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Full Length Research

Flood vulnerability assessment of Eleyele Dam and its catchment area, Ido Local Government Area, Oyo State, Nigeria

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ABSTRACT: Over the past 30 years, cities in Nigeria have experienced many physical developments, in terms of building, manufacturing industries and others without appreciable infrastructures such as drainages, roads and canals to support them. These developments have made floods a critical challenge for many Nigerian cities. Hence, this research aimed to assess the causes and effects of flood from Eleyele Dam to the nearby settlements in Ido Local Government Areas in Oyo State Nigeria and proffer possible solutions to avert the feature occurrences of flood in the urban area. This research adopted Geographical Information System and Remote Sensing techniques to generate the flood vulnerability map. The study used Shuttle Radar Topographical Mission (SRTM) derived Digital Elevation Model (DEM) (30 m resolution and Quickbird and Sentinel 2 Landsat satellite images (0.25 and 0.75 resolution), topographic maps, soil maps and meteorological data. Seven contributing factors were examined namely; stream power index, distance from the river, Land Use and Land Cover (LULC), drainage, elevation, slope, and flow accumulation. Data was processed using ArcGIS 10.8 and Arcscene 10.8. Multi-criteria analysis through the analytical hierarchical process (AHP) was used to determine the weight of the contributing factors. The results revealed very low (8.3%), low (32.04%), moderate (32.3%), high (21.85%), and very high (5.51%) vulnerable area(s). Generally, the result of flood vulnerable map of the study area revealed the factors responsible for the flooding with proximity to the river (21%), slope (21%), drainage (17%), and Land Use and Land Cover (14%) being the major contributing factors in the study area. Building close to the river bank should be stopped to reduce the vulnerability to flooding. This research therefore recommended regulation of physical development along the river bank to minimize the potential risks and damage associated with flooding in the study area.

Keywords: Contributing factors, mitigation, multi-criteria, vulnerability.

INTRODUCTION

Urban development and management policies with poor implementation have led to the thoughtless development of buildings in/and along floodplains without following the rules and regulations and advice from appropriate development agencies. Building in/and along the riverine areas causes flooding when close to river banks and water moves into adjacent low-lying areas (Ijigah and Akinyemi, 2015). Vulnerability is the main reason for disasters, it is very important to develop our perception of vulnerability (Klein, 2004). Flood vulnerability is one of the main components in risk management and flood damage assessment (Connor and Hiroki 2005). Threats from floods are still very prevalent despite increased vulnerability (Birkmann, 2007). Flood events can impact various entities both in urban and rural areas, while the extent of the impacts tends to be very high in urban areas (Tamiru and Dinka, 2021).

Nigeria has witnessed many flood events over the years with different forms of impact, with the flood event of 2012 seen as the most catastrophic among many (Amangabara and Obenade, 2015; Nemine, 2015; Ajaero *et al*., 2016; Eboh *et al*., 2017; Chigbu *et al*., 2018; Ezeokoli *et al*., 2019; Akukwe *et al*., 2020; Okafor, 2020; Chukwuma *et al.,* 2021). The 2012 flood scenario, according to the National Emergency Management Agency (NEMA), affected 30 States in Nigeria, with 7 million people affected in these States, 597,476 houses destroyed, 2.3 million displaced, and 363 deaths reported with a significant track of farmland, and other means of livelihood destroyed, animals and other biodiversity were also gravely impacted upon (Amangabara and Obenade, 2015; Okafor, 2020).

Flooding events that occurred in Ibadan in August 2011 and July 2013, claimed many lives and properties. This historical update shows that flooding and flood management have become one of the issues to contend with in the capital city of Oyo State. Eleyele areas being a populated environment now keep increasing in population due to socioeconomic activities around the area. The increase in population brings different developments to a particular area. Some of the causes of flooding in Nigeria are lack of drainage network, indiscriminate disposal of wastes leading to the blockage of drainage channels, climate change, heavy rainfall, melting of glacial and ice sheet, tidal waves, population increases in urban coaster areas, etc. and the combination of these factors cause flood disaster (Adeoye *et al.,* 2009).

Farinmade *et al.* (2021) assessed flood vulnerability areas in the Eti-Osa area of Lagos. Their study employed Geographical Information System (GIS) and remote sensing in preprocessing and processing of acquired spatial information. Five flood-vulnerable zones were identified from the analysis and are; very highly vulnerable zone (23.59%), highly vulnerable zone (12.23%), moderately vulnerable zone (10.04%), less vulnerable zone (9.52%), and none-vulnerable zone (44.62%). Their findings show that residential areas are vulnerable to socio-economic development because of loss and damage to the properties of residents.

Olayinka *et al*. (2017) assessed flood-vulnerable areas of Lagos Island and Eti-Osa Local Government Areas of Lagos State. Their study used HEC-HMS (Hydrological Engineering Centre-Hydrologic Model System), HEC-RAS (Hydrological Engineering Centre-River Analysis System), and Analytical Hierarchy Process (Pairwise Comparison Approach) to determine flood-vulnerable areas. Ugoyibo *et al.* (2017) examined flood susceptibility in Anambra East Local Government, Anambra State, Nigeria. Their study used Boolean operation (ArcGIS raster calculator tool) to identify flood vulnerability areas and accounted that 76.24% of the total land area is prone to flood and most of the flood-prone area is for agricultural purposes. Their study only identified flood-prone areas and the extent of spatial development in those identified areas and accounted for the number of buildings to be affected by flooding in flood-prone areas.

Atijosan and Isa (2023) assess flood vulnerability assessment using an improved integral value of inverse function ranked, Fuzzy Analytical Hierarchical Process (FAHP) technique for fast and accurate computation of flood vulnerability assessment across Oyo State, Southwest Nigeria with the purpose of determining the spatial extent and flood vulnerability class of cultivated lands, settlements and road infrastructures across the study area for effective flood management. The study used an improved integral value ranked FAHP technique using both the left and right inverse function of a triangular membership function with an index of optimistic function to derive the weight for each input criterion. The result revealed classes of flood vulnerability of cultivated lands, settlements and paved road infrastructures across the study area.

Adelalu *et al.* (2024) assess the socio-economic impact of Yedzeram River bank erosion and floodings on the livelihood of Southern Mubi community dwellers in Adamawa, Nigeria. Random sampling method was used to sample 113 households with 7 key informants selected from among local leaders: 4 “Maiagwan” and 3 officials responsible for disaster risk reduction and management at the state level from the study. The results indicate that river bank erosion and flooding are the primary hazards affecting the communities in the study area. The study recommends floodplain zoning to lessen the impact of this erosion on the populace along the Yedzeram River.

Therefore, inhabitants around Eleyele Dam settlement and its catchment area(s) raised alarm about flooding and its effects on the lives of people and their properties. This underscores the need for this study to map the floodplain area(s) and determine the contributing factors in the study area in order to find a reasonable solution, prevention and mitigation strategy for this menace.

MATERIALS AND METHODS

The study area

The study area is Eleyele and its environs which is partly located at Ido Local Government Areas and Ibadan North West Local Government Area in Ibadan metropolis. The study areas lie at approximately latitude 7°25'30'' to 7°26'30'' N and longitude 3°51'30' to 3°52'30'' E. The Dam is surrounded by a variable margin of woodland, beyond which is urban development on all sides of the Dam and mostly dominated by the rural fishing communities of Ilaje and Yorubas. Eleyele Dam is located to the north-west of the Ibadan City centre bounded by Eleyele urbanisation in the south, the areas of Apete in the east, Awotan in the north and Ologuneru in the North-west. Eleyele Dam is a vital resource for fishery, domestic water supply and flood control; the reservoir is fast being degraded due to various anthropogenic activities around its catchments (Bolaji, 2010; Olanrewaju *et al*., 2017). Eleyele Dam is exposed to flooding, notable among which was the flood event which took place after a heavy downpour of 187.5 mm in about 4-5 hours on August 26, 2011. This flooding occasion was induced by the overflow from Eleyele Dam, causing the

