MULTI – HAZARD VULNERABILITY MAPPING: AN EXAMPLE OF AKWA IBOM STATE, NIGERIA

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Abstract

Vulnerability mapping has emerged as one of the mitigation strategies in the midst of increasing losses due to environmental hazards in recent years. It generally improves the ability of policy makers to promote disaster reduction thereby protecting inhabitants and their livelihoods, the natural environment, infrastructure and property. Although vulnerability maps can be created manually, they are now mostly created with the assistance of computer technology called Geographic Information System (GIS). Mapping the vulnerability of the region in a GIS environment allows for ease of data editing, integration, analysis, storage and visualization. The resultant product will help to identify, and locate sensitive populations so that emergency managers can customize disaster relief efforts based on needs determined by the identified vulnerability. Vulnerability of the study area was conceptualized in a GIS environment as a combination of Exposure, Sensitivity, and Adaptive capacity maps. The three surfaces for each hazard were generated and combined using the Single Output function of Arcmap 9. The study area is Akwa Ibom State located in the South East Coast of Nigeria, an area prone to sea level rise, coastal erosion and flooding. The result shows that the high and moderate zones are concentrated in the North East and Southern parts of the state while the low zones can be found in the North West. As the state borders the Atlantic Ocean, the study confirms the fact that the southern parts of the state are highly vulnerable to climate change related hazards.

Keywords: Hazard, Vulnerability, Mapping, Akwa Ibom State

Introduction:

Increasing losses due to environmental hazards in the past two decades have led to a general shift in policy from mere postevent response to emphases on loss reduction measures like mitigation, preparedness and recovery programmes (Cutter, Michell and Scott, 2000). Understanding of the intensity in which a population is vulnerability to hazard, has come to play an important role in designing loss mitigation measures.

Coburn et al (1994) sees vulnerability as a measure of how the elements at risk in a landscape would be damaged if they were exposed to the same level of hazard. It is usually seen as being prone to or susceptible to damage or injury. In refining this definition, Blaike et al (1994) sees it as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of an hazard. Vulnerability can be seen as a way of conceptualising what may happen to an identified population under conditions of particular risks and hazards. It describes the condition of groups of people impacted by haz ards who are at different levels of preparedness , resilience and with varying capacity to recover. It equally goes beyond the likelihood of a particular hazard injuring or killing a people, to include the livelihood the people are engaged in and the impact of different hazard on them (Cannon, Twigg and Rowell, nd).

According to Alexander (2012), vulnerability is a vital component of risk and the principal element of disaster impact. The study of vulnerability has come to be seen as part is now called risk assessment. Mitchell (1989) asserts that risk assessment involves the identification of hazards, estimating the threats they pose to humanity and the environment and the evaluation of such risk in a comparative perspective. Granger et al. (1999) emphasized that risk modelling must be seen as an "understating of the probability of occurrence of events of particular severity and the levels of uncertainty that exist in the data employed and the models themselves." Traditionally, the procedure and rationale of risk assessment according to Van Westen (2008) can be summarized as follows: Hazard disaster depends on two factors: hazard and vulnerability. While hazard refers to the probability of occurrence of potentially damaging phenomenon, vulnerability is the degree of loss resulting from the occurrence of the phenomenon. In order to create a risk map, you first generate a qualitative hazard map by combining several factor maps. Then, a vulnerability map is made. The combination of hazard and the vulnerability map results in a risk map. The synthesis of data and the essential mapping of the spatial relationships between the hazard phenomena and the elements at risk require the use of tools like Geographic Information System (GIS).

In most risk management tasks, at least 90% of the information used has some form of spatial content. Hence, to accommodate this spatial emphasis, extensive use is made of GIS in this study which allows one generate, store, analyse and display environmental data easily. The capability of applying GIS in various aspects of risk assessment has been demonstrated by many researchers. Van Westen (2008) used simple data sets from

Colombia (South America) to demonstrate on a national scale the meaning of hazard, vulnerability and risk. Similar procedure were used by Damen and Van Westen (2008) to model cyclone hazard zonation in the South of Chittagong, Bangledish, Van Westen and Tertien (2008) to demonstrate the potentials of GIS in hazard zonation of landslides triggered by earthquakes in Manizales, Colombia, and Van Westen (2008) to demonstrate the use of quantitatively defined weight values in the making of hazard maps.

