British Journal of Applied Science & Technology
5(2): 123-129, 2015, Article no.BJAST.2015.012
ISSN: 2231-0843

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How Vulnerable is Akwa Ibom State of Nigeria to Climate Change?

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Authors' contributions

This work was carried out in collaboration between both authors. Author JCU designed the study, wrote the first draft of the manuscript and managed literature searches. Author AN performed the GIS analyses and managed the database. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2015/12503
Editor(s):
(1) Rui Xiao, School of Energy and Environment, Southeast University, China.
Reviewers:
(1) Yahya Farhan, Department of Geography, Faculty of Arts, The University of Jordan, Amman, Jordan.
(2) Anonymous, Nepal Engineering College-Center, Nepal.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=713&id=5&aid=6457

Original Research Article

Received 2nd July 2014
Accepted 1st September 2014
Published 10th October 2014

ABSTRACT

Aims: The aim of this study was to identify and map the vulnerability of the study area to climate change.
Study Area: Located in the South Eastern coastal area of Nigeria, Akwa Ibom State is highly vulnerable to hazards that are associated with climate change – erosion, flooding and sea level rise.
Methodology: In this research, some of the key determinants of vulnerability were identified and mapped based on recommendations in literature. Data on the three main vulnerability components of exposure, sensitivity and adaptive capacity were produce and combined in a Geographic Information System (GIS) environment to reveal the vulnerability of the study area to climate change.
Results: The resultant vulnerability surface showed that the High vulnerability class covers an area of 616 km2 (9%), Medium 4996 km2 (73%), and Low 1232 km2 (18%). While High Vulnerability areas are found in parts of Uyo, Ikot Ekpene, Eket, Itu, Nsit Ibom, Okobo, Oron and Itu, Medium in the other North East and Southern LGAs, and the Low vulnerability are found in the North East portion of the study area.
Conclusion: The study has revealed the ability of vulnerability maps to communicate information

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concerning environmental risks. In this way, disaster impact reduction can be communicated effectively to stake holders, hence leading to a better understanding of climate change mitigation.

Keywords: Multi hazard; risk assessment; Akwa Ibom state; GIS techniques.

1. INTRODUCTION

It is now been accepted that climate change brings changes in the biophysical, biological, and socio-economic systems globally. Vulnerability to climate change is described as the degree to which these systems are susceptible to, and, unable to cope when exposed to the adverse effects of climate change. It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system [1]. Focus on vulnerability in recent has come because of the growing recognition of the need to prepare for and manage the effect of climate change [2]. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has identified Africa as the most vulnerable continent to climate change - a situated compounded by a combination of low adaptive capacity and multiple stresses [3].

In recent years, concerns about the adverse effects of climate change have increased interests in vulnerability assessment and mapping. Referring specifically to climate change hazard, IPCC sees vulnerability as a function of the character, magnitude and rate of climate variation in which a system is exposed, its sensitivity, and its adaptive capacity [4]. This can be expressed as: Vulnerability = 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 [5]. 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 [6]. Although vulnerability maps can be created manually, they are now mostly created with the assistance of computer technology called Geographic Information System (GIS). As a geographic problem needing a geographic solution, climate change has greatly benefited from advances in GIS, leading to informed decision making in reducing climate related risks [7].

Different studies have utilized the GIS to investigate vulnerability in various aspects of the environment. These include ground water vulnerability to contamination [8,9,10,11]; human vulnerability to cyclone [12]; tsunami vulnerability [13]; and, vulnerability of farming sector to climate change [14].

The main objective of this work was to identify and map the vulnerability of the study area to climate change related hazards using the framework set forth in the IPCC report [4] and utilized by [5] and [15]. Hence, vulnerability is mapped as function of Exposure, Sensitivity and Adaptive Capacity.

Located in the South Eastern coastal area of Nigeria, and with a population 3.9 million people [16], Akwa Ibom State is highly vulnerable to hazards that are associated with climate change – erosion, flooding and sea level rise.

