Vulnerability of Riverine Communities to Flooding in Makurdi Town, Nigeria

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Abstract

Riverine environments are of significant economic, ecological and social importance to the global population. They are however, under increasing pressure from rapid anthropogenic developmental activities and the effects of climate change. This paper characterizes vulnerable riverine communities, their level of vulnerability, and suggests adaptive measures for the vulnerable communities. Coastal vulnerability index (CVI) adapted by Palmer (2011) is used to measure prescribed physical parameters of Bank width, Coastal slope, Distance of vegetation behind back of the River Bank, Distance of communities from the river, Percentage rock outcrop, Avalanche risk and Presence of braided channels. Vulnerability levels of the communities were classified based on the CVI index (Very low, Low, Moderate, High and Very high). The result shows that Wurukum and Wadata with indices of 26 and 25 respectively have very high vulnerability to flooding, Fiidi has an index of 22 indicating high vulnerability while both High level and North Bank have values of 14 each meaning low vulnerability. The study recommends dredging of river Benue, building of embankments and avoiding building in marshy areas that are flood prone in Makurdi town.

Keywords: Communities and parameters, Flooding, Riverine, Vulnerability

Introduction

Since early civilization, coastal areas have been attractive settling grounds to human population as they provide abundant marine resource, fertile agricultural land and possibilities for trade and transport (Scheartz, 2005). The characteristics of coastal environments, however pose some great challenges to human habitation. Coastal zones are highly dynamic natural systems that interact with terrestrial, marine and atmospheric processes and undergo continuous change in seasons to these processes (National Oceanic and Atmospheric Administration 2016). Over the years, human societies had often failed to recognize the hazards related to these dynamics and this has led to major disasters and societal disruption to various degrees.

Coastal zones, land we lived on, are been more exposed to natural hazards and many disasters are associated with them. Implying communities settling along coastal zones face a worsening situation as the effects of climate change which can be influenced to create floods due to arising of storm surges. Heavy rainfall of long duration or high intensity is becoming more severe (Nicholls, 2004). The vulnerability is the degree to which a system is susceptible to or unable to cope with adverse effects of climate risk, including climate variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC, 2001). It is a function of the character, magnitude and rate of climate change and the degree to which a system is exposed, along with its sensitivity and adaptive capacity. It increases as the magnitude of climate change or sensitivity increases, and decreases as adaptive capacity increases (OECD, 2009).

In Nigeria, series of flood hazards from various parts of the country at different periods have occurred. For instance, in 2001coastal communities in Abia, Adamawa and AkwaIbom states witnessed heavy down pour and rainstorm which affected about 5000 people. In the same year about 12,300 persons were displaced by torrential rain which destroyed farmlands, damaged property and submerged buildings in Zamfara state. In 2012, a widespread devastating river flood which

severely affected the coastal communities in major cities of 14 states that border the Niger-Benue River. The worst affected States were Adamawa, Taraba, Benue, Kogi and Anambra state (Nkeki et al 2013).

Okereke (2007) highlighted the basic effects of flooding to include loss of human lives, submerging of farmland, residence and streets, inflow of sewage, damage of property, health hazard, clean-up cost, disruption of services, traffic obstruction, aesthetic discoloration, economic loss and infrastructural damage. Makurdi town is situated within the valley plains of river Benue. The proximity of the town to the channel of the Benue river in combination with the low elevation of the flood plain within which the town is situated makes it vulnerable to flooding.

