An Assessment of Urban Encroachment on Greater-Port Harcourt Watershed Using GIS and Remote Sensing Techniques

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Abstract. Developing countries have been rapidly urbanizing over the last decades, resulting in major environmental impacts and increased vulnerability to natural disasters. The main aim of this study is to critically examine the effects of urban spread along the headwaters of bonny river in Port-Harcourt metrolopolis. Methodologically, various aspects of data acquisition systems such as the use of unmanned aerial vehicle and remotely sensed data were applied. The output was further used to map flood hazards, flood zones and damage potential of the study area. Priority areas and infrastructure at risk were identified by means of their location in flood zones and exposure to floods with high damage potential. In terms of the extent of change, this study revealed that urbanization and loss of agricultural land had been the dominant and intensive land use change along the headwaters of bonny river. Again, the study found that as much as about 20 km^2 of urban land lie under low risk. A number of districts selected for analysis indicated that there are more floodplain dwellers in the high-risk zone 1 area than medium risk zone 2 areas. Zoning is more effective in bare areas, and may be less effective where there are existing structures. It is projected to have a considerable impact on peak flow in a number of watersheds, which could have severe implications for flash flooding in some areas. Therefore to reduce flood risk where there are existing structures, this study suggests the need for the integration of structural and non-structural measures as well as relocation of flood channel dwellers to safer areas could also help reduce flood risk. The research was able to produce the flow extent map using elevation model. The research produced the flow direction of the study area which shows the channel direction of flow. It was observed that flood water flows from higher region to a lower region. This study was able to identify areas vulnerable to flooding using multi criteria approach.

The study concludes that although the impact of urbanization is projected to be insignificant at the watershed scale. Priority infrastructures and areas of high flood risk within the study area is approximately 15.85 km^2 and 19.61 km of road networks are at greater risk of flooding by means of their exposure to floods with the highest damage potential. Urbanization increased flood risk due to greater exposure of elements at risk in the flood plains to damaging floods which includes residential and commercial buildings, roads, schools, clinics and farmlands.

Key words: Urbanization, Headwaters, Flooding, Unmanned-Aerial-Vehicle

Introduction

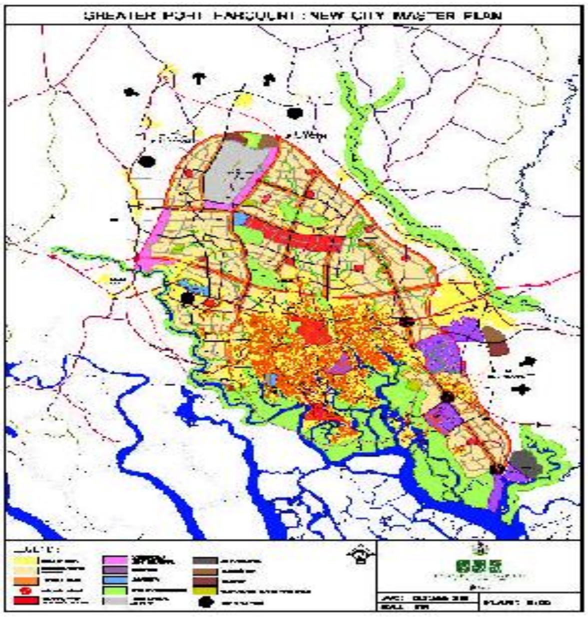
Cities in developing countries are growing at an unprecedented rate, resulting in profound and unintended environmental impacts. In particular, tropical cities in developing countries are increasingly at risk of flooding due to worsening natural and anthropogenic influences. These natural forces include intense precipitation, high tide and low topography. Moreover human influences due to urbanization that resulted in rapid land use changes and increased flood risk require better management (Owei et al., 2010). Greater Port-Harcourt city of Rivers state is a rapidly growing city undergoing planned and unplanned expansion. Urban areas can be flooded by rivers, coastal floods, pluvial and groundwater floods, as well as artificial system failures, but often human factors such as urbanization aggravate floods.