2. METHODOLOGY

Based on contemporary literature, the vulnerability of the study area to climate change hazard was modeled as the sum total of Exposure, Sensitivity and Adaptive Capacity maps.

2.1 Exposure Mapping

The exposure of the landscape to the hazards of climate change was modeled using flood, erosion, and distance from the coast layers. Distance from the coast was used as proxy for sea level rise. Flooding data was derived from buffering around rivers to get the flood plains. The surfaces generated were combined to get the exposure surface of the study area in the ARCGIS spatial analyst environment.

2.2 Human and Ecological Sensitivity Mapping

The population density of the study area based on the 2006 population census [9] was used to model human sensitivity climate change hazard; while, land resource potential map was used as a proxy for ecological sensitivity.

2.3 Coping Capacity

Socio economic, technological and infrastructural data were used as indicators of the coping capacity of the study area to climate change hazard. 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, socio economic data were compiled from the United Nations Development Program's Niger Delta Human Development Report [17]. Human Development Index (HDI) measuring the average achievements - human developments – in the study area, and the Goss Domestic Product (GDP) were derived from the report. 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). GDP is the monetary value of all the finished goods and services produced in an area. It is one of the primary indicators used to gauge the health of a country's economy.

Poverty incident data extracted from [18] is an important indicator of the level of socio economic development in an area as it reflects the ability of individuals to attain a minimum standard of living. While technological surface was generated from combining data on man - made water sources and industrial activities; infrastructural surface was generated by the combination of data on transportation and communication [19].

Generally, economically marginalized people create two sources of vulnerability - their access to livelihood and resources are insecure and less rewarding therefore generate higher levels of risk to hazards: and, the people are likely to be a low priority for government interventions intended to deal with hazard mitigation [20]. These imply that socio economy is a major determinant of the coping capacity of a people to any form of hazard.

3. DATA MANIPULATION AND GIS ANALYSIS

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 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 modeling.

Vulnerability of the study area to climate change was conceptualized in a GIS environment as a combination of Exposure, Sensitivity, and Adaptive capacity maps. In order to derive the Index for the components, the constituent socio economic data were normalized using the formulae [5]:

$$\textit{Dimension index} = \frac{\textit{Actual value – Minimum value}}{\textit{Maximum value- Minimum value}}$$

Flood, erosion and sea level rise layers that consisted the exposure layer were weighted almost equally in the equation and combined using the Single Output function of Arcmap Spatial Analyst Extension as follows: Exposure = (Flooding*.34)+(Erosion*.33)+(Sea level rise*.33).

In generating the sensitivity layer, the formula used was:

Sensitivity layer = (Population density*.5) + (Land resource potential layer*.5)

For the Adaptive Capacity, the weighting was:

Adaptive Capacity = (Socio economic layer*.5) + (Technological layer* .25) + (Infrastructural layer*.25).

The three surfaces were combined to generate the Vulnerability of the study area to climate change:

Vulnerability layer = (Exposure layer*.4) + (Sensitivity layer*.3) + (Adaptive Capacity layer*.3). Each of the component layers and the final vulnerability layers were reclassed into three classes of low, medium and high vulnerability based on their index values of below 0.33 (low), 0.33-0.66 (moderate), and above 0.66 (high).