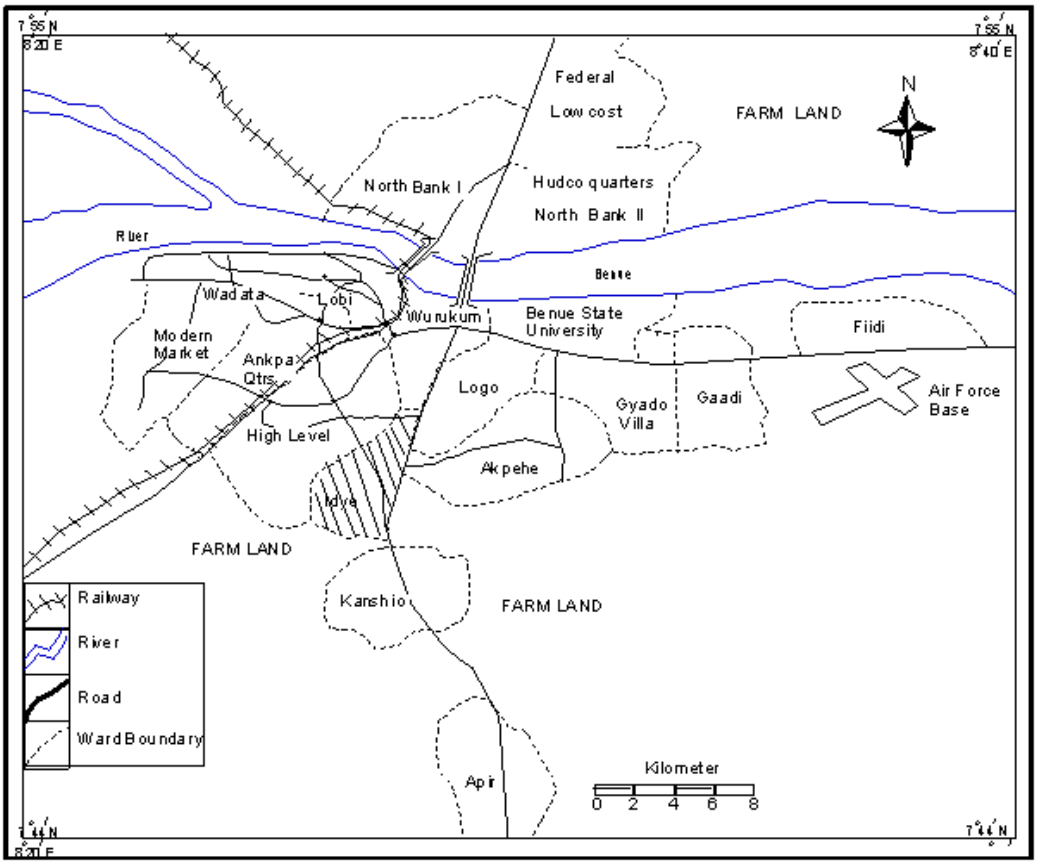
Materials and Methods

Study area

Makurdi town is located at $7^0\ 43^1\ 5^{11}$ N and $7^0\ 45^1\ 47^{11}$N and $8^0\ 32^1\ 10^{11}$ E and $8^0\ 33^1\ 40^{11}$ E. The town is situated astride river Benue in the North central part of Benue state, divided by the river Benue. The city of Makurdi, defined politically, has a radius of about 10km with an area of about 314.2km2. The city stretches from the airport along Gboko road in the West; in the South the town is bounded by Apir while in the North it is bounded by Agan toll gate. Makurdi falls within the tropical wet and dry (Aw) climate. The climate is dominated by South West and North East monsoons that determine the wet and dry seasons respectively. Seasons of three different temperatures are experienced in the study area (Tyubee, 2004). High temperatures are experienced especially in the months of March and April, daily temperature average is about 36^0C. January is regarded as the coldest month with mean temperature of about 30^0C. Average daily temperatures are as high as 32^0C and rarely fall below 20^0C. The vegetation of Makurdi is typical of Guinea Savannah, made up of trees and grasses of various types. Agriculture, especially subsistence farming is widely practised together with market gardening at the valley of river Benue. Most Makurdi dwellers are civil servants and traders, fishing and brick laying are other economic activities carried out at the Benue river. The choice of this study area is owing to its location

along the banks of river Benue and the Coastal Vulnerability Index is best at analysing flooding vulnerability along a stretch of coastal area. The town is shown in the Figure 1.