Granger et al. (1999) equally utilized GIS to synthesize and model the spatial relationship between vulnerability and hazard in order to study the risk faced by Cairns in Australia to multi – hazard phenomenon. Miller and Onwuteaka (1999) evaluated the vulnerability of the landscape to oil spills in the East Central area of coastal Nigeria; while Udoh and Ekanem (2011) assessed the risk oil spill in the coastal areas of Akwa Ibom State. Risk assessment procedure now integrates multi criteria technique with GIS in dealing with environmental problems as GIS has an added advantage, the ability to integrate a wide spectrum of data sets in order to satisfy many stakeholders. Hence, various researchers have effectively applied this combination. These include Jorin et al. (2001) for land suitability assessment; Pramojanee et al. (2001) for flood vulnerability mapping and, Bell and Glade (2004) for Multi-Hazard Analysis in Natural Risk assessment.

Vulnerability can be conceptualized as a function of the character, magnitude and rate of an hazard is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001) . This can be expressed as:

Vunerability = f (Exposure, Sensitivity, Adaptive Capacity)

While exposure here is defined as the nature and degree which a system is exposed to hazards; sensitivity is seen as the degree on which a system is affected either adversely or beneficially by the hazard. Adaptive capacity in the other hand is defined as the ability of a system to adjust to the hazard, to modify and moderate the potentially damages from it, to take advantage of opportunities , or to cope its consequences. The IPCC report upon which the definitions are based, is now being used as the framework for vulnerability mapping (Yussuf and Francisco, 2009).

Worldwide interest in different aspects of hazards has led to the emergence of vulnerability mapping as an important component of risk assessment. Edwards et al (2007) asserts that vulnerability mapping generally improves the ability of policy makers to promote disaster reduction thereby protecting inhabitants and their livelihoods, the natural environment, infrastructure and property. Although vulnerability maps can be created manually, they are now mostly created with the assistance of computer technology called Geographic Information System (GIS). Mapping the vulnerability of the region in a GIS environment allows for ease of data editing, integration, analysis, storage and visualization. The resultant product will help to identify, and locate sensitive populations so that emergency managers can customize disaster relief efforts based on needs determined by the identified vulnerability.

The main objective of this work was to identify and map the vulnerability of the study area to flood and erosion hazards using the framework set forth in the IPCC (2001) and utilized by Yusuf and Francisco (2009) and Udoh (2012). The study area is Akwa Ibom State located in the South East Coast of Nigeria, an area prone to sea level rise, coastal erosion and flooding.

Materials and Methods:

The sum total of Exposure, Sensitivity and Adaptive Capacity maps of the study area were combined to model the multi – hazard vulnerability map of the study area . The exposure of the landscape to flood and erosion hazards were modeled from proxy data of relief, flood plain and slope maps. The surfaces generated were combined to get the exposure surface of the study area in the ARCGIS spatial analyst environment.

The population density of the study area based on the 2006 population census was used to model human sensitivity to flood and erosion; while, Normalized Difference Vegetation Index (NDVI) , a measure of the area of stressed and non-stressed vegetation, was used to model ecological sensitivity. **NDVI** have been found to be a good indicator of the condition of green vegetation.

Human development index (HDI) and poverty index were used as an indicator of the coping capacity of the study area to oil spill. Based on IPCC report, the adaptive capacity is taken as the ability of a system to adjust to hazard, to moderate the potential damages from it , to take advantage of its opportunities or to cope with its consequences. For the study, the United Nations Development Programme’s Niger Delta Human Development Report was used to compile the data (UNDP, 2006). HDI measures the average achievements - human developments – in the Niger Delta region. To calculate HDI, index were created for 3 dimensions of :

- Long and healthy life as measured by life expectancy at birth
- Knowledge as measured by adult literacy rate (with 2/3 weight) and the combined primary m secondary and tertiary gross enrolment ratio (1/3 weight)
- A decent standard of living as measured by GDP per capita.

HDI was then calculated as :

HDI =1/3 (life expectancy index) + 1/3 (education index) + 1/3(GDP index), The HDI figures for the 13 LGA of Akwa Ibom State were extracted from the Nger Delta Human Development Report (UNDP, 2006) while Poverty index was extracted from Ekpo and Uwat (2005).

The political map of the state obtained from Ministry of Lands and Town Planning on a scale of 1:125,000 were scanned into a GIS environment, geo- referenced, and digitized. The attribute table of each Local Government Area (LGA), digitized as a polygon was used to link the datasets to create the base maps used for the GIS analysis. The base maps were converted from vector based shape files to grids (raster based). The conversion made it possible to use all data sets that were connected to shape file with administrative boundaries for further analysis and modelling.

Vulnerability of the study area was conceptualized in a GIS environment as a combination of Exposure, Sensitivity, and Adaptive capacity maps. The three surfaces for each hazard were generated and combined using the Single Output function of Arcmap 9.