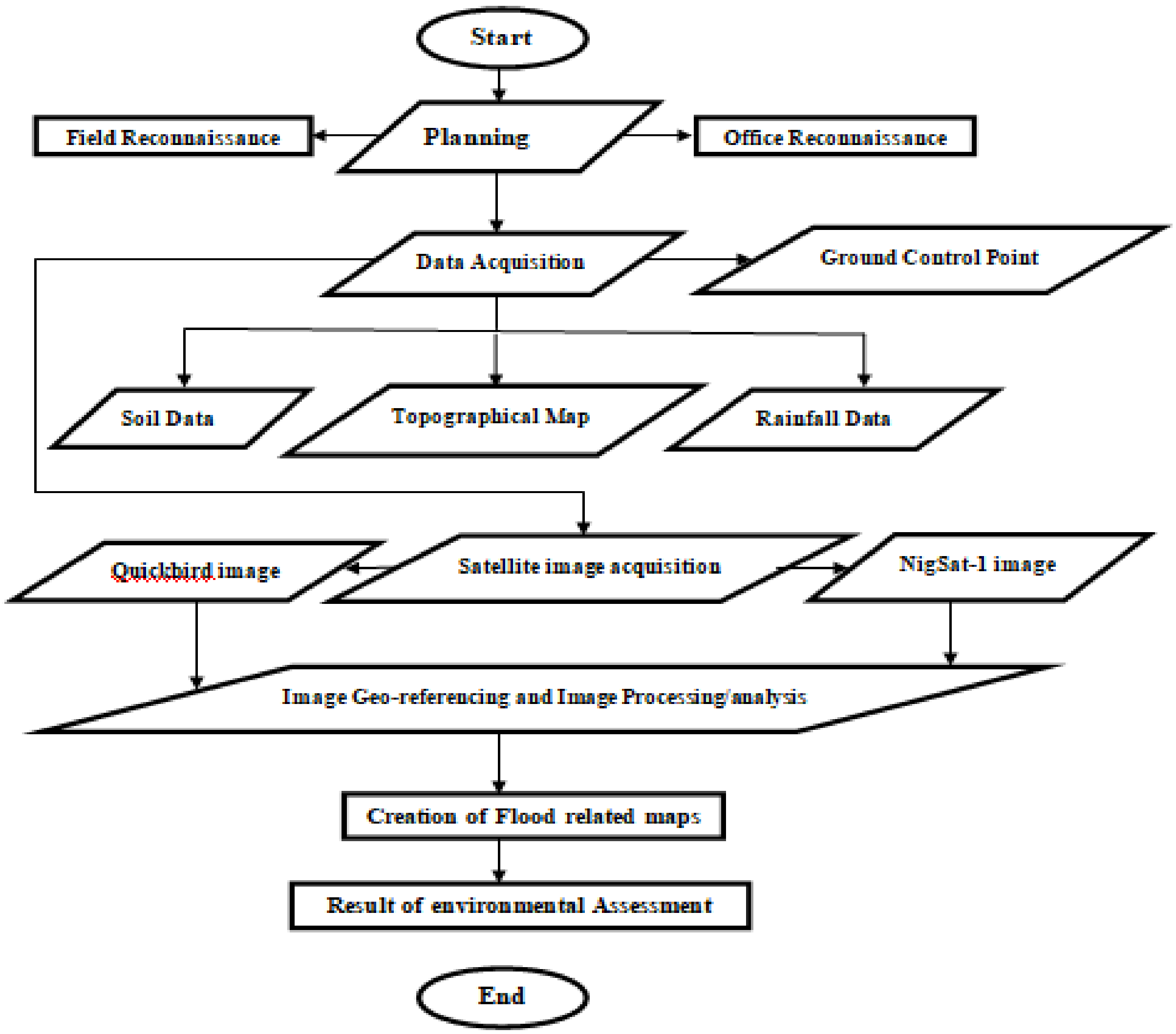

Figure 1. Research methodology/design workflow for the study.

death of over 120 people and serious damage to infrastructure, with many bridges collapsing, roads washed away, and substantial property lost (Adeleru, 2017).

Method of data acquisition

Geospatial data from both primary and secondary sources was used for the study. This will include Ground Control Point (GCP), Topographic maps at the scale of 1:50,000 for spatial referencing, soil map, meteorological data (rainfall) and Sentinel 2 Landsat image 7 (0.75 m resolution). Sentinel 2 Landsat images were used to classify different land-use classes; water/bodies, trees, flooded vegetation, crops, built-up area(s)/ and rangeland. However, people's opinion through structured questionnaire and oral interviews was done. Multi-Criteria Analysis (MCA) using the Weighted Linear Combination (WLC) approach was employed. The brief methodology applied in the present investigation is shown in Figure 1.

Data sources

Data used in this research were acquired from online sources for Shuttle Radar Topographic Mission (30 m DEM), Rainfall data and Sentinel 2 Landsat image and soil data was obtained from the archive of the Office of the Surveyor General of the Federation (OSGOF) Abuja. Table 1 describes the dataset and its source.

Image processing and analysis

Digital elevation model (DEM), Sentinel 2 Landsat image covering the study area were processed using ArcGIS

Table 1. Dataset used, sources and description.

Dataset	Description	Source
SRTM (DEM 30m)	Used for elevation modeling and other hydrological analysis	https://earthexplorer.usgs.gov
Rainfall data	Used to estimate the impact of rainfall to flooding	https://fao.org
Sentinel 2 Landsat	Used for Land Use and Land Cover analysis	https://livingatlas.argis.com
Soil map (shapefile)	Used to determine the soil type of the study area	OSGOF Achieve Abuja

Source: Author compilation 2024.

10.8 and analysed using hydrology in spatial analysts tools in ArcGIS environment for further hydrological processes and production of flood risk zone area(s) in the study area.

Hydrological analysis

ArcGIS hydrology toolbox in ArcGIS 10.8 was used to perform a number of operations on the DEM dataset in order to examine the hydrological characteristics of the study area and their implications for flood susceptibility. Below are among the operations carried out.

1. **Filling of DEM:** This is done to remove minor flaws and depressions from the DEM that can potentially interfere with continuous flow routes. The downloaded DEM was filled using the fill option in the arctool box.
2. **Flow direction:** To determine the direction of the sharpest descent from each DEM cell, the flow direction operation applied the D8 approach.
3. **Flow accumulation:** The flow accumulation operation was carried out to determine the accumulated flow or the number of upstream cells that contribute to the flow of each cell, based on the flow direction raster.
4. **Stream extraction:** The stream extraction operation was used to draw the boundaries of the research area's stream networks using the flow accumulation raster-generated flow direction using a raster calculator.

RESULTS AND DISCUSSION

Some of the factors that determine flood mapping are; land use, elevation, slope, stream power index, rainfall, and proximity to the river channels. Modelling of Eleyele Dam resulted in the generation of contour and elevation maps, slope maps, flow direction maps, flow accumulation, flow length, watershed stream order map, flow basin, stream power index map, and proximity of river channel to the nearby features in the study area. The flood vulnerability map was produced from the weight of the seven (7) contributing factors such as stream power index, distance from the river, land use and land cover, drainage, elevation, slope, and flow accumulation and classified into five (5) classes namely; low, and very low, moderate, high and very high. Rainfall and soil data of the study area consist of only one class and cannot be used together with other seven (7) contributing factors to estimate weighted criteria during the process of weighted sum/overlay.

Topography map of Eleyele Dam and catchment area

The topographic map of Eleyele Dam and its catchment (Figure 2), shows features found on the earth's surface. The characteristics of this map are that the shape of the earth's surface is shown by contour lines, which are imaginary lines which join points/areas of equal elevation on the surface of the land above or below a reference surface, such as mean sea level. The contour map of Eleyele Dam and its catchment area is shown in Figure 2. It shows the amount of land at different heights i.e. lands with the same height are joined with the same contour line. Five (5) meter contour intervals were specified with respect to elevation in the interpolation of the contour map using ArcGIS 10.8. The result from the contour map shows the area with hills which implies that an area of high ground, the ground slopes down in all directions. The contour line forming a ridge tends to be U-shape or V-shape.

The contour revealing the equal elevation of points of the study area ranges from 150 to 240 m above the mean sea level. The highest elevation is at the northern side (left) and the lowest elevation is at the south (downward) of the study area (Figure 2 and Figure 3). The very gentle to gentle slope occurred majorly in the eastern and Southeastern parts, and the strong slope occurred in the north and southeastern parts and downward of the Eleyele Dam (Figure 4). A model (flow direction) of how surface runoff contributes to flooding is important in hydrologic modelling because, to determine where flood water drains, it is necessary to determine the direction of flow for each cell in the landscape (Monsur and Ahmed, 2019). The results of flow direction in this study (Figure 6) revealed water flow in all directions in the study area and range from 1 to 128. The results of flow directions may contribute to surface runoff and lead to flooding (Figure 6).

