Application of Geographic Information System (GIS) towards Flood Management in Calabar, Nigeria

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Key words: coastal zone management, Geoinformation, GIM, risk management, flooding, GIS, drainage network

ABSTRACT

Calabar, the capital city of Cross River State is located on a fan shaped alluvial formation of the Niger delta region, south-south of Nigeria. It is characterized by fast growth in population, economic activities and urbanization, like most coastal cities of the world. The challenges of climate change, rapid land use changes and the fragile geomorphic state of the city were investigated to determine the spatial flooding situation and degree of susceptibility. Geographic Information system was deployed; consequently, sea level rise, increased annual precipitation, and change from pervious vegetated surfaces to impervious concrete surfaces, availability and non-availability of drainage infrastructures were captured and integrated into a common geo-referenced framework (Model). The identified flooding indicator/factors were represented as thematic layers and subsequently simulated to generate flooding susceptibility map. The apparent increase in natural water supply through the swelling ocean, increase in precipitation, expansion of impervious concrete surfaces, about 20% of the city where drainage and waste disposal infrastructures are available and residential structures are well planned, minimal or no flooding is experienced. Floodplains were found to be highly liable to flooding, while areas that are poorly planned with no drainage facilities were found to be highly susceptible to flooding. Digital terrain model (DTM) was developed for the study area. An ideal drainage channel/network for sustainable urban development in the city was thus attempted while other counseling for urban planning were also suggested.

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1. BACKGROUND

Calabar, the capital of Cross River State in south-south Nigeria is geospatially located between latitudes 5.55oN and 5.58oN and longitudes 8.15oE and 8.22oE. It is a coastal city, barely 60 kilometres from the Atlantic Ocean, encompassed by numerous creeks and rivers that drain the alluvial poorly drained lithology. The city is characterised by lowland terrain with the highest point being a little above 200meters above mean sea level, while the lowest point is as low as zero meter above mean sea level. This configuration (see figure 1.1) is highly disposed to seasonal inundation from the ocean due to sea level rise consequent upon the phenomenal global climate change. The influx of the ocean water has been unprecedented because the natural coastal defence services the mangrove forest has been undermined over the year. Increase in population and urban expansion has altered land use and land cover and have ensued rapid conversion of vegetated pervious cover to paved and impervious covers. This development has not only reduced infiltration of rainstorm water, over flooded bank water and ocean surge but have also complicated flood water management in the city and the surrounding suburbs. Moreover, (Okeke, 2003) notes that current environmental problems in the Niger Delta is flooding which comes from rainfall and runoff from rivers and urban chains, and tidal movement and wind.

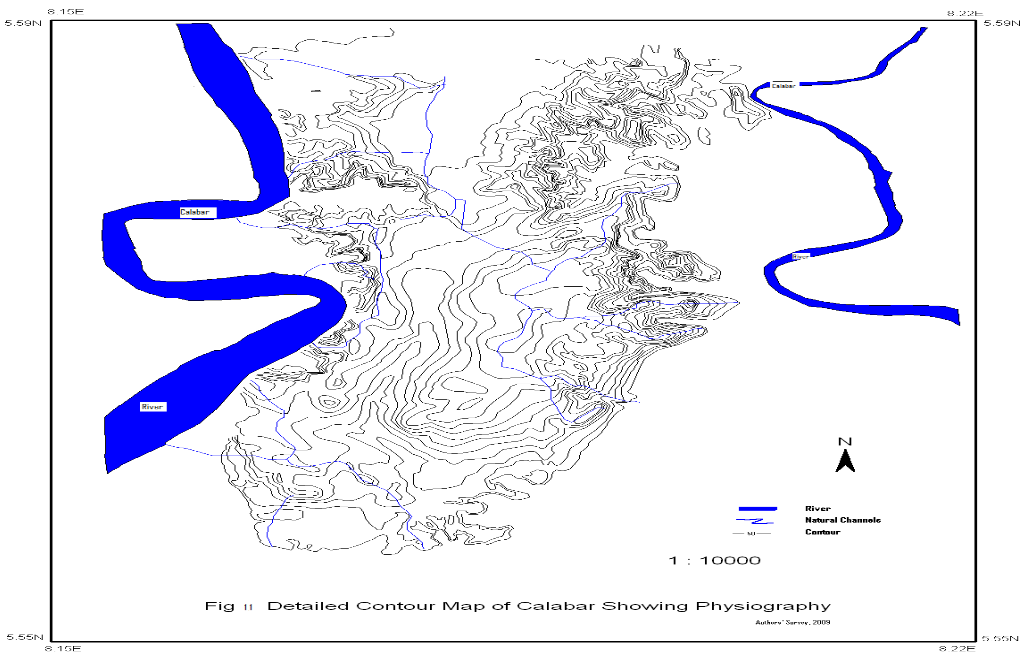


Fig 11 Detailed Contour Map of Calabar Showing Physiography

The environmental challenges of the coastal city is myriad and is corroborated by (Ogba and Utang 2007) who highlighted the degree of vulnerability of the coastal cities of Niger delta to flood and other coastal related hazards. The most affected stakeholders are usually the vulnerable poor who do not have access to areas that are physically planned with drainage structures and other infrastructural facilities. The trend of urban expansion has continued just as industrial activities have opened up new fields without critically considering the consequences of this unbridled development on the environment.