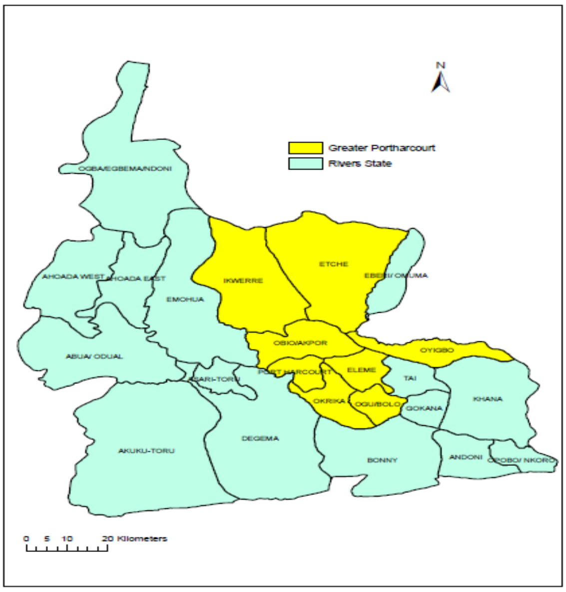
Statement of Research Problem

Greater Port-Harcourt is a rapidly growing city within one of the most important and sensitive wetlands in the world (Abam, 2001). The city is the main economic capital of the Niger Delta widely known as the economic hub of Nigeria's rich oil economy and at the same time the world's third largest wetland. Demographically, it is one of two cities in the delta confronted with high population influx resulting from economic and industrial activities in the area. Very little research has been conducted to investigate the flood impacts on the greater portharcourt city with respect to its rapid urbanization. The risk of flooding to flood plain dwellers of the new city has not been adequately investigated. It is against this backdrop therefore that this study is necessitated.

Greater Port-Harcourt city includes the Port-Harcourt city and the surrounding areas laid out for, urban redevelopment expansion and modernization. It is an agglomeration or conurbation of the old Port Harcourt city and parts of other Local Government Areas originally made up of three LGAs that is: Port-Hrourt, Obio-Akpo and Okrika LGAs Hence, in the urban plan, Greater Portharcourt city now includes eight LGAs such as Port-Harcourt, Obio-Akpor, Okrika, Oyigbo, Ogu-Bolo, Etche, Eleme and Ikwerre. The area of the entire Rivers State is about 11,077 sq km and the Greater Portharcourt city area span 1,900 sq km. Importantly, the watershed delineated for this study span about 0.0156 sq km representing 0.30% of the entire area

Study Area





Aim and Objectives

The aim of this research is to assess the potential flood risk to flood-plain dwellers in parts of Greater ort-Harcourt city of Rivers State in relation to urbanization.

The objectives are:

1) To identify major flood watersheds and natural water ways within the Greater Port-Harcourt city using orthophoto imagery of Rivers State.
2) To determine the flood causative factors and map flood hazard-prone areas within the study area.
3) To make recommendations on how to improve future planning from the outcome of this study.

Materials and Methods

Data Acquisition

This study used both primary and secondary data collection methods. In terms of primary data, Unmanned Aerial vehicle (drone) was deployed to the study area for data acquisition purposes.

Secondary data used for the study consist of:

1. Imageries from Rivers state survey department.
2. Greater Portharcourt city master plan from (GPHCDA)
3. Flood impacted household data from Rivers state Ministry of special duties.
4. Soil data from the FAO was used for determining hydrologic soil groups and runoff potential.
5. Observed daily rainfall data from the Nigerian Meteorological Agency (NIMET).

Data Processing

The background datasets such as Greater Port Harcourt city master plan and imagery of the study area were uploaded into ArcMap algorithm for thematic information extraction. The imagery was processed for geometric precision correction and ortho-rectification. Similarly, the imagery were filtered, registered and enhanced to produce second level images. Pre-assessment maps for the study area were produced based on the background data which gave us the preliminary details about the size, land use, economic activities and development encroachment within the watersheds. The elevation data for the flood watersheds were processed using Pix4D image processing algorithm to generate 3-D surfaces, flood water flow pattern and direction as well as contour maps.

Data Analysis

Geographical analysis allows the study of real-world processes by developing and applying models. Such models illuminate underlying trends in the geographical data and thus make new information available. A GIS enhances this process by providing tools, which can be combined in meaningful sequences to develop new models.

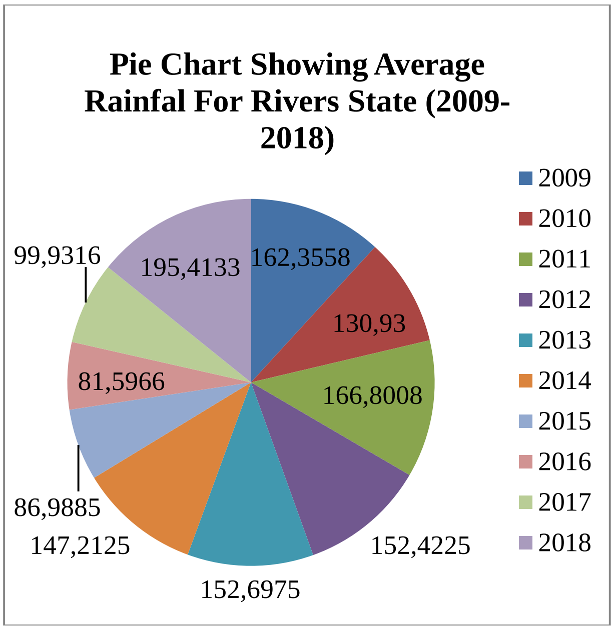
Flood impacted household data was used to determine the amount of people impacted by flooding and there spatial distribution. Soil data were used for determining hydrologic soil groups and runoff potential. Observed daily rainfall data was used to determine the amount of rainfall over the study area. The datasets were analyzed through qualitative and quantitative methods. Some of the analytical tools employed include; calculation of Areas and Distances, Proximity and Overlay Analysis. Vulnerability maps, Graphs and Tables were generated.