4. RESULTS AND DISCUSSION

Figs. 1, 2, 3 and 4 show the index maps of Exposure layer, Sensitivity layer, Adaptive Capacity layer and Vulnerability layer of the study area. Fig. 1 shows that the three classes of exposure are found in almost all the LGAs but the state is predominantly moderately exposed. An analysis of the exposure data shows that Moderate areas occupy 982.4 km^2 (15.49%); High area is 1914 km^2 (30.8%); and, Low 982.4 km^2 (15.49%). The Highly exposed areas are found in coastal LGAs of Eastern Obolo and Udung Uko. It is also found in parts of Ibeno, Ikot Abasi, Mkpat Enin, Mbo, Urue Ofong Oruko, and Oron. Okobo, Itu, Ibiono Ibom, Uyo and Ikono. The High exposure areas are found in the coastal and eastern portions of the study area. The Moderate exposure classes are foud in the noth cental and south western portions of the state. The LGAs involved include parts of Ini, Ikono, Ikot Ekpene, Uyo, Abak, Essien Udim, Etim Ekpo, Ukanafun, Oruk Anam, Ikot Abasi, Nsit Ibom, Onna, Eket, Nsit ad Ibesikpo Asutan. The Low Esien Udim, Ika, and Etim Ekpo. It is also found in parts of Nsit Ubium, Nsit Atai Okobo and Ibesikpo Asutan LGAs. The spatial Sensitivity classes are shown in Fig. 2. The analysis of the spread shows that the Low sensitivity areas cover 3906 km^2 (52.8%), Medium 2481 km^2 (36.3%), and High 448 km^2 (5.55%). Areas of High sensitivity are found in predominantly in parts of Etinan, Eket, Nsit Ibom, Uyo, and Oron LGAs. Medium in Ikot Ekpene, Nsit Atai, Urue Offong it Eket, Mbo, Ud, and, parts of Oruk Anam, Ikot Abasi, Mkpat Enin, Onna, Eung Uko, Oron, Okobo, Uruan, Ibesikpo Asutan, Uyo, Nsit Ibom, Etinan, Itu, and Ini. The low sensitivity areas are found in the North East, North West and Coastal fringes of the study area.

