Asian Journal of Geographical Research

Volume 6, Issue 3, Page 9-21, 2023; Article no.AJGR.103444
ISSN: 2582-2985

Spatial Assessment of Elevation-based Flood Risk Level of Communities and Mitigation Measures in the Wetlands Areas of Rivers and Bayelsa States, Niger Delta Region, Nigeria

G. B. Horsfall [a*], A. A. Obafemi [a] and M. Ogoro [a]

[a] Department of Geography and Environmental Management, Faculty of Social Sciences, University of Port Harcourt, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJGR/2023/v6i3185

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103444

Original Research Article

Received: 25/05/2023
Accepted: 31/07/2023
Published: 11/08/2023

ABSTRACT

The study examined the spatial assessment elevation-based flood risk level of communities and mitigation measures in the wetlands areas of Rivers and Bayelsa States, Niger Delta Region, Nigeria. The study made use of the elevation data from the Shuttle Radar Topographic Mission, flood height and tidal inundation data to determine the flood risk levels of communities in the study location. Similarly, 400 copies of questionnaire were administered to the residents from the wetland communities using random sampling technique. Descriptive and inferential statistics were used for the analysis. Findings revealed that majority of the coastal region in the study area is generally low lying and highly exposed to flood event. Results also showed that most communities in the

Corresponding author: E-mail: wyethbaker@yahoo.com;

Ogba/Egbema/Ndoni Local Government Areas are very highly exposed which included Ahoada, Azagbene, Eben, Kpopkie, Owenegbene, Bisagbene, Ekeni among others while the very risk exposed communities included Okpogo, Ebubu, Aboigbene among other. Findings showed that damage compensation and government relief funds were the major ways used to tackle the negative impact of flood. The popular methods of flood abatement in the study area were restoring meanders in brooks and rivers and coastal wetlands protection. The study concluded that many communities in the coastal parts of Rivers and Bayelsa States in the Niger Delta Region of Nigeria are highly prone to flood risk. The study recommended among others that the use of dam for flood abatement and prevention should be adequately established in the study area; and apart from embankment, other flood defense and control measures such as flood barrier, mobile flood wall, coastal sand supply, bypasses to safeguard wetlands, connect rivers to existing lake, dredging rivers, and river bed widening should be adequately put in place to reduce the levels of flood impact in the study area.

Keywords: Elevation-based; flood risk; mitigation; Niger delta.

1. INTRODUCTION

“Flooding is a natural event that causes widespread destruction, adversely affects daily life and raises vulnerability, including physical, social, economic, and environmental exposure. Flood is a natural hazard that cannot be control completely but the risk can be reduced by taking some measures. A risk is generally described as the uncertain product of a hazard and its potential loss” [1,2]. “Flood has been identified as an upward condition of water levels in coastal areas, reservoirs, streams, and canals” (Abah and Clement, 2013). About 350 million people in the world are affected by floods. It is also predicted that the flood destruction will be double by the end of 2050.

Flood risk has been defined as a degree of the overall adverse effects of flooding. It incorporates the concepts of the threat to life and limb, the difficulty and danger of evacuating people and their possessions during a flood, the potential of damage to the structure and contents of buildings, social interruption, loss of production and damage to public property. Dang et al. [3] suggest that “flood risk assessment requires interdisciplinary approaches and studies. They specifically suggest that the potential flood risk can be reduced by decreasing the level of vulnerability, reducing the exposure value and by reducing the hazard. Mapping and prediction of flood hazards are important aspects of flood risk assessment”. “Flood nature, intensity, and frequency of occurrence are better understood through mapping and simulating of both the already occurred and potential flood hazards. They are essentially used for assessment of the level of risk (knowing the affected people and properties), providing early warning in case of future reoccurrence and hydraulic design, especially for potential flood management and disaster risk reduction” [4].

In recent years, the world’s attention has been shifted from the flood hazard control to flood impacts/risks assessment [5]. “Risk according to the UNISDR is defined as the combination of the probability of an event and its negative consequences” (UNISDR, 2013) [5]. Earlier researchers (e.g., Birkmann, 2013) [5] have put forward that hazards occurrences do not result into disaster and that for actual assessment of the disaster situations and losses, various element such as vulnerability and exposures have to be included [5]. “This has become the basic methods used today in disaster risk analysis. Flood risk therefore is the product of the flood hazards, the vulnerability and the exposure of the people” [5].