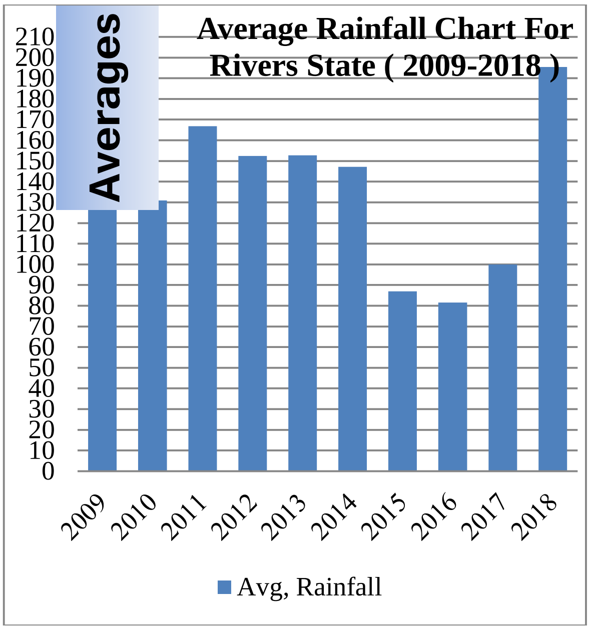
Watershed Morphometry

Watershed	Area (Sqm)	Perimeter (M)	Average Elevation (M)	Road Segment (M)
A: RUKPOKWU	5,808,318	10,493	73	770
B: ALUU	3,414,130	7,665	49	87,366
C: IGWURUTA 1	2,690,218	7,379	58	31,332
D: IGWURUTA 2	1,975,118	7,429	50	118
E: IPO	1,958,831	5,954	62	76,588
Total size (sq km)	15.85 sq km			19.61 km

Result Presentation

Excessive rain, low soil permeability and high water table, the development during construction is likely to encourage runoff due to vegetation clearing since topsoil is vulnerable if devoid of vegetation.