Flow accumulation denotes the total flow received from the upstream area(s) to a certain place within the boundary. The higher the flow accumulation, the easier to form a run-off which is likely the valley area(s) and an area with 0 values (low) indicates ridge area(s) and such area(s) is of high elevation. The result of the analysis revealed

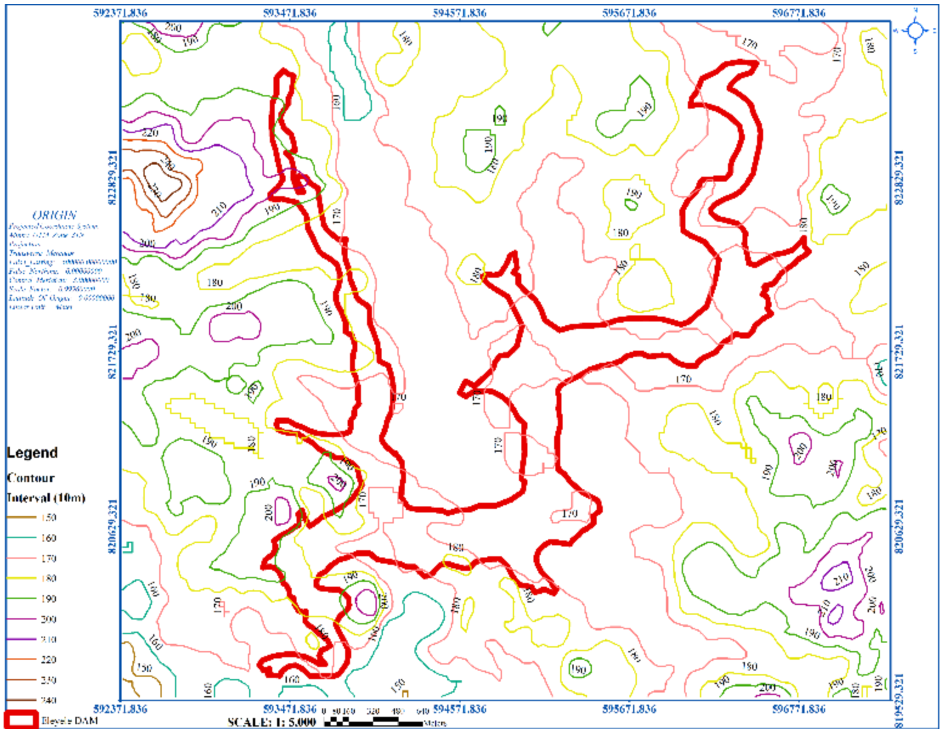

Figure 2. Contour map of the study area.

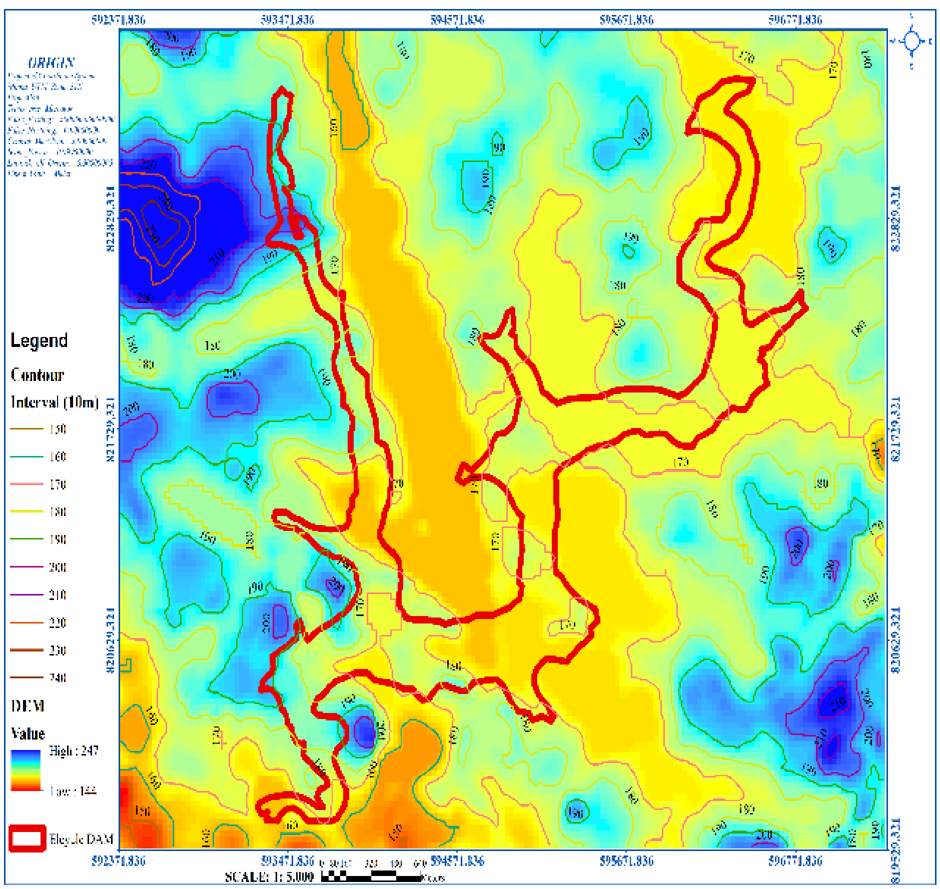

Figure 3. Elevation model of the study area.

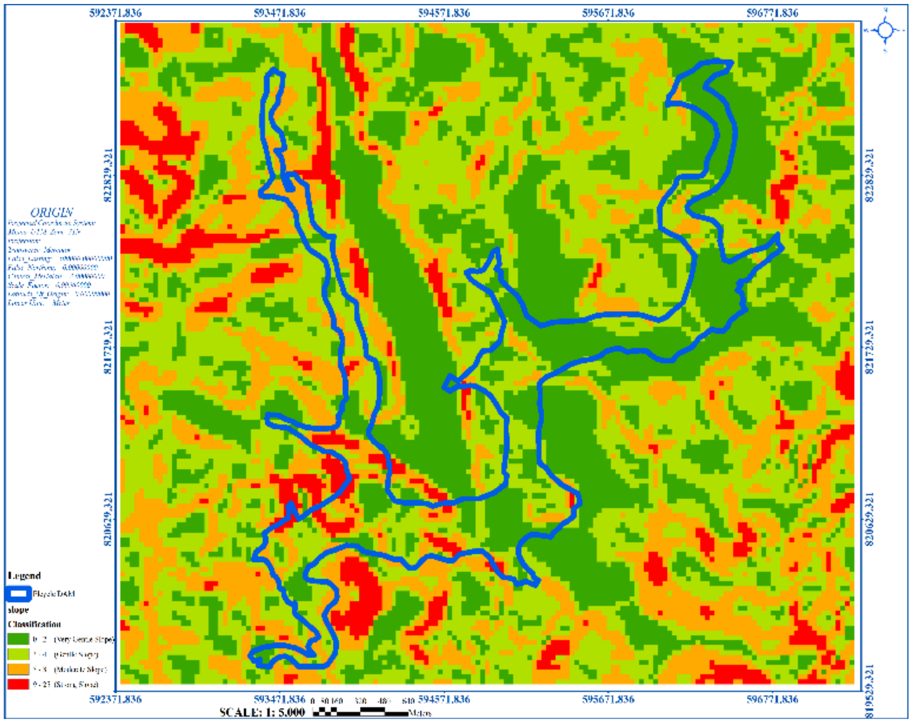

Figure 4. Slope direction of the study area.

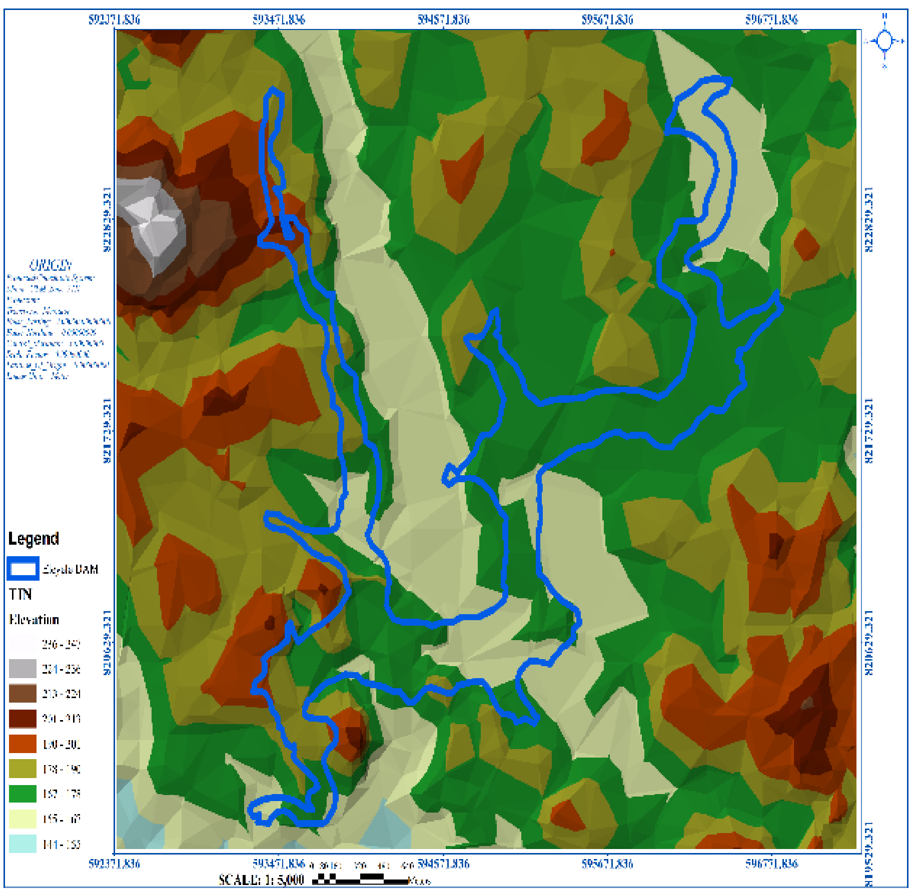

Figure 5. Triangulated irregular network.