The multiplier effects of poor physical planning have assumed a worrisome dimension in the coastal city of Calabar that necessitate proactive and integrated approach instead of reactive and non coercive formula that has been applied. This study attempts to deploy a geo-information technique that will leverage collaborative and conscious efforts by planners, engineers, surveyors and other relevant professionals to appreciate intuitively and cognitively the challenges of satisfying the need of the society and at the same time making living unbearable by majority of the populace.

2. OBJECTIVES

This work attempts to use the state-of-the art technology to achieve the following:

1. To use GIS to identify the causative factors responsible for coastal area flooding
2. To facilitate data integration that will enable graphic and holistic appreciation of environmental challenges peculiar to the coastal area urbanisation.
3. To evolve and streamline decision making mechanism in a clear manner that offers a forceful and convincing solution to complex man induced environmental quagmire.
4. To initiate a departure from traditional way of adopting remedial solution rather than prevent hazard occurrence.

3. METHODOLOGY

The approach applied in this study is basically a geo-information technique that deployed GIS to acquired secondary data from topomap and added value to the set of data. The generated data were integrated in a digitally geo-referenced framework that enabled better understanding and knowledge for intelligent decision making.

ILWIS- (Integrated Land and Water Information System), was used to prepare the required geospatial dataset for the GIS operation. Contour and point maps were generated from a toposheet. The toposheet of the study area was scanned, geo-referenced and digitised to produce point map and contour maps, referred to as thematic layers. A contour interpolation using nearest neighbour algorithm was applied to allocate height value to every available pixel within the study area (fig 1.2). A digital elevation model was carried on the interpolated raster to express the configuration of the map. The statistics of the digital elevation showed the relative area of the different landform.

An orthophoto covering the study area was examined and digitised to capture the planned area and poorly planned. These layers were not overlaid or crossed because they had different geo-reference. Consequently they were put side by side and compared.

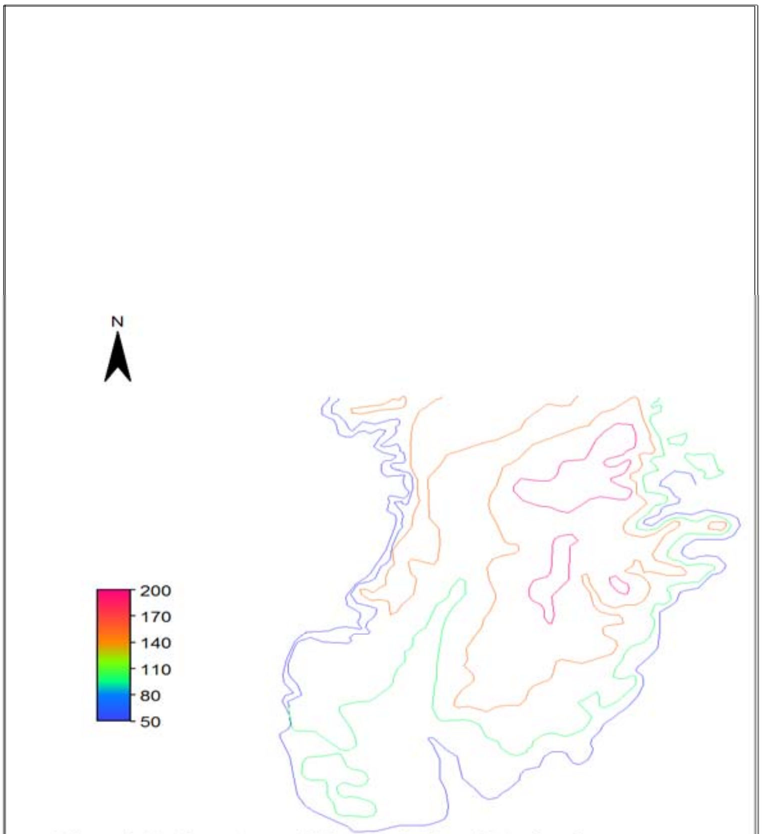
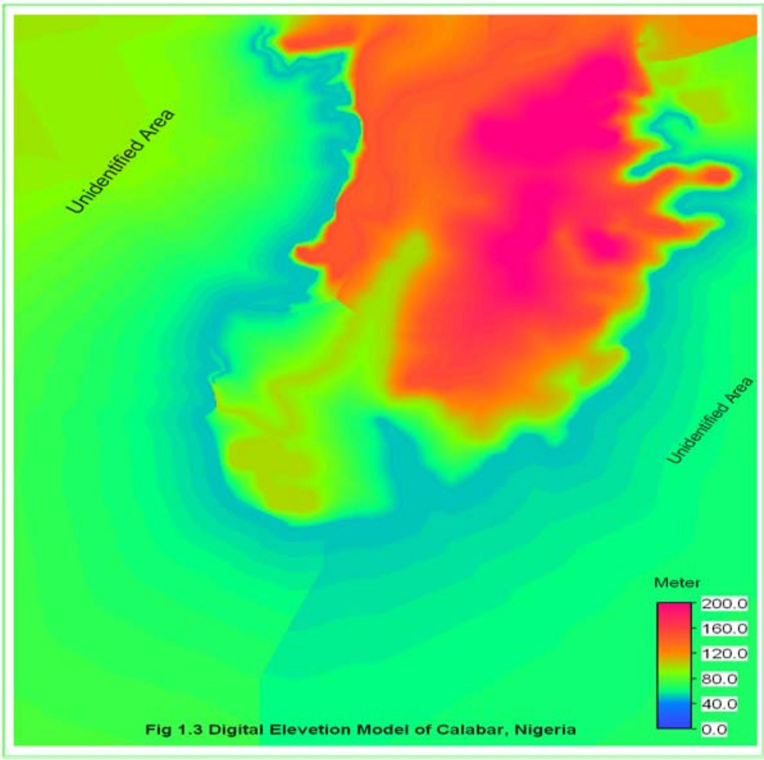