Smith et al. (2011) stated that “risk is a statistical concept and probability refer to a negative event or condition which affect people, infrastructure and environment. For the last two decades advancement in the field of remote sensing and geographic information system (GIS) has greatly facilitated the operation of flood mapping and flood risk assessment”. “It is evident that GIS has a great role to play in natural hazard management because natural hazards are multi-dimensional and the spatial component is inherent” [6]. “The main advantage of using GIS for flood management is that it not only generates a visualization of flooding but also creates potential to further analyze this product to estimate probable damage due to flood” (Hausmann et al. 1998), [7]. Smith [8] reviews “the application of remote sensing for detecting river inundation, stage and discharge. Since then, the focus in this direction is shifting from flood boundary delineation to risk and damage assessment".

Assessment of flood risk and dissemination of this information to all stakeholders (general public, decision-makers, and water managers) is very important in overall process of flood management. Knowledge of flood risk could aid decision-makers in: developing land development plans and land use zoning; in planning emergency response strategies; in waste disposal site selections; in making infrastructure budgetary decisions; in developing guidelines for operating of existing infrastructure and settlement; in regional planning; and in general policy development at all levels. Shrubsole [9] mentions "government responsibilities in flood management. The Saguenary and Red river valley events were discussed and preparedness, response and recovery from these events were described. It suggests that economic flood losses are at least partially development on current flood management strategies. The study provided alternative flood management strategies considering ecosystem management, partnerships and the role of science. It discusses the factors affecting flood damages and suggested that the best combination of structural and non-structural solutions can lead to sustainable settlement development" [10,11].

Menzinger and Brauner [12] discuss flood risk from an insurance perspective. The elements and conditions of flood insurance were provided. The study utilized the risk assessments method in the geo-information sciences. Findings suggested that, the availability of flood insurance protection of the risk collectively is broad enough and should be affordable to low and high risk areas. Blong [13] introduced "a new damage index used in estimating the replacement costs of damaged buildings. The study presents the development and construction of the damage index in an Australian context. The results were values (ranging from 1-20) which were compared on a time-independent scale to assess the impact of damages to buildings resulting from natural hazards". Carter [14] analyzed "flood risk as a combination of threat, consequence and vulnerability. The report also discussed the federal role in investment decisions of flood control structures like dams and levees. It was illustrated in the report that the federal policy focus only on certain elements of risk and it suggests alternative measures for incorporating other elements of flood risk into the decision making processes. It discussed the reduction of property damage vulnerability and overall flood risk. Hurricanes, Katrina and Rita are used to illustrate flood disaster events, policies and decision making".

Werritty et al. [15] discussed "the social impacts of flood events in Scotland including attitude and behavior toward flooding events, warning, evacuations and consequences. The study considered questionnaires, which were distributed to households in seven cities and a rural population in Scotland. From these questionnaires focus groups were conducted to provide insights into human behavioral responses to flood events. Impact assessment was performed by considering intangible or tangible and immediate or lasting impacts to assign impact values. The study suggested the enhancement of social resilience for sustainable flood management and provides further recommendations in flood emergency management for Scotland".