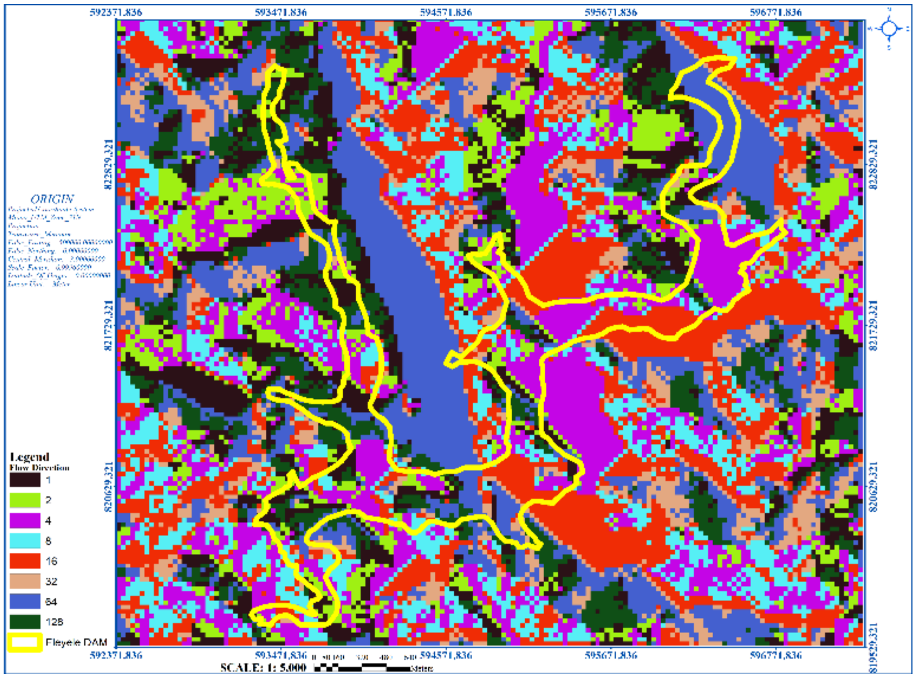

Figure 6. Water flow direction.

area(s) that form run-off (valley) has a high value of 22,866 m and ridge area(s) of low elevation with 0 value (Figure 7).

Water flow length determines the flood flow pattern and displays regions with low and high flood flow and regions liable to flood. The flow length from Eleyele Dam and its catchment area revealed low and high flow length which ranges from 0-8,000 m (Figure 8) which indicates that the longest flow path moves at 8 km. The water flows downward at the southern part of the river in low-length movement while it flows at moderate to high-length movement. This indicates that areas with high elevations tend to have low floods. Thus, all water tends to flow to places of low elevations. The result from the analysis shows that the low area(s) has less volume of water been accumulated; moderate area(s) with a moderate volume of water been accumulated; high area(s) with a low accumulation of volume of water and very high area with a lower volume of water accumulation. The result revealed a low flow length across some parts of the study area, a moderate flow basin cut across the North-Western part and part of the South-West and North-East area and a very high water flow length at the North and South-Eastern part of the study area.

Basin is area(s) required to transport/convey the flow of flood**.** Flow basin maps show how water flow is distributed within the catchment area. Flow basin maps are delineated with the analysis area by identifying ridge lines between basins. Western part and with a high basin majorly at the Northern part of the catchment area. Low flow basin contributes to 78.4% of the Eleyele Dam and its catchment with an area covering 16.752 km^2 of the total catchment, moderate basin is 2.3% of the catchment with an area covering 0.489 km^2**,** high basin is 14.2% of the catchment with area covering 3.029 km^2 and very high basin is 5.2% of the catchment with area covering 1.103 km^2 (Figure 9). A watershed is the land area that drains into the water body.

Watershed is an area characterized by run-off that is being transported to the same outlet. A series of outlet discharged water to the river. This is the stream order which is of different types some are big streams, and small water channels/outlets as seen in Figure 10 (grid code 1-3). Stream order 3 forms from the left upper corner (north) of the study area where stream order 2 joins and enters to Eleyele River. Some of these outlets joined and drained into the river.

Drainage density is an important influencing factor for flood hazard because an increasing drainage density implies increasing flood peaks (Pallard *et al*., 2009). The higher the drainage densities, the lower the infiltration of water to the soil and the lower the drainage density, the higher the infiltration of water to the sub-surface. Very high drainage density occurred at the upper part of the northern area of the study area therefore contributing to high surface runoff to the stream discharge (Figure 11). The larger drainage density causes the water discharge to rise (Ress *et al*., 2020). From Eleyele Dam, drainage, densities are within very low to moderate which means that the density of drainage of water does not flow from the river but from other streams that form tributaries within the study area.

The stream power index (SPI) measures the erosive power of flowing water. This determines the area(s)/