Figure 1: Map of Makurdi town, Benue State, Nigeria.



Data collection

The data for this study were collected from;

i. Topographic map of the riverine communities.

ii. Co-ordinates of the communities under study.

iii. Elevation (m) and proximity (km) of the river line communities to adjourning river Benue.

iv. Bank width (m), Coastal slope (degrees), Percentage rock outcrop, Avalanche risk and Presence of braided channels.

v. Vegetation, occupation and water sources of inhabitants.

Topographic map of the study area were collected from the Ministry of Lands and Survey, Makurdi and was used to determine the parameters. The ground truth verification by observation and measurement was also done to confirm the map information.

The Coastal Vulnerability Index was used to calculate the vulnerability of the riverine communities under study to flooding. The Coastal Vulnerability Index has been used and modified by many researchers to the needs of their research. For the purpose of this research, the method used by Palmer (2011) was adapted. The choice of this method is that it ensures a quick and efficient measure of assessing vulnerability over a long stretch of coastline. This method uses absolute figures (indices) which are used to rank the attributes of the variables under study. The attributes which were used to evaluate the coastal vulnerability are:

a = Bank width
b = Coastal slope
c = Distance of vegetation behind back of the river bank
d = Distance of communities from the river
e = Percentage rock outcrop
f = Avalanche risk
g = Presence of braided channels
The formula used is as stated below:

Relative CVI = a + b + c + d + e + f + g .....(8)

Where a, b, c, d, e, f, g are the ranked index given to the assessed variables. Therefore, the highest rank index is four (4) and the maximum value for CVI is twenty-eight (28) i.e.

a = River Bank width - 4
b = River Bank slope – 4
c = Distance of vegetation behind back of the River Bank - 4
d = Distance of community to river - 4
e = Percentage rock outcrop - 4
f = Avalanche frequency - 4

g = Presence of braided channels – 4
Total = 4 + 4 + 4 + 4 + 4 + 4 + 4 = 28

Major vulnerable factors of flooding hazard

A field study guided by requirements of the Coastal Vulnerability Index considered seven (7) major factors posing as threats to flooding in Makurdi town. These factors are:

River bank width

Various structures are referred to as banks in different fields of geography but in general a river bank refers to the land alongside a body of water (Luna, Gordon and Miller 1995). The river bank width mentioned here is the extent from the river bank to the mainland i.e. the wideness of the Benue bank at the various locations in the study area. The wider the river bank, the shallower and the more the chances of water spilling into the neighboring areas leading to create flood.

River bank slope

The river bank slope is the gradient of elevation between the river bank and the mainland. This is referred to the steepness and length of line connecting the river at the bank and the mainland. Due to the verifying nature of the underground rocks and vegetation at the river Benue bank, there is varying degrees of erosion and hence, the slope of the river bank is not uniform throughout the study area. The steeper the river bank gradient, the less vulnerable the area is to flooding. Contrary, a gentle or flat bank allows water to spill more easily in the surrounding areas increasing the level of vulnerability to flooding.

Distance of vegetation behind the bank

This refers to the distance between the river bank and where vegetation grows along the river bank of the Benue. The vegetation has a role of acting like a giant sponge that holds water and release to the environment gradually. Where vegetation is closer to the bank, it helps to prevent water from directly moving into the neighborhoods.

Distance of community to river

The further a neighborhood is away from river Benue the lesser the chances of flood water moving into it and the closer the more the risk. Distances of neighborhoods in Makurdi were measured and included as a variable in determining the neighborhoods' risk level to flooding.

Percentage rock outcrop

This is the amount and frequency of rock formation that appears above the surface of the surrounding land. This affects the vulnerability along the bank of river Benue, in that its presence reduces the rate of erosion process while its absence makes it easier as the normal soil offers less resistance.