However, there are some methods that have been engaged in order to determine the flood risk among which included geospatial techniques. These include the use of Geographic Information System (GIS), remote sensing, global positioning system (GPS) and so on to solve the issue of flooding in a given area. "Geographic Information System (GIS) is defined as any system that integrates, captures, stores, analyzes shares, manages, and displays data that is linked to location or geographic data. GIS merges computer database technology with geo-referenced and cartographic information, resulting in digital maps and databases with fundamental applications in areas such as natural resource management, ecosystem conservation, environmental studies, utility management, infrastructures and transportation planning, town and regional planning, municipal government and also commercial applications. It is an ideal tool for integrating data from the land itself (e.g. data gathered from satellites) and socio-economic data (e.g. tax records). The power of a GIS lies in its ability to analyze relationships between features and their associated data. This analytical ability results in the generation of new information, as patterns and spatial relationships are revealed" [16]. "Although there are several definitions of GIS, ranging from the technologically-based to those focusing on organizational aspects, GIS is about evaluating geographical relationships through spatial analysis, database management/analysis and graphical display" [17]. "The main advantage of using GIS for flood management is that, not only does the system generate a visualization of flooding but also it creates means to further analyse and estimate probable impacts of flooding incidence" (Hausmann et al, 1998). "Great attention has been given to the use of GIS and Remote Sensing to manage and control floods and in the production of flood risk maps. A lot of research has been done using diverse methodologies in the production of flood risk maps. Flood risk mapping is very important for land use and planning in flood prone areas. It creates easily read, rapidly accessible charts and maps which aids with the easier identification of flood risk areas and prioritize their mitigation effects" [18]. "It is primarily necessary in planning to ensure that works undertaken to provide mitigation or warning systems produce a sound return on the investment. It is also useful to assist with post-disaster recovery planning and management. A vital component for appropriate land use planning in flood-prone areas is Flood Risk Mapping. Flood Risk Mapping is a presentation of easily-read, rapidly-accessible charts and maps which facilitates administrators and planners to identify areas of risk and prioritize their mitigation and response efforts. Owing to the continually changing nature of land use, flood-prone areas need to be examined because of how they affect development or might be affected by development" [19]. "The application of GIS, performing analysis and carrying out simulations can be a very useful tool in Flood Risk Mapping because it provides vital information in the case of planning and in the events of emergency. Flood Risk Mapping further aids in analysing the characteristics of the nature of the terrain of the study area and the drainage network system. These contribute immensely to accurate and timely intervention strategies and curbing the impacts thereafter" [20]. "Continuous updating and monitoring of risk maps is, therefore, most important for proper flood risk management: decision makers need up-to-date information in order to allocate resources appropriately" [21]. Many of the previous studies have applied GIS and remote sensing but very few gave attention to applying geospatial technologies to assess the risk levels in the flood hazards of the Southern Nigeria which is still somehow rare in the literature. Against this backdrop, the study examined the spatial assessment of elevation-based flood risk levels of communities in the wetland areas of Rivers and Bayelsa States, Niger Delta Region, Nigeria.

2. MATERIALS AND METHODS

The study was carried out in both Bayelsa and Rivers States, Niger Delta Region of Nigeria. Bayelsa State lies along latitudes between 4° 48' 00" North and 5° 24' 10"East; and longitudes between 6° 12' 00"E and 6° 39' 30"E (Fig. 1). It is bounded by Rivers State on the North and Delta State by the East and has a population of 1,704,515 by 1996. Yenagoa is the capital city of Bayelsa State. It has a population size of 24,335 people, according to 2006 population census estimates. Rivers State is one of the 36 states of Nigeria. The climate of the region is an equatorial type of climate. There are two distinct seasons in the region in a year, they are called rainy and dry seasons. The rainy season begins from the month of February and gradually rises to its peak in the month of July. The major vegetation in the study area comprises of mangrove and freshwater swamp. The region is located within the lower Delta Plain believed to have been formed during the Holocene of the quaternary period by the accumulation of sedimentary deposits. Generally, region is lowland with mean elevation of between 3m and 7m above mean sea level and characterized by flood plains. Umeuduji and Aisebeogun [22] identified that the area is within the belt of beach ridge barrier complexes generally trending in an east-west direction with height which vary between 10-25m above sea level. The net features such as lagoons are dominant relief features in the study area and are drained by many rivers and creeks among which are Epie Creek, Nun River, Orashi River, and Ekole Creek. Abam and Fubara (2022) also reported that the River Niger follows a relatively straight southwesterly trajectory after Onitsha. The flood plain is a homo-climate geomorphic structure whose trends west ward and southwards' are broken in many places by small hogback ridges and shallow swamps basic. The soil of the sandy ridges are mostly sandy or sandy barns and supports crops like Coconut, oil palm, raffia palm and cocoyam. The major geological characteristic of the state is sedimentary alluvium. The region lies on the recent coastal plain of the eastern Niger Delta.

The elevation of communities in the study area was generated using the Shuttle Radar Topography Mission (SRTM) data which aided in the generation of a digital topographic map of the study area surface at a 30 meter resolution with an absolute horizontal and relative vertical accuracy of 90% confidence level (USGS, 2006). Karwel [23] specified that STRM data can serve