Fig. 1.2 Contour Map of the Study Area

4. RESULTS

The outcome of the digital elevation model showed well graphically distributed landform and terrain. See figure 1.3. The statistic of the DTM showed more than 60% of the entire study area to be low land (flood plain), (50 to 80m), while about 20% is occupied by medium height of about 85 m to 160. See figures 1.3 and 1.4.



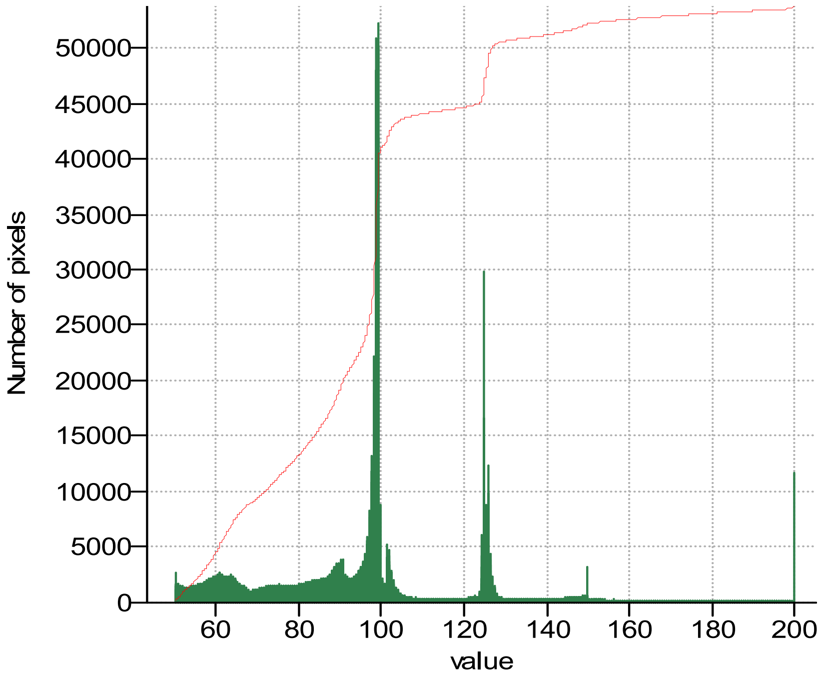


Fig 1.3 The Spectrograph of the DEM

5. DISCUSSION

The results of the analysis showed the graphical representation of the terrain and proportional distribution of study area configuration. It was dominantly lowland, occupying more than 60% of the entire study area. The low areas are relatively very low and considering the proximity of 60km to the ocean and being as low as 0 meter, it is liable to flooding, coastal erosion and other coastal related environmental challenges. This study shows from the DTM, that the study area is highly vulnerable to flooding and there is urgent need to manage the problem by identifying suitable water drainage channels and sites, particularly floodplain that is a not suitable for locating structures and buildings

This information is indispensable for planners and managers of environmental resources to ensure sustainable development.

6. CONCLUSION

The nature and characteristics of the terrain of the study could be appreciated through this study. Apart from easy identification of landscape, natural water drainages could be identified and flood plains were visible yet houses were found on these flood prone areas, which disturbs natural stream flow, perturbs the hydrologic cycle and tendency for flooding. It was discovered from this study that even though nature contributes to hazards significantly, man should be much more accountable for flood. To this end therefore, flood management in the study area requires the prudent utilization of resources and reducing the rate of land cover/use change.

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