Avalanche frequency

This is a geological phenomenon that includes a wide range of ground movements, such as rock fall, deep failure of slopes and shallow debris flow. This has left the river bank of River Benue prone to flooding, for instance, in places where it occurs in high frequency it loosens and levels the river bank making it easier for water to rise above the river bank into the neighboring communities.

Presence of braided channels

A braided channel is a channel or water path that consists a network of smaller channels separated by small and often temporary islands. The presence of many of these channels means it is easier for the River Benue to spread its water inland during flooding. The higher the concentration of these channels the more vulnerable a place is to flooding.

For this research, the values in Table 1 were used to rank the index:

Table 1: CVI Parameter ranking

Physical parameters	**Extremely Low (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
River Bank (width)	> 150m	100-150m	50-100m	< 50m
River Bank (slope) Distance of community to river	$> 12^{O}$ >4km	12^{O}-8^{O} 2 -4 km	8^{O}-4^{O} 1- 2 km	$< 4^{O}$ <1km
Distance of vegetation behind the back of Bank (RB)	> 600m	200-600m	100-200m	< 100m
Percentage Rocky Outcrop	> 50%	20-50%	10-20%	< 10%
Avalanche frequency	0	1-10	11-50	>50
Presence of braided channels	0	1- 2	3- 4	> 4

Source: Adapted from Palmer (2011)

With ranking applied, these values were then inputted into a simple equation (CVI = a + b + c + d + e + f + g) to calculate each riverine community's CVI score; a score that indicated each riverine community's vulnerability comparative to other communities along the river line. The minimum score possible is 6 and the maximum is 28.

Palmer (2011) organized the CVI scores into five (5) categories of very low, moderate, high, and very high vulnerabilities. Riverine communities scoring within the mid-range (between 25% and 75% percentiles) were ranked as moderate vulnerability while communities scoring below or above the moderate class are categorize as lower or higher vulnerability respectively. This ranking system is presented below:

Very low = 6 – 12
Low = 13 – 15
Moderate = 16 – 18
High = 19 – 22
Very high = 23 – 28

Result and Discussion

Classification of flood vulnerability levels among neighborhoods in Makurdi town

Using the Coastal Vulnerability Index requirements, the variables for each of the Neighborhood are presented in table 5.1. With rankings applied as in table 5.2, these values were then input into the equation to calculate each communities score.

Relative CVI = a + b + c + d + e + f + g

Fiidi

Relative CVI = a + b + c + d + e + f + g

= 4 + 4 + 1 + 4 + 3 + 4 + 2 = 22

Wurukum

Relative CVI = a + b + c + d + e + f + g

= 4 + 4 + 4 + 4 + 4 + 4 + 2 = 26

High Level

Relative CVI = a + b + c + d + e + f + g

= 4 + 2 + 2 + 1 + 2 + 2 + 1 = 14

North Bank

Relative CVI = a + b + c + d + e + f + g

= 4 + 1 + 4 + 1 + 1 + 2 + 1 = 14

Wadata

Relative CVI = a + b + c + d + e + f + g

= 4 + 4 + 4 + 4 + 4 + 4 + 1 = 25

The vulnerability index as presented by Palmer (2011) indicated the levels as:

Very low	=	6 – 12
Low	=	13 – 15
Moderate	=	16 – 18
High	=	19 – 22
Very high	=	23 – 28

According to the above results, Fiidi with a CVI score of 22 has a high vulnerability level to flooding, Wurukum with a CVI score of 26 has a

very high vulnerability level to flooding, High level with a CVI score of 14 as interpreted by the CVI ranking has a low vulnerability to flooding, North Bank which has a CVI score of 14 also can be considered as a low level of vulnerability, and Wadata with a CVI score of 25 can be identified as a very high vulnerability to flooding.