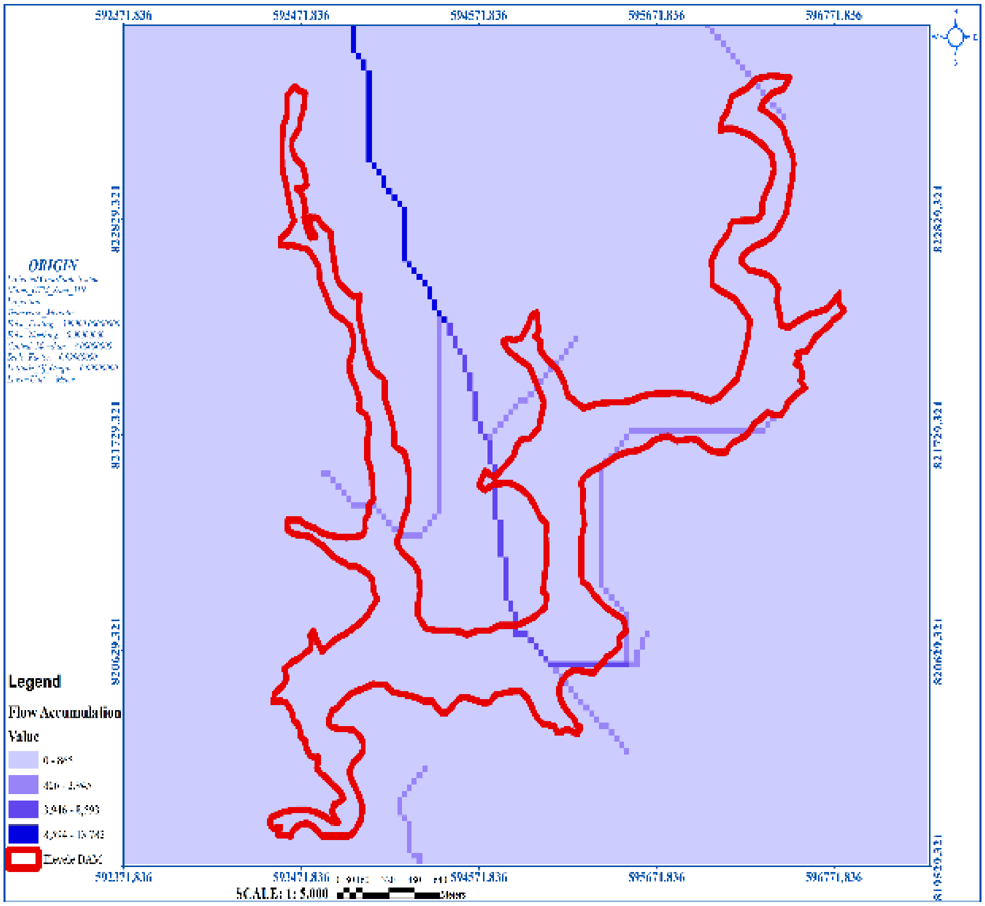

Figure 7. Water flow accumulation**.**

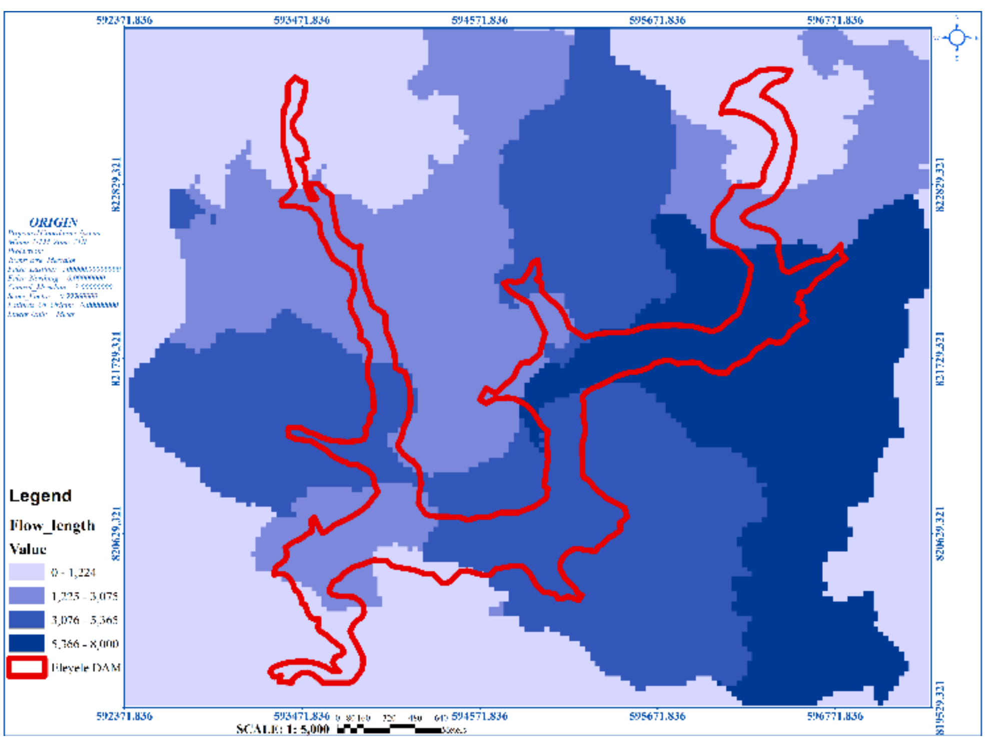

Figure 8. Water flow length.

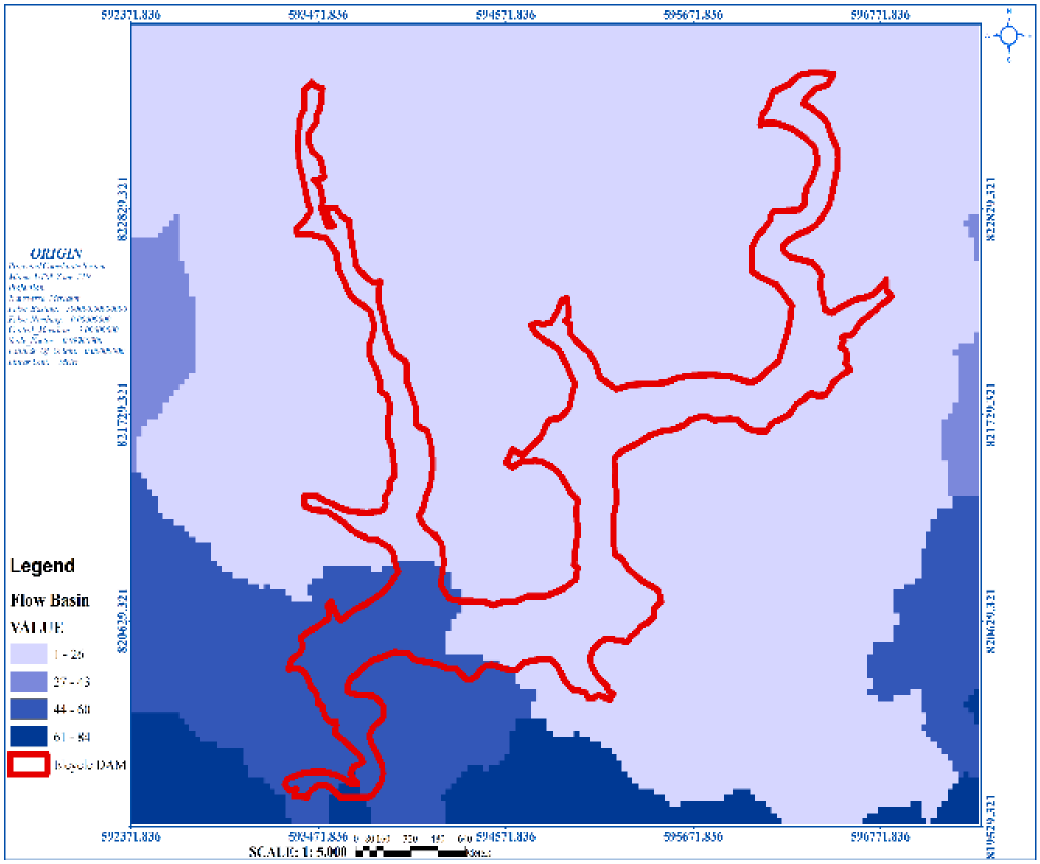

Figure 9. Water flow basin.

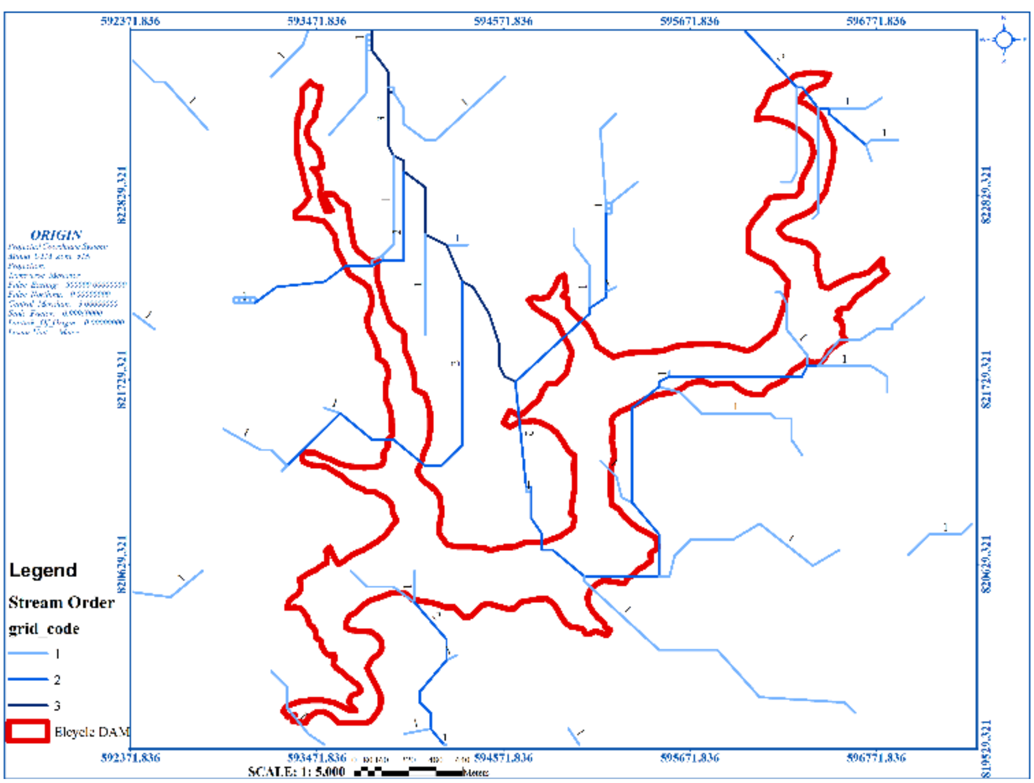

Figure 10. Watershed stream order.