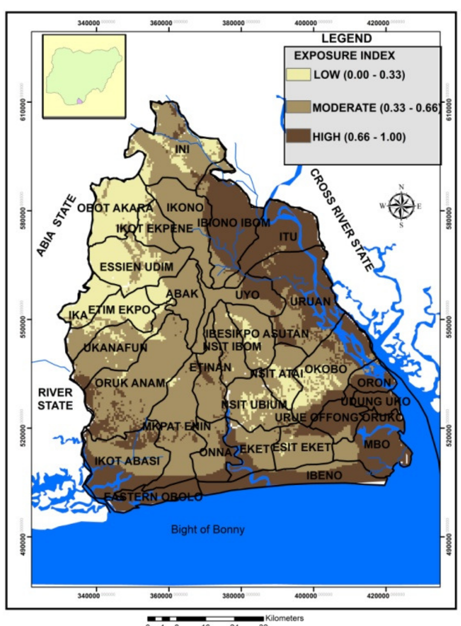

Fig. 1. Exposure classes of the study area

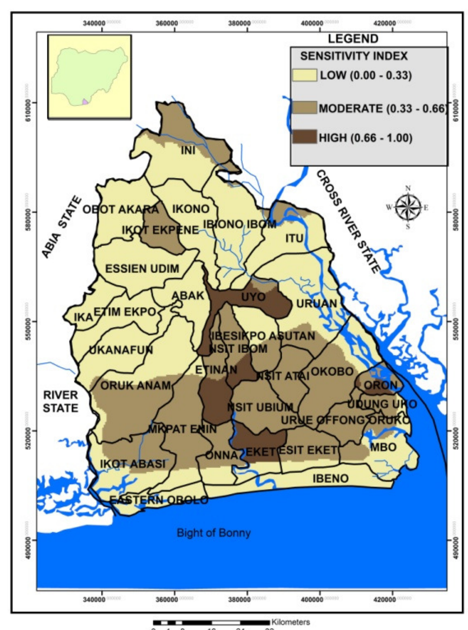

Fig. 2. Sensitivity classes of the study area

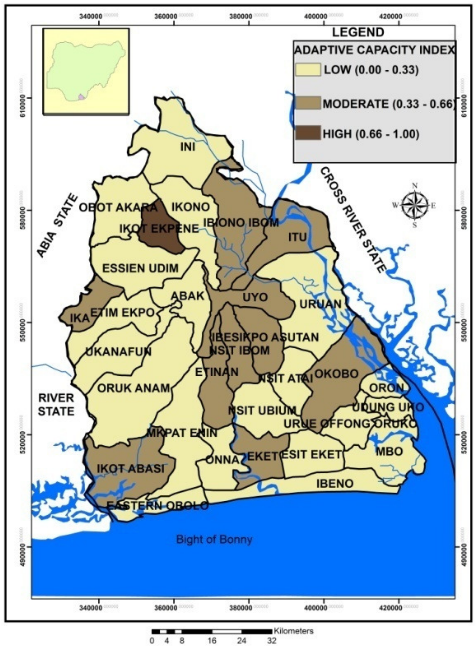

Fig. 3. Adaptive capacity of the study area

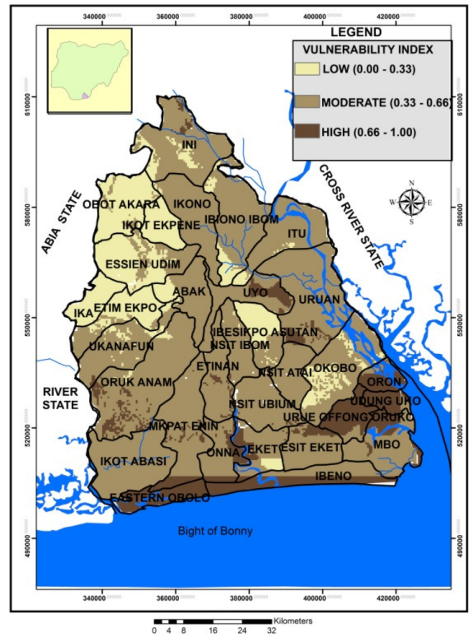

Fig. 4. Vulnerability classes of the study area

Fig. 3 shows the Adaptive Capacity of the study area with the High class found only in Ikot Ekpene LGA, Medium in Ika, Ikot Abasi, Eket, Okobo, Etinan, Nsit Ibom, Ibesikpo Asutan, Uyo, Itu and Ibiono Ibom. The Low classes are found in the other 20 LGAs. While the High class occupies 110 km2 (1.6%), Medium 2204 km2 (32.18%), and Low 4534.3 km2 (66.21%). Fig. 4, a combination of the three vulnerability components show the vulnerability of the study area to climate change. The High class covers an area of 616 km2 (9%), Medium 4996 km2 (73%), and Low 1232 km2 (18%). While the High Vulnerability areas are found in parts of Uyo, Ikot Ekpene, Eket, Itu, Nsit Ibom, Okobo, Oron and Itu, Medium in the other North East and Southern LGAs, and the Low vulnerability are found in the North East portion of the study area.

The study confirms the widely held view that the most vulnerable areas are found in the coastal areas of the state and around the major river basins of Imo, Kwa Iboe and Cross. These are the area that are likely to be more affected by sea level rise. The study, like similar studies reveals some surprises [5]. For an example, Uyo located about 50 kms from the Atlantic coast ranks high in vulnerability, this can be traced to the high sensitivity (population density and Land resource potential). Also parts of Uyo equally rank high in erosion hazard hence high hazard exposure. Ini LGA located in the northern part of the state also has high vulnerability because of the high exposure to hazards. The findings agree with [14] that areas most exposed to climate change do not always overlap with areas with high sensitivity and low adaptive capacity. For an example, Itu, Ibiono Ibom and Uruan LGAs with high exposure to hazard have medium vulnerability. However, Obot Akara and Essien Udim axis have consistently ranked low in exposure, sensitivity and the resultant vulnerability.

