Geographic Information System application in flood risks prevention, hazards reduction and planning

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Abstract. The effects of Flood hazard mapping and flood inundation modelling in saving lives and properties in our societies cannot be overemphasized. Haphazard land use planning and lack of compliance to rules and regulations concerning setbacks have been observed to worsen the impacts of flooding and equally pose as major contributing factors to the exposure of people to flood risks in the study area. The study aimed at determining the built areas within the floodable area. Integrated Geographic Information System (GIS) and Remote Sensing were utilized to analyze the topographic data and the land use data generated from the satellite imagery of the area. The study revealed that nearly half of the buildings and infrastructures in the study area lie within the flood plain. Applications of GIS and Satellite Imagery analysis techniques were used to estimate the population at risk of flooding in the study area. We submit that space based and Geospatial data analysis and applications in flood risks assessment and planning prior to infrastructural development would go a long way in the preservation of lives and properties and prevent great economic loss as a result of flooding.

Keywords: Geographic Information System (GIS), flooding, risk prevention, planning, and sustainable infrastructure.

1. Introduction
The negative effects of flooding on lives and properties cannot be over emphasized and can only be imagined than experienced, these include loss of lives and properties, inconveniences of relocation and recoveries [1]. The increase in global temperature that has led to heavy rainfall, polar ice melting, rise in sea level and other environmental challenges call for concern. Flooding has been one of the major problems causing havoc in many parts of the globe. These havoc need to be tackled with effective planning, and respect for setbacks. Geographic Information Systems can provide a platform for planning and flood risks prevention mechanism. The efficacy of Information Technology in Risks Assessment and analysis is of great importance to enhance qualitative decision making in order to save lives and properties.
Worldwide, flooding poses a significant danger to lives and property. It is also responsible for about a third of all fatalities, injuries and damages from natural disasters [2]. Flood hazard mapping and flood inundation modelling are the crucial parts in flood mitigation measures and land use planning. Progresses in geospatial technologies (GPS, Remote Sensing and GIS) has empowered the procurement of data and analysis of the river basin for flood mitigation ventures for the safety of structural or non-structural features in a speedier and more precise ways. GIS encourages incorporation of spatial and non-spatial data for adequate decision making in a problem solving environment. Flood maps assist in critical decision-making in flood mitigation, land use planning, emergency management and general public awareness mechanism. GIS can combine and analyze data like precipitation, land use, elevation, social and economic information. These could be inventoried for some time later. Flood maps are helpful in flood damage appraisal, future flood mitigation planning and flood control. Causes of flooding: [1] opined that causes of flood in Nigeria could be either natural or man-induced. Natural causes can arise from heavy or torrential rains, rainstorm, ocean storms and tidal waves usually along the coast. [2] observed that man-induced causes include burst of main water pipes, dam burst, levee failures and dam spills. Flooding occurs throughout Nigeria in the following forms; coastal flooding, river flooding, flash floods, urban flooding, Dam bursts and spills and levee failures. The built environment is quickly changing. Fresh advances might influence vulnerability, and in fact hazards, significantly. Therefore, the map apprising should progress at similar pace as hazard map or any significant alterations in the flood plain. The United Nations Sustainable Development Goal 11 laid emphasis on making human settlements inclusive, save, resilient and sustainable. Applications of Geographic Information System and remote sensing in planning would support in the achievement of this goal.

2. Methodology
The satellite image and the elevation data of the study area were obtained. The hill shade map of the area was produced from the elevation data using ArcGIS 10.5. Land use map of the area
was produced by feature extraction and digitization of the satellite imagery. Five classifications were made from the base map which include; built-up areas, roads, water body, grassland, and vegetation. The land use map was overlaid on the hill shade map to determine the land use features in the floodable zones of the hill shade and the areas in the high elevation zones. Geoprocessing analysis of intersection was carried out to intersect the floodable layer and the residential area so as to determine the residential areas that falls within the floodable zones.

![Figure 2. Hill shade map of the study area](image)

![Figure 3. Land use map of the study area](image)
3. Results
It was observed that nearly half of the floodable zones in the area are residential, while more than half of the study area falls within the low elevation area. Roads and vegetation including farmland in the area are vulnerable to the effects of flooding. The residential locations that fall within the floodable zone may be submerged in case of heavy rainfalls due to the river overflowing its boundaries and erosion from the high elevation areas. Figure 1 is the satellite imagery of the study area. Different land use could be inferred from the imagery. Figure 2 shows the digital terrain model of the study area. The brighter areas are the regions with high elevation while the darker areas have lower elevations. It can be observed that there are patches of built-up areas in the region with low elevation. Figure 3 is the hill shade map of the study area. 3D view of the areas can be observed; the extent of depression and elevations can be clearly distinguished. Visual deduction of floodable areas can also be made. The extraction of the floodable areas from the hill shade map was done and shown. Figure 4 is the land use classification map of the study area, overlaying the land-use map and the floodable region.

4. Discussion
Flood map has the capacity of empowering residents and property owners with useful information that allows them to make informed decisions about the imminent flood risks and this would guide their levels of emergencies preparedness. [3] opined that recent cases of major flooding across the globe has further spiked the calls for urgent and thorough flood risk assessments in both rural and urban settings: Pakistan had a major flooding incident in 2010; Australia experienced one between 2010 and 2011, while China, Thailand, Laos, Nigeria and United Kingdom all endured devastating flooding incidents between 2011 and 2012. The need for attitudinal change and adequate land use planning is of great importance in flood control and management especially in the developing world. In some instances, drainages have been observed to be blocked by solid wastes thereby hindering the free flow of water.[4]opined that increasing population growth, lack of suitable waste treatment and disposal sites and inadequate town planning have been observed as palpable causes of poor waste management in our societies. [5] The landfill citing
process requires the evaluation of several criteria such as land use, vegetation classification, road networks, hydrological and elevation data in addition to other socio-economic data. [6] observed that “flooding is the temporary inundation by water of normally dry land, and it can occur in coastal and lake areas, along rivers, from stream blockages and failure of engineering works including dams”. [3] opined that Myriads of approaches and methods exist to determine flood hydrographs and inundation areas. Their selection hinges on the intended accuracy of the maps and the accessible data and resources.

5. Data availability
Flood mapping majorly depends on data availability. The need for accurate and reliable data is of high importance in flood modelling and predictions. Various current flood hazard maps require revision since they are outdated [7][8][9]. The concerted and coordination efforts of UNOOSA, UNSPIDER, USGS and other geospatial data providers have made it possible to obtain accurate and usable digital data for hazards control and mapping. This has helped to ameliorate the problems of certain geospatial data availability.

6. Conclusion
Efficacies of Geographic Information Systems in planning and hazard reduction should constantly be employed in order to save lives and property. Detailed environmental analysis of built environment, should be done before building approval is given by the authorities and agencies concerned. Similarly, in the larger scheme of global environmental management, GIS can be a viable tool in pattern delineation and assessment.

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