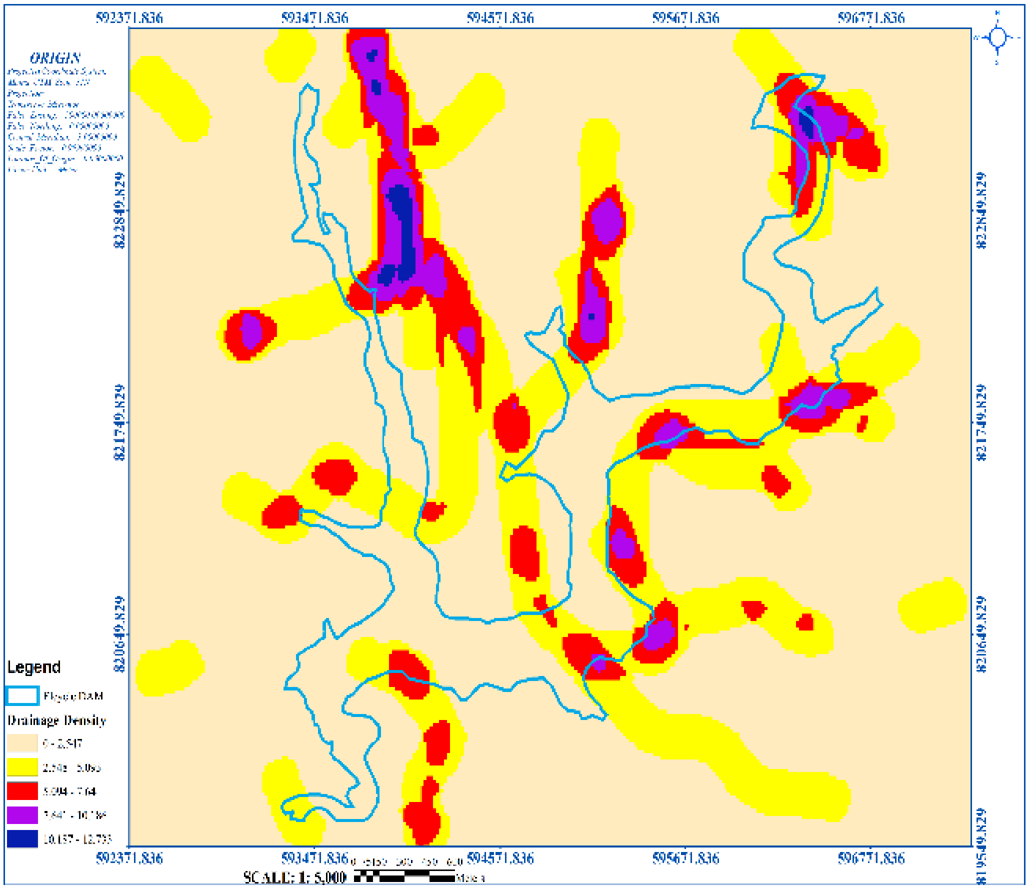

Figure 11. Drainage density.

locations where gullies are likely to form on the landscape. The flow is redistributed between the branches in favour of bigger and deeper ones, which results in silting and drying up of the smaller branches and erosion of the bigger ones. The red areas as indicated are area(s) where erosion is formed which are negative values (-) while the green indicates the area(s) where deposition occurs which are positive values (+) (Figure 12). The high area(s) with the value of 1.207 m (red colour) revealed deposition area(s) and the low area(s) with -3.108 m indicates erosive area(s).

Total surface volume of water in Eleyele Dam

The total surface volume of water in Eleyele Dam was calculated as 286201786.492 m^3. This was done by selecting the highest contour value within the Dam and surface volume was calculated using the height below the highest value. However, the Dam total area covered by water in 2D was 17735221.820 m^2 and 3D was 17785512.402 m^2 (Figure 13).

Flood simulation mapping in the study area

Flood simulation mapping was done in the Arcscene environment using the raster image and the base height of the study area. The raster image base height was generated from ArcGIS 10.8 and imported to Arcscene 10.8 environment to prepare flood simulation map of the study area. Figure 14a indicates the flow of flood to the surface of the study area. The blue colour indicates the flood level underneath the landscape. The flood simulation was done at 15 seconds as seen in Figure 14c. From Figure 14a and Figure 14c, the yellow colour indicates the highest height and navy blue indicates the lowest height above the landscape.

Flood risk assessment of Eleyele Dam and its catchment area(s)

The floodplain map of Eleyele Dam and its catchment shows the areas that are inundated with flood in the Eleyele catchment. This can be determined by various surface analysis tools prerequisite to Triangulated Irregular Network (TIN) in a GIS environment. Triangulated Irregular Network is the Digital Terrain Model which satisfactorily shows areas that are prone to flooding (floodplain). Figure 5 is the Triangulated Irregular Network (TIN) map of the Eleyele catchment topography. The TIN of the catchment explains the areas that are prone to flood

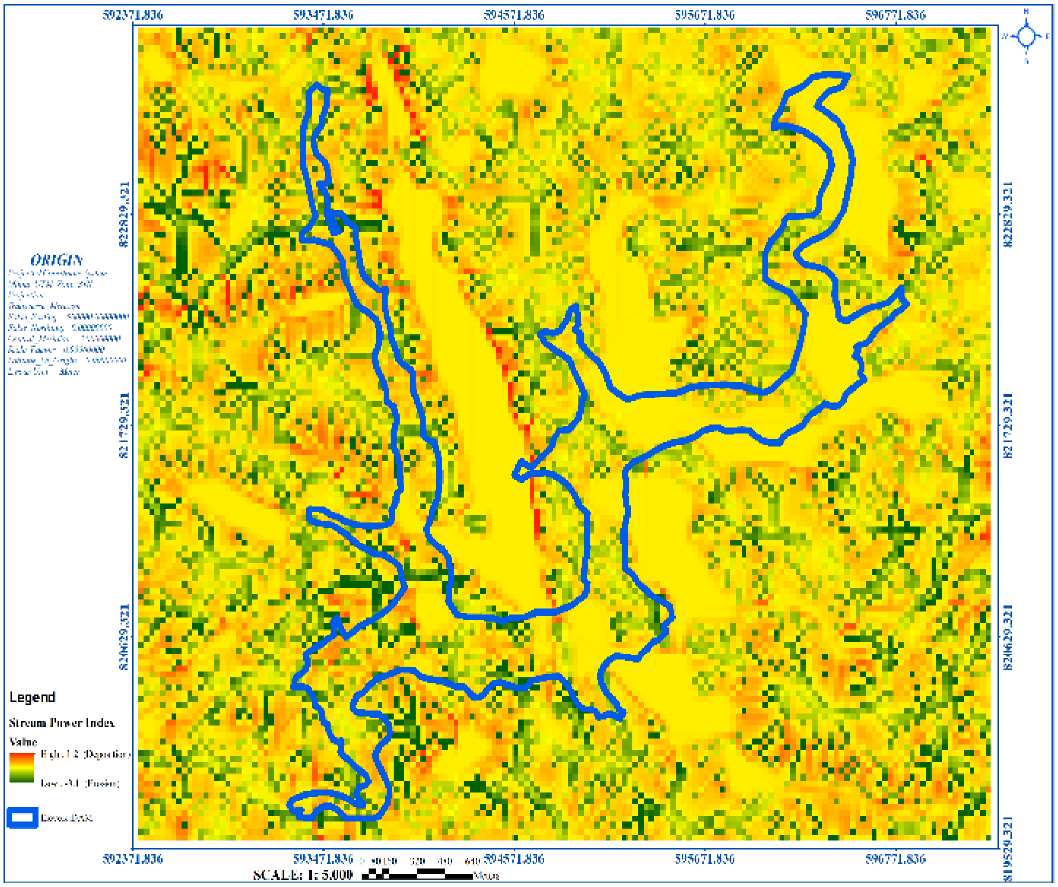

Figure 12. Stream power index.

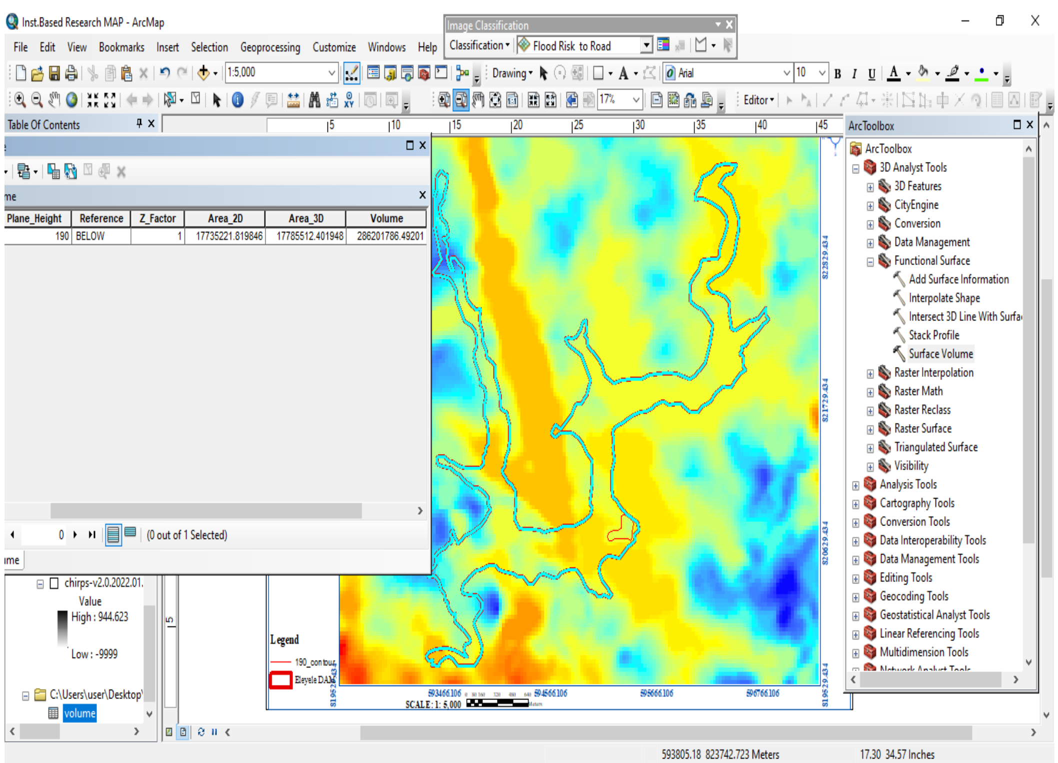

Figure 13. Surface volume of Eleyele Dam.