Results:

Figures 1 – 4 show the resultant maps that show the vulnerability coverage of the study area expressed as index maps. A combination of the hazard exposure index map, sensitivity index map and the coping capacity map form the final vulnerability map. The areal coverage of the vulnerability surface zones which has been divided into three zones – High. Medium and Low. Analysis shows that moderate vulnerability zone occupies 3175.04 km2 (49.83%), low 2219.82 km2 (34.83%) and High 977.31 km2 (15.34%). The vulnerability index map shows that the high and moderate zones are concentrated in the North East and Southern parts of the state while the low zones can be found in the North West.

The study confirms similar studies that show the high vulnerability in the coastal areas of the study area to climate change related hazard (Udoh and Nkan, 2015). The pattern of the vulnerability shows that out of the components, it is mostly influenced by the exposure layer that also tend to have higher values along the coastal areas and the valleys of the major rivers. The high vulnerability along Ikpa river basin encompassing parts of Uyo, Itu, Uruan and Ikono LGAs is also worthy of note. The hazard exposure levels in this area are high. Uyo being the state capital has been witnessing increasing urban expansion into the neighbouring LGAs. All these show that there is need for closer monitoring of hazard vulnerability in the study area. As a result of the expect increase in the negative influence of climate related hazard, the study brings out the need for mitigation areas to be put in place so as to ameliorate the resultant negative consequences.

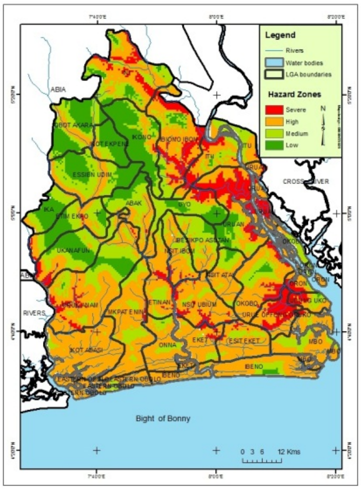

Fig.1: EROSION AND FLOOD EXPOSURE MAP

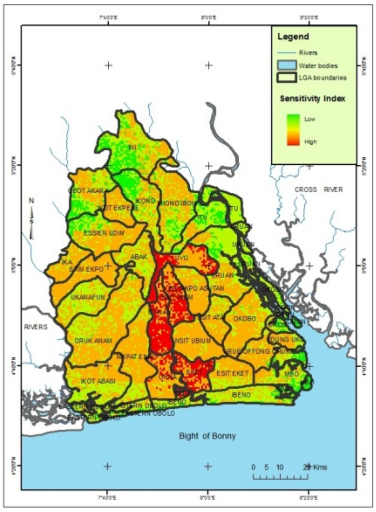

Fig. 2: SENSITIVITY INDEX MAP

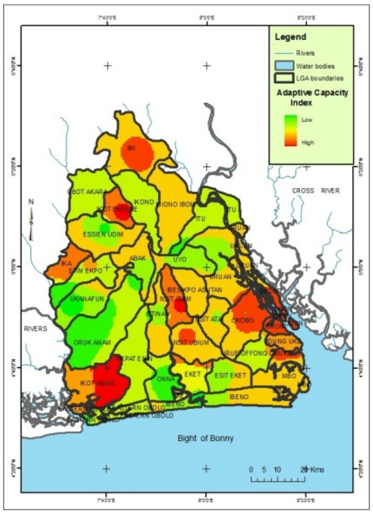

Fig. 3: ADAPTIVE CAPACITY INDEX MAP

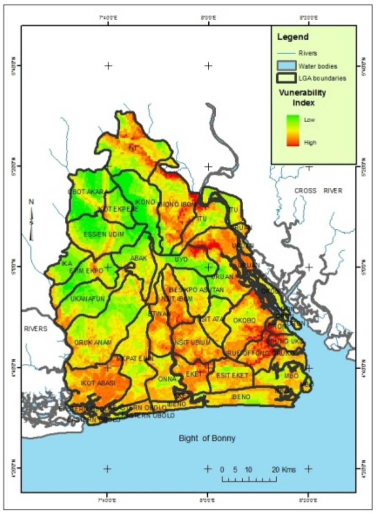

Fig. 4: VULNERABILITY INDEX MAP

Conclusion

The paper utilized the GIS environment to generate and combine Exposure, Sensitivity and Adaptive capacity datasets to create an erosion and flood vulnerability map in the coastal areas of Akwa Ibom State of Nigeria. The final vulnerability maps and the table show the spatial extent and areal coverage of flood and erosion in the study area.

The study has also revealed the ability of vulnerability maps to communicate information that will enable the communicate of environmental risks. In this way, disaster impact reduction can be communicated effectively to stake holders, hence leading to a better understanding of environmental management. As the state borders the Atlantic Ocean, the study confirms the fact that the southern parts of the state are highly vulnerable to climate change related hazards.

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