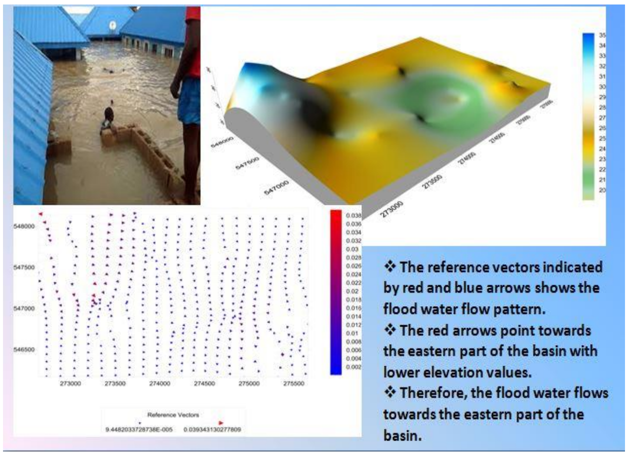


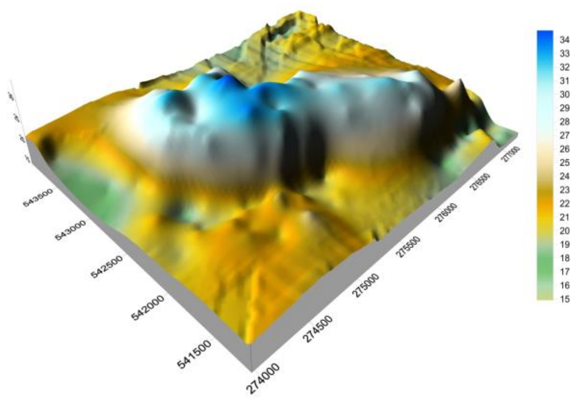


Digital Elevation Analysis

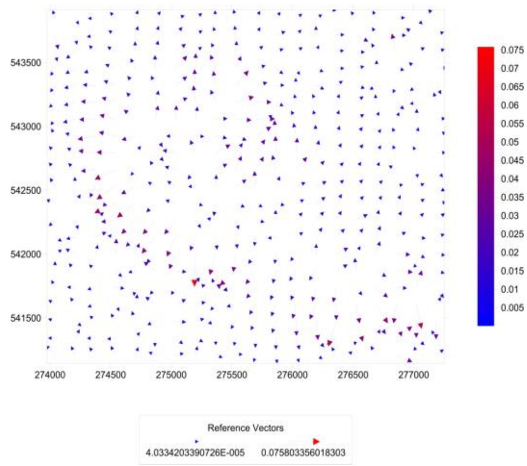
GIS can build three dimensional models, where the topography of a geographical location can be represented with an x, y, z data model known as Digital Elevation Model (DEM). The x and y dimensions of a DEM represent the horizontal plane, and z represent spot heights for the respective x, y coordinates.

The data sets derived from a Digital Terrain Model can be used to analyze environmental phenomena or engineering projects that are influenced by elevation, aspect or slope. The visualization (display) power of the computer allows the terrain data to be visualized in three-dimensional form, often from any angle of view (this is known as point-of-view analysis).