Table 2: Index values used to rank the data

S\N	Communities	Location	River Bank Width (a)	River Bank Slope (b)	Distance from River (c)	Distance of Vegetation (d)	Percentage Rock Outcrop (e)	Avalanche Frequency (f)	Presence of Braided Channel (g)
1.	Fiidi	Lat 7^0 48^1 Long 8^0 39^1	40m	2^o	3km	30m	12%	72	2
2.	Wurukum	Lat 7^0 46^1 Long 8^0 33^1	30m	2^o	650m	20m	2%	60	1
3.	High Level	Lat 7^0 47^1 Long 8^0 33^1	32m	12^o	4km	4km	45%	8	0
4.	North Bank	Lat 7^0 51^1 Long 8^0 36^1	32m	14^o	400m	650m	70%	7	0
5.	Wadata	Lat 7^0 50^1 Long 8^0 34^1	30m	2^o	500m	18m	5%	70	0

Source: Field Survey 2017

Table 3: Ranking of the field data in accordance with the CVI

S/N	Communities	a	b	c	d	e	f	g
1.	Fiidi	High(4)	High (4)	Extremely low (1)	High (4)	Moderate (3)	High (4)	Low(2)
2.	Wurukum	High(4)	High(4)	High(4)	High(4)	High(4)	High(4)	Low (2)
3.	High Level	High(4)	Low(2)	Low (2)	Extremely Low (1)	Low(2)	Low(2)	Extremely Low (1)
4.	North Bank	High(4)	Extremely Low(1)	High (4)	Extremely low (1)	Extremely Low(1)	Low (2)	Extremely Low (1)
5.	Wadata	High (4)	High(4)	High(4)	High(4)	High(4)	High(4)	Extremely Low (1)

Source: Field Survey 2018

Conclusions and Recommendations

It is no doubt that every community bordering a water body is vulnerable to any one form of flooding but the nature of such impact is distinct to every region. This is the case in the research which reveals that the communities along river Benue in Makurdi town are vulnerable to flood at different levels. Wadata and Wurukum communities have very high vulnerability; Fiidi has high vulnerability while High Level and North Bank have low vulnerability to flooding. The study recommends dredging of river Benue, building of embankments and avoiding to build structures in marshy areas that are flood prone in Makurdi town to avert and mitigate the impact of flooding.

References

Intergovernmental Panel on Climate Change- IPCC (2001). *Climate Change 2001: Impacts, Adaptation and vulnerability, Working Group II Contribution to Third Assessment Report of the International Panel on Climate,* Chapter 18, pp. 877-912.

Luna B, Gordon W., Miller J. (1995). *Fluvial processes geomorphology*, New York, New York Dover Publication.

National Oceanic and Atmospheric Administration - NOAA (2016). Extended reconstructed sea surface temperature (ERSST.v4). available at: www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst (accessed March 2016).

Nicholls, R.J. (2004). Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socio-economic scenario, *Global Environmental Change*, Vol.14 No. 01, pp. 69-86.

Nkeki, F. N. Henah, P. J. Ojeh, V. N. (2013). Geospatial Techniques for the Assessment and Analysis of Flood Risk along the Niger - Benue Basi in Nigeria, *Journal of Geographic Information System,* Vol. 5 No. 2, pp.123-135.

Okereke, R. A. (2007). Incidence of flooding in southern Nigeria, *International Journal of Environmental studies,* Vol. 5 No. 1-2, pp. 20-28.

Organization for Economic Co-operation and Development: OECD (2009). Integrating Climate Change Adaptation into Development Co-operation: Policy Guidance, available at http://www.oecd.org/env/cc/44887764.pdf (accessed March 2016).

Palmer, W. C. (2011) in Davies, W. T. (2012). Applying a coastal vulnerability index to the Westfjords, Iceland: preliminary assessment, Master's thesis, University of Akureyri, Faculty of Business and Science, University Centre of the Westfjords.

Schwartz, M. (2005). *Encyclopedia of Coastal Science*, Springer. available at: www.springer.com (accessed 28 July 2017)

Tyubee, T.B. (2004). Fluctuations and Trends in Rainfall Characteristics over the Middle Belt of Nigeria, *Journal of the Nigerian Meteorological Society (NMS)*, Vol. 4 No. 1.