5. CONCLUSION

The paper utilized the GIS environment to generate and combine Exposure, Sensitivity and Adaptive capacity datasets to create an climate change vulnerability map in the coastal areas of Akwa Ibom State of Nigeria. The final vulnerability maps and the tables show the spatial extent and areal coverage of climate change vulnerability in the study area. The study has also revealed the ability of vulnerability maps to communicate information concerning environmental risks. In this way, disaster impact reduction can be communicated effectively to stake holders, hence leading to a better understanding of climate change mitigation in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Schneider SH, Semenov S, Patwardhan A, Burton I, Magadza CHD, Oppenheimer M, Pittock AB, Rahman A, Smith JB, Suarez A, Yamin F. Assessing key vulnerabilities and the risk from climate change. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK. 2007;779-810.
2. O'Brien K, Sygna L, Leichenko R, Adger WN, Barnett J, Mitchell T, Schipper L, Tanner T, Vogel C, Mortreux C. Disaster risk reduction, climate change adaptation and human security. Report prepared for the Royal Norwegian Ministry of Foreign Affairs by the Global Environmental Change and Human Security (GECHS) Project, GECHS Report. 2008;3.
3. Boko M, Niang I, Nyong A, Vogel C, Githeko A, Medany M, Osman-Elasha B, Tabo R, Yanda P. Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK. 2007;433-467.
4. IPCC (Inter-governmental Panel on Climate Change. Climate Change: Impacts, Adaptation, and Vulnerability. J. McCarthy; O. Canziani; N. Leary; D. Dokken; and K. White (eds) Cambridge University Press. Cambridge; 2001.
5. Yusuf, Arief Anshory, Francisco Herminia. Climate change vulnerability mapping for Southeast Asia, Economy and Environment Program for Southeast Asia (EEPSEA), Singapore; 2009.
6. Edwards J, Gustafsson M, Näslund-Landenmark B. Handbook for vulnerability mapping, EU Asia Pro Eco project' Disaster Reduction through Awareness, Preparedness and Prevention Mechanisms in Coastal Settlements in Asia, Demonstration in Tourism Destinations, Swedish Rescue Services Agency; 2007.
7. ESRI. GIS Best Practices: GIS for Climate Change, ESRI, 380 New York Street, Redlands, CA 92373-8100; 2009.
8. Gougazeh M, Sharadqah S. Groundwater vulnerability to contamination in Jordan evaluated in two levels of analysis. Journal of Civil Engineering. 2009;3(4).
9. El-Naqa A, Hammouri N, Kuisi M. GIS-based evaluation of groundwater vulnerability in the Russeifa Area, Jordan. Revista Mexicana de Ciencias Geológicas. 2006;23(3):277-287.
10. Elfarrak H, Hakdaoui M, Fikri A. Development of vulnerability through the DRASTIC method and Geographic Information System (GIS) (Case Groundwater of Berrchid). Morocco Journal of Geographic Information System. 2014;6:45-58.
11. Mohamad MAA, Hiyama T, Kato K. A GIS-based DRASTIC model for assessing aquifer vulnerability in Kakamigahara Heights, Gifu Prefecture, central Japan, Science of the Total Environment 2005;345:127–140.
12. Sheikh M, Hossain N, Singh A. Application of GIS for assessing human vulnerability to cyclone in India 2002 Esri International User Conference, 2002, Conference proceeding San Diego, CA; 2002. Available:http://proceedings.esri.com/library/userconf/proc02/pap0701/p0701.htm Assessed 24/7/2014.
13. Hart D, Knight G. Geographic information system assessment of tsunami vulnerability on a dune coast. Journal of Coastal Research. 2009;25(1):131-141.
14. Gbetibouo GA, Ringler C, Hassan R. Vulnerability of the South African farming sector to climate change and variability: An indicator approach. Natural Resources Forum. 2010;34:175–187.
15. Udoh J. Oil spill vulnerability mapping of the coastal areas of Akwa Ibom State, Nigria, in, geospatial technologies and digital cartography for national security. Tourism and Disaster Management, GEOSON/NCA Publication, Benin City; 2012.
16. National Population Commission. National Population Census Result, NPC, Abuja; 2006.

17. UNDP Niger Delta Human Development Report, United Nations Development Programme, Abuja, Nigeria; 2006.
18. Ekpo AH, Uwatt BU. Akwa Ibom State of Nigeria: Poverty Profile and Economic Transformation, Foundation for Economic Research and Training, Uyo; 2005.
19. AKSEED. Awa Ibom State Economic Empowerment and Strategy. Ministry of Economic Development, Uyo, Nigeria; 2004.
20. Blaikie P, Cannon T, Davis I, Wisner B. At Risk: Natural Hazards, People's Vulnerability and Disasters, Routledge, London; 1994.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=713&id=5&aid=6457