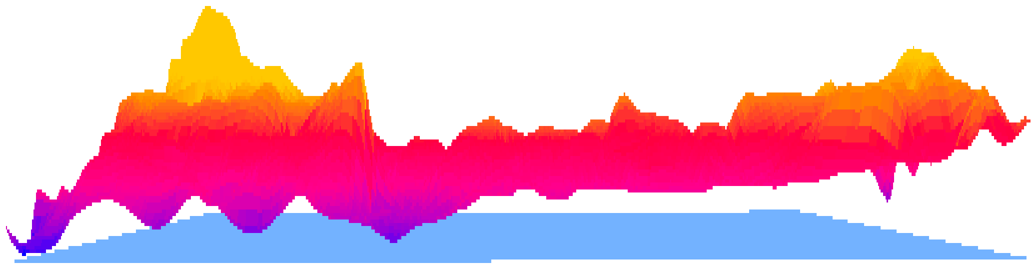

Figure14a. 2D Position of risen of flood to the surface.

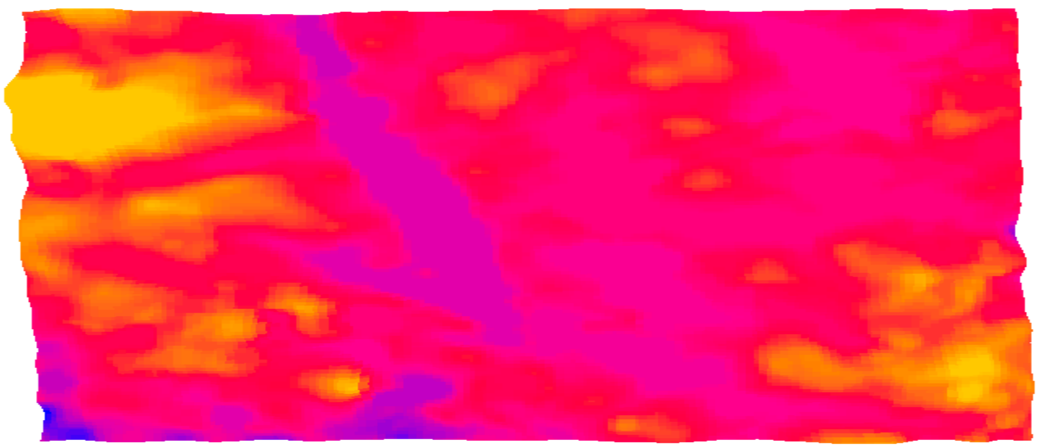

Figure 14b. Base height of the study area.

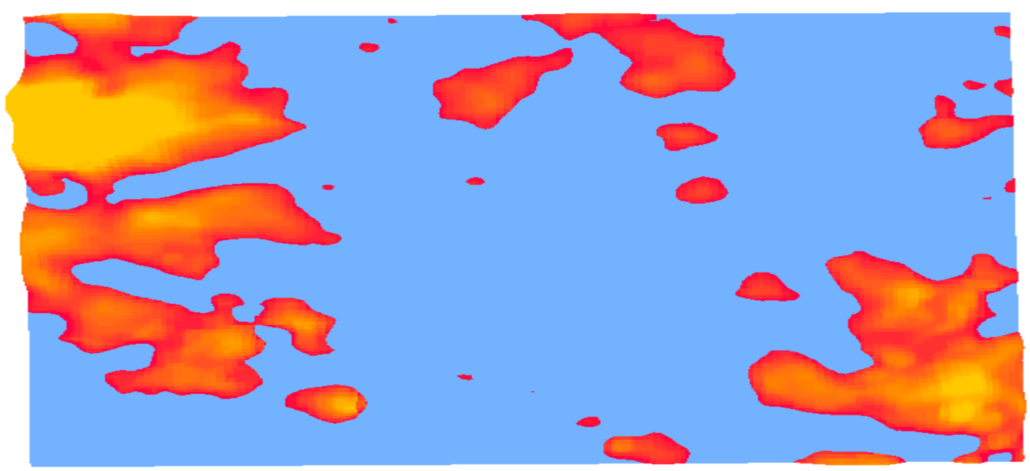

Figure 14c. Flood simulation at 15 seconds to the surface of the study area.

going with the fact that water will always flow from areas of high elevation to areas of low elevation.

Land use and land cover

From Table 2 and Figure 15, the total area covered by land is 21,195,100 m^2 = 2,119.51 hectares = 21.1951 km^2). However, the land use area by each category was revealed as water area(s) covers 379,600 m^2, trees area(s) covers 828,600 m^2, flooded area(s) covers 14,800 m^2, crop area(s) covers 12,500 m^2, built-up area(s) covers 1,746,4200 m^2, and rangeland area(s) covers 2,495,400 m^2. Moreover, the land cover shows that the study area

Table 2. Land use and land cover of the study area.

LULC Category	Area in Km^2	Area in Hectares	Area in m^2	Area in %
Water	0.3796	37.96	379,600	1.79
Trees	0.8286	82.86	828,600	3.91
Flooded Vegetation	0.0148	1.48	14,800	0.07
Crops	0.0125	1.25	12500	0.06
Built Area	17.4642	1,746.42	17,464,200	82.40
Rangeland	2.4954	249.54	2,495,400	11.77
Total	21.1951	2,119.51	21,195,100	100

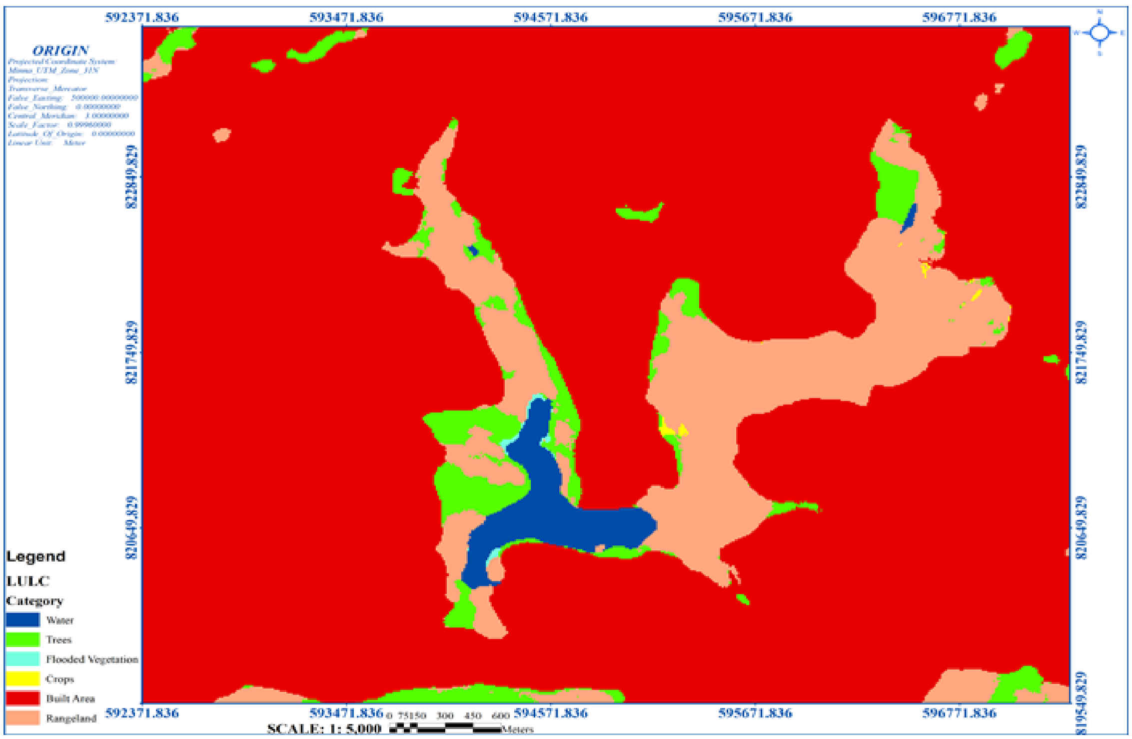

Figure 15. Land us e and land cover of the study area.

has been built up by 82.40% of the total area covered. The built-up area was regarded as a high vulnerability because the presence of hard surfaces can prevent easy infiltration and thereby enhance higher runoff which can easily cause flood (Berezi *et al*., 2019). Hence the connection between built-up areas and floodplain/wetland/riparian vegetation can be influenced by urbanization leading to the reclamation of sensitive land areas such as floodplains. However, the water area(s) is very small with 1.79% land cover and flooded vegetation of 0.07%.

