchment) lies between longitude $E03^048^l04^{ll}$ and $E03^055^l17^{ll}$ and latitude $N07^021^l49^{ll}$ and $N07^029^l55^{ll}$ and it also comprises of areas such as Apete, Awotan, U.I, Akere, Ojo, Atalapa, Gege, Odo-ona. The dam is a modified natural riverine wetland type with area of about 1.290 km^2 and a catchment area of 10.303 km^2.

Eleyele catchment, Ibadan has a tropical wet and dry climate (Köppen climate classification *Aw*). Ibadan's wet season runs from March through October while November to February forms the city's dry season. The mean total rainfall for Ibadan is 1420.06 mm, falling in approximately 109 days. The mean maximum temperature is 26.46 C, minimum 21.42 C and the relative humidity is 74.55%. (BBC Weather, 2010).

3.Materials and Methodology

The materials used for this study include Topographic Map of Eleyele Catchment (Scale 1: 100,000) Year 1967 and Digital Elevation Measurement Map (DEM) of Eleyele Catchment (Scale 1: 100,000). Hydrographical data/Input map used in this study is the topographical map and the digital elevation measurement map of the study area. The hydrological maps were transferred into the GIS interface in JP2 and TIFF**.** The inputed maps were geo-referenced, rectified, updated and digitized in the GIS interface. It was then used to develop the digital elevation measurement map (DEM) and the hydrological models (The models include; the flow direction map, flow accumulation map and flow basin map of the study area) which were obtained by processing the digitized hydrological input. These outputs were post-processed by laying-out and exporting them as shown in Figure 1.

The flood risk map was produced by generating the Triangulated Irregular Network (TIN) of Eleyele catchment topography. The flow diagram showing watershed delineation process is shown in Figure 1.

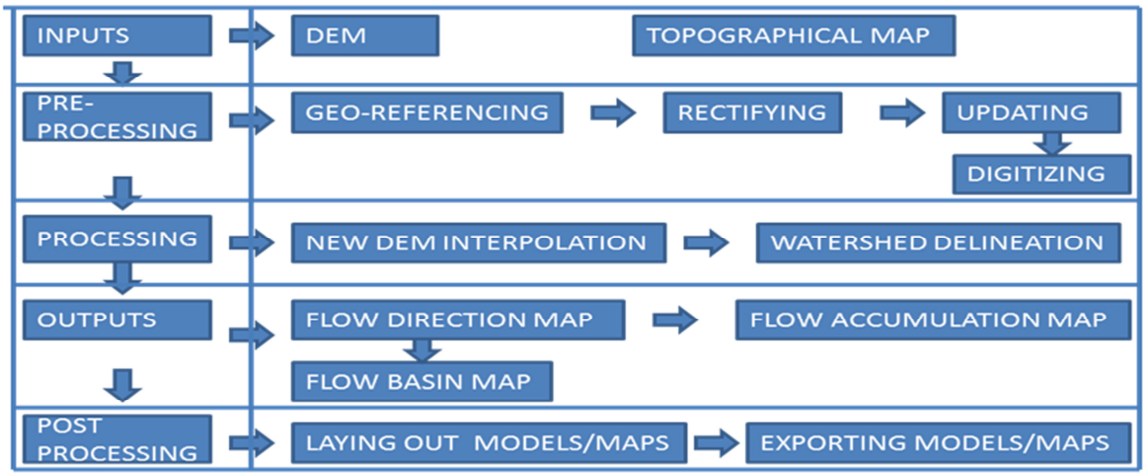

FIGURE 1: A Flow Diagram Showing Watershed Delineation Process

4.Results and Discussion

Topographical Maps of Eleyele catchment

The topographical maps of the catchment showed a lower Elevation within the catchment (Figure 2a, b). This is evidently due to various human activities leading to change in topography. The elevation of the catchment in 1967 and 2014 are (492-999) foot and (485-997) foot respectively. Various anthropogenic activities that have taken place in Eleyele catchment over the stretched years had lowered its elevation. Table 1 show the difference in elevation by considering eight locations within the catchment. All the locations reduced in elevation except Odo ona whose elevation remains constant. The reduction in the elevation is due to anthropogenic activities within the areas which include farming, industrial activities and fishing. Human activities were at a minimal level within Odo ona area of the catchment. Figure 2a and 2b show the topographical map of the catchment in 1967 and 2014 respectively