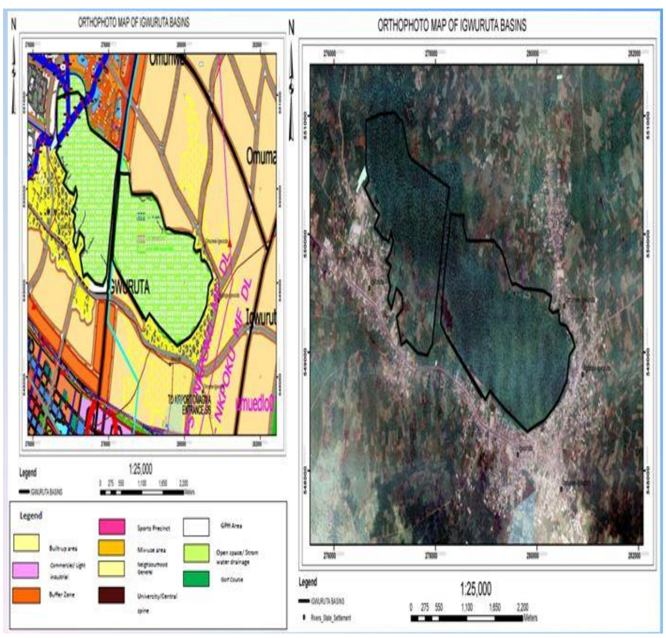


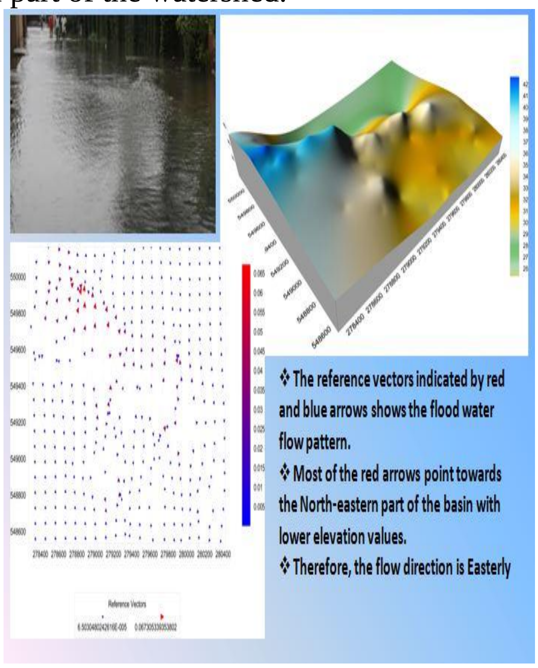


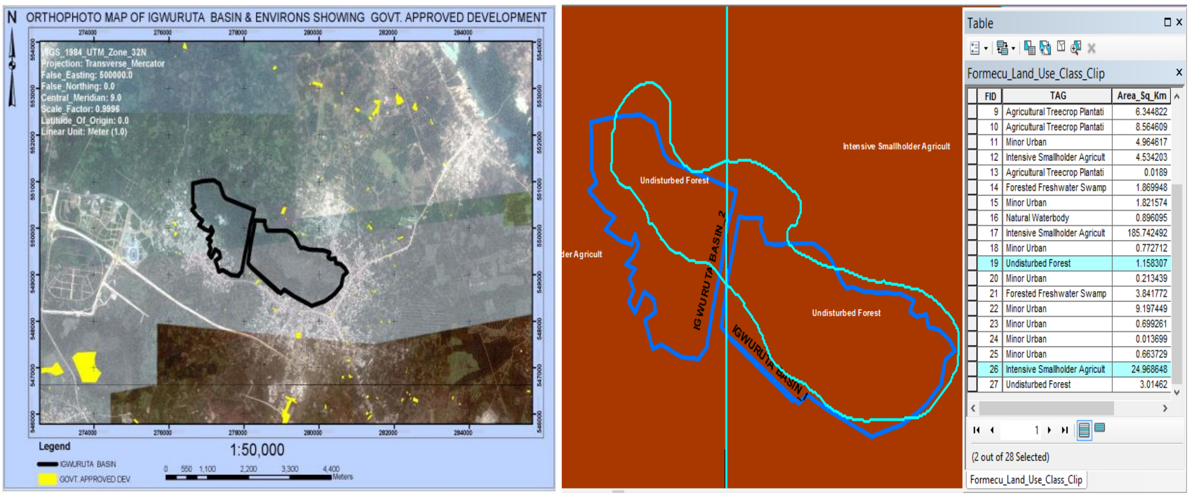
Digital Elevation Model of Aluu Digital Terrain Model of Rukpokwu



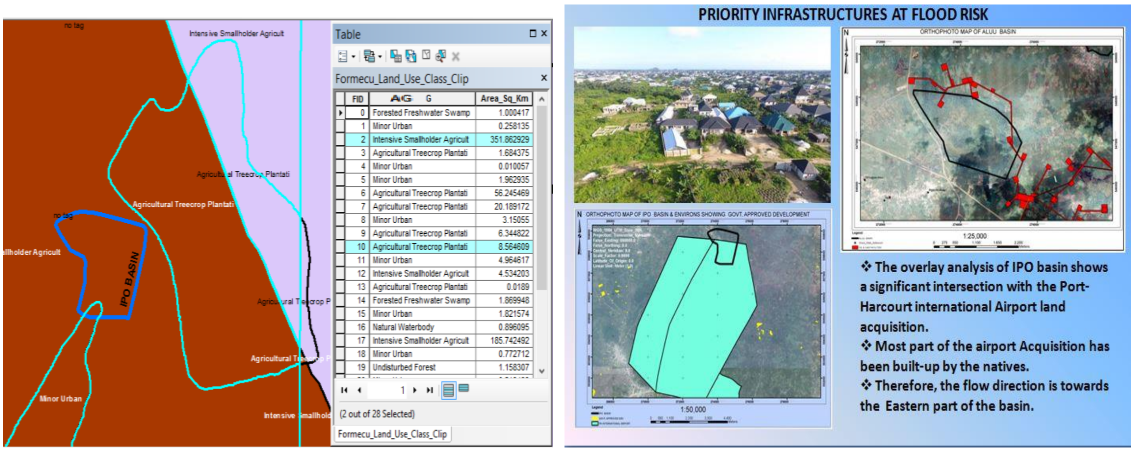
The reference vectors indicated by red and blue arrows show the flood water flow pattern. The red arrows point towards the eastern part of the watershed with lower elevation values. Therefore, the flood water flows towards the eastern part of the watershed.







Querry on the geospatial database showing the predominent agricultural land use type within the Igwuruta watershed.



Querry on the geospatial database showing the predominent agricultultural land use type within the IPO watershed.

Impacts of Flooding in Greater Portharcourt City

I. Property damage
II. Loss of life: drowning, electrocution, etc.
III. Property devaluation
IV. Damage to infrastructure
V. Logistics challenges and man-hour losses
VI. Refuse dispersion
VII. Pollution; especially of groundwater
VIII. Diseases and epidemic risks
IX. Effects on businesses and livelihoods

Recommendation and Conclusion

In view of the results obtained from this study, the following are recommended;

1. There should be an improved drainage capacities across the new city.
2. There is need for construction of large capacity canals to drain the northerly ponded areas
3. The government should ensure the Enforcement of the Greater Portharcourt master plan in respect to infrastructural development.
4. There should be intensive advocacy both from the government and private sectors on conservation of the flood watershed.

5. Give allowance for the possibility of flooding during building and road construction.
6. Provision of early warning systems, risk and disaster mapping & other soft measures Flooding in Greater Port Harcourt city is both natural and man-made and can be controlled by a combination of soft and hard engineering measures; the trend will be more frequent and severe if nothing is done now and there will drain on the city's economy and also displacement of wildlife such as snakes and other dangerous reptiles.

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