Multi-criteria analysis (MCA)

Multi-criteria analysis using AHP was employed to determine the weight of the flood contributing factors. The Analytical Hierarchy Process (AHP) method prioritized erosion-prone areas via pair-wise comparison for studying erosion factors (Zlaugone *et al*., 2020). Before carrying out the AHP method, each of the contributing factors is reclassified into five classes which are later classified into five namely; very low, low, moderate, high and very high. AHP is a technique in ArcGIS which is a powerful tool for making suitability maps. AHP is a structured approach; the flood-causing factors were ranked, weighted, and combined to create an extensive food risk map using the AHP. AHP was used to rank and weight the seven (7) flood indicators in order to identify areas at risk and determine the degree of food vulnerability in the study area.

From the Table 3, seven (7) factors were considered for flood hazard which are; stream power index, distance from the river, land cover, drainage, elevation, slope and flow accumulation. The consistency ratio (CR), random index (RI) and consistency index (CI) were used to confirm the

Table 3. Analytical hierarchical process (AHP) factors affecting flood.

Inducing Factor(s)	SP I	DR	LU LC	Drainage	Elevation	Slope	FA	NPEV (%)
Stream Power Index	1	1/7	1/3	1/7	1/3	1/3	1/6	9
Distance to River	1/3	1	4	2	1/7	2	2	21
Land Cover	1/6	4	1	1/5	1/3	2	1/5	14
Drainage	1/7	1/3	3	1	1/3	3	2	17
Elevation	1/3	1/6	1/3	1/2	1	2	1/3	11
Slope	1/7	2	3	2	2	1	1/6	21
Flow Accumulation	1/3	1/3	1/2	`1/3	1/5	1/6	1	7
Total	2.44	7.97	12.16	6.17	4.33	10.5	5.87	100

Key: DR = Distance to River; FA = Flow Accumulation; NPEV = Normalized principal eigenvector.

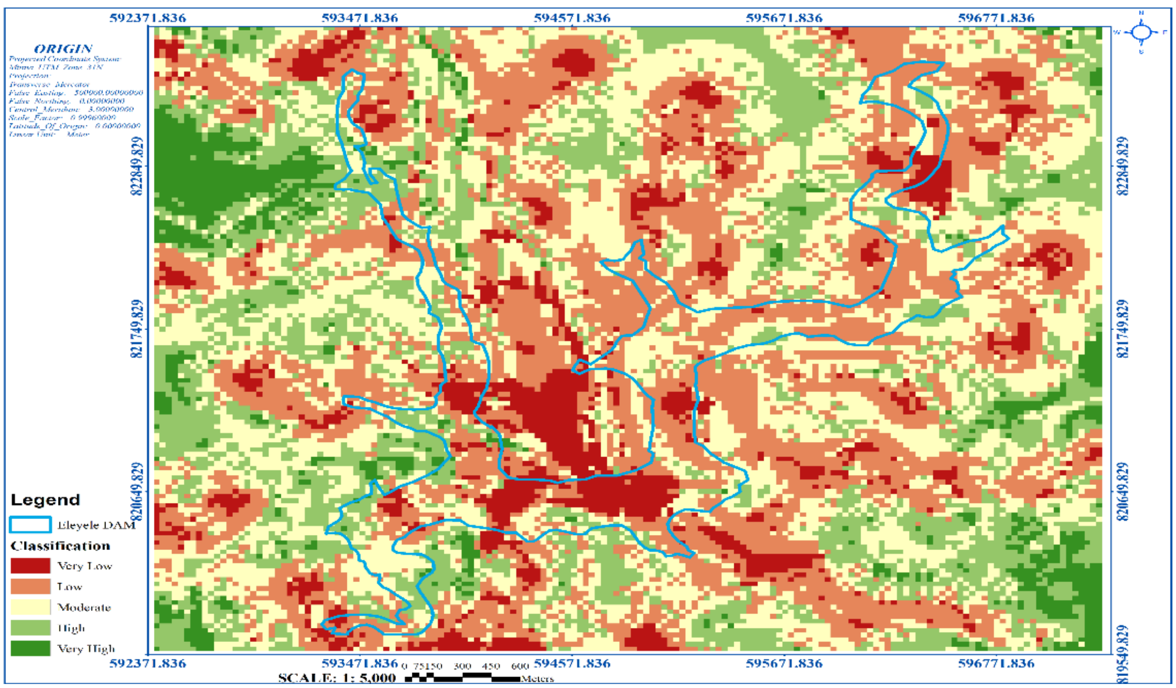

Figure 16. Flood risk map of the study area.

test consistency. However, Table 4 reveals consistency ratio and consistency index less than 0.1 i.e., CR and CI <0.1. The consistency ratio was obtained by dividing the consistency index (0.04) by the random index (1.36). The four (4) factors with the highest effects on the flood hazard in this research are distance from the river with a weight of 21%, slope with a weight of 21%, drainage with a weight of 17% and LULC with a weight of 14%. Other contributing factors are elevation with 11% weight, stream power index with 9% weight and flow accumulation with 7% weight. The result shows that distance from the river contributes greatly to flooding in the study area. This implies that during the rainy season, the river overflows its bank and spreads water to the surroundings. From the above AHP method, the area with each factor is revealed which shows the flood-vulnerable area(s).

Areas at risk of flooding

Five levels of flood risk were identified (Figure 16) and the area of each flood risk category was computed and expressed in square kilometres (Table 5).

1. **Very low risk:** This category included 1.759 square kilometres of land. Due to suitable topography, efficient drainage systems, and low human density, these areas are characterized by reduced flood risks.
2. **Low risk:** There were 6.79 square kilometres of low-risk regions. Although there are certain flood risks in these areas, the risk is generally low because of things like the moderate topography, adequate drainage systems, and controlled population density.
3. **Moderate risk:** The areas with medium risk, which

Table 4. AHP consistency parameters.

Consistency check	Obtained value
Consistency Ratio (CR)	0.03
Consistency Index (CI)	0.04
Random Consistency Index (RI)	1.36

Table 5. Areas under each flood risk category.

Flood risk category	Area (km^2)	Area (%)
Very low	1.759	8.3
Low	6.79	32.04
Moderate	6.847	32.3
High	4.632	21.85
Very High	1.167	5.51
Total	21.195	100

encompass 6.847 square kilometres, are defined by a balanced mix of risk characteristics, such as places with varied land use, moderate population density, and varying topography.

4. **High risk:** There were 4.632 square kilometres of high-risk zones. Due to factors like a dense population, inadequate drainage systems, and adverse geography, these areas are vulnerable to frequent and severe flooding.
5. **Very high risk:** This group included 1.167 square kilometres of territory. These areas have the worst topography, the highest population density, and the worst drainage systems, making them the most vulnerable.

From Figure 16, the areas that are of high vulnerability to flooding can be seen majorly in the northern part (left side) of the study area. From the Eleyele Dam, it majorly shows low to moderate which means that flooding can only come up and high from the river and other adjoining tributaries if there is heavy rain.

Conclusion

This study has mapped the spatial distribution of the flood risk zones of the Eleyele River and its catchment area(s) using the Multi Criteria Analysis through Analytic Hierarchy Process (AHP) method incorporated into the Geographical Information System (GIS) in order to reveal the area vulnerable to floods. The study was the first to use multi-criteria analysis to assess flood zone areas in the study area. The results presented in this research are useful for flood mitigation and control. The proposed methodology showed that very-high and high-flood zones can be mainly identified in the North-Eastern and South-Eastern parts of the watershed. This methodology could serve as the basis for an integrated flood vulnerability assessment. The findings from this research have revealed that high flooding occurred from Eleyele Dam only if there is heavy rainfall within the study area as the riverine area is identified as from very low to low and moderate vulnerable classes. The result of flood vulnerability mapping is very important for the strategic management of flood disaster risk. Finally, the result can help the government, policymakers, and other stakeholders to come up with effective flood control and reduction through the expansion of waterways such as stream/river tributaries, discouraging/removing illegal buildings along the river and making sure that waste/refuse is not deposited along the waterways within the study area.

Recommendations

In order to stop the overflowing of water and protect the river bank from further movement that causes erosion/flooding, this study proposed the following recommendations:

1. Community enlightenment programme on the effects of building close to the river bank and its associated risk of flooding
2. Construction set-back along the river bank to serve as a barrier such as a jetty as part of engineering solutions in mitigating the effect of flood water at the North-Western part of the catchment should be encouraged. The barrier will serve as a barrier to the flow of water down the catchment and also impound water for domestic and industrial use.
3. Need for floodplain regulation to control future occurrences of flooding in the study area.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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