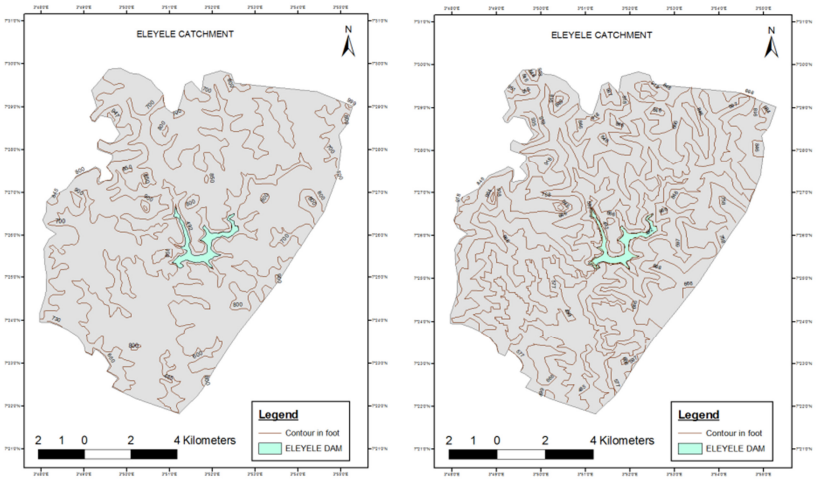

FIGURE 2a: Topographical Map of Eleyele Catchment (1967)
FIGURE 2b: Topography Map of Eleyele Catctment (2014)

TABLE 1: A Table Showing Change in Elevation of Eleyele Catchment

S/N	Location	Elevation(ft) (1967)	Elevation(ft) 2014	Change in Elevation (ft)	Comments
1	AKERE	947	918	29	Decrease
2	APETE	600	597	3	Decrease
3	ATALAPA	730	666	3	Decrease
4	AWOTAN	600	597	3	Decrease
5	GEGE	600	597	3	Decrease
6	ODO ONA	485	485	0	No changes
7	OJO	700	666	34	Decrease
8	SANGO	800	758	42	Decrease

Figure 3a and 3b show the flow accumulation map of Eleyele catchment in 1967 and 2014 respectively. The areas that are red in colour are the possible path through which water will flow. The flow accumulation maps show that greater flows are accumulating into Eleyele dam in the year 1967 as compared to that of year 2014. This reduction in flows over the years explains the reduction in capacity/discharge of Eleyele dam. One the major cause of reduction in Eleyele dam is therefore due to change in topography caused by various human activities. The change in flow accumulation maps due to topography is responsible for the reduction in the impoundment capacity of Eleyele dam.

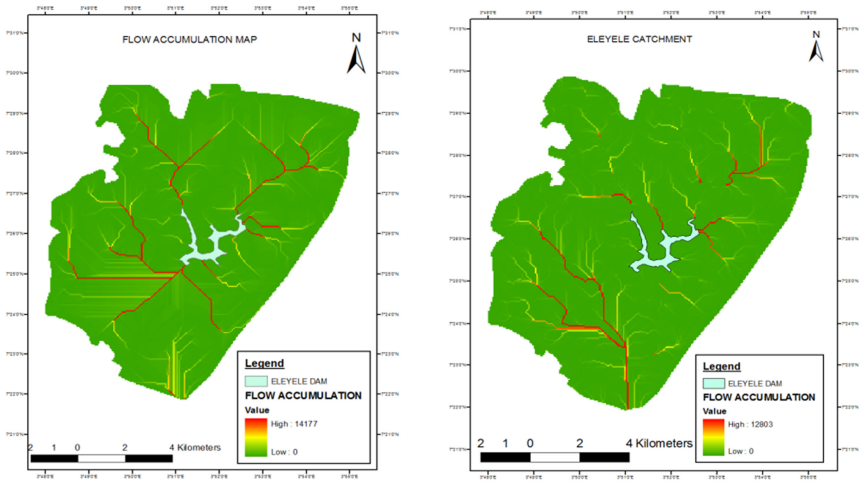

FIGURE 3a: Flow Accumulation Map of Eleyele Catchment (1967)
FIGURE3b: Flow Accumulation Map of Eleyele Catchment (2014)

Flood Risk Map of Eleyele Catchment

The TIN of the catchment shows the areas that are prone to flood. This is because water will flow from areas of high elevation to areas of low elevation. The areas which are red in colour from Fig. 4 below are of low elevation and are therefore at the flood risk zone. The flood risk areas include; Apete, Awotan, U.I, Gege and Odo ona. These areas were flooded in September 2011 flooding. The flood zone area is approximately 2.6km^2 which covers 25.24% of the Eleyele catchment area. Table 2 shows areas of low elevation in the Eleyele catchment that are prone to flooding.

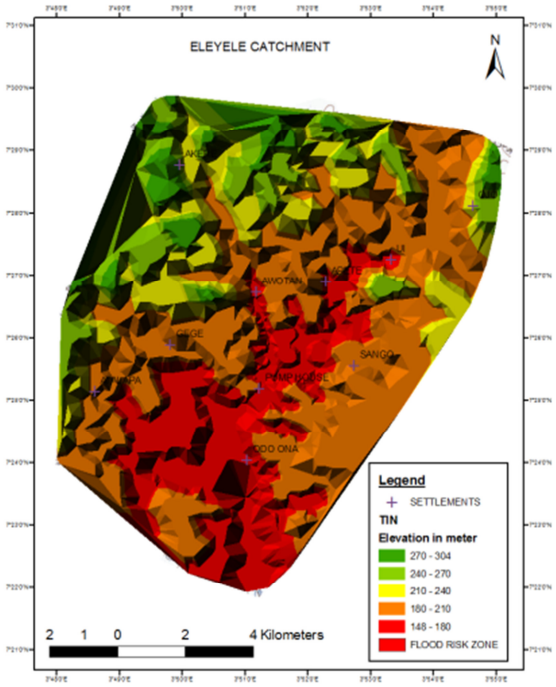

FIGURE 4: Map Showing TIN of Eleyele Catchment Indicating Flood Risk Areas

TABLE 2: Table Showing Areas Prone to Flooding Within Eleyele Catchment

S/N	Location	Susceptibility to Flooding	Elevation (meter)	Comments
1	AKERE	No	280	Very High Elevation
2	APETE	Yes	180	Low Elevation
3	ATALAPA	No	203	High Elevation
4	AWOTAN	Yes	180	Low Elevation
5	GEGE	No	190	Moderate Elevation
6	ODO ONA	Yes	148	Very Low Elevation
7	OJO	No	203	High Elevation
8	SANGO	No	231	High Elevation

4. Conclusions and Recommendations

The study investigates the application of GIS to water management in eleyele catchment. The topographical and DEM maps of Eleyele catchments show that there is notable lowering of elevations in the catchment which has affected the hydrological pattern of the catchment. The flow accumulation maps of Eleyele catchment showed the reduction in the impoundment capacity of Eleyele dam. The flows that are accumulating into the dam in the year 1967 have been blocked and reduced due to various anthropogenic activities over the years. The flood risk map of the study area shows that 25.24% of the areas are prone to flooding and these areas are notably of low elevation. There should be control of urbanization and various human activities within Eleyele catchment. The development of flood contingency master plan for the flood plains in Eleyele catchment and Nigeria at large is imperative. Communities should be strongly discouraged from settling within the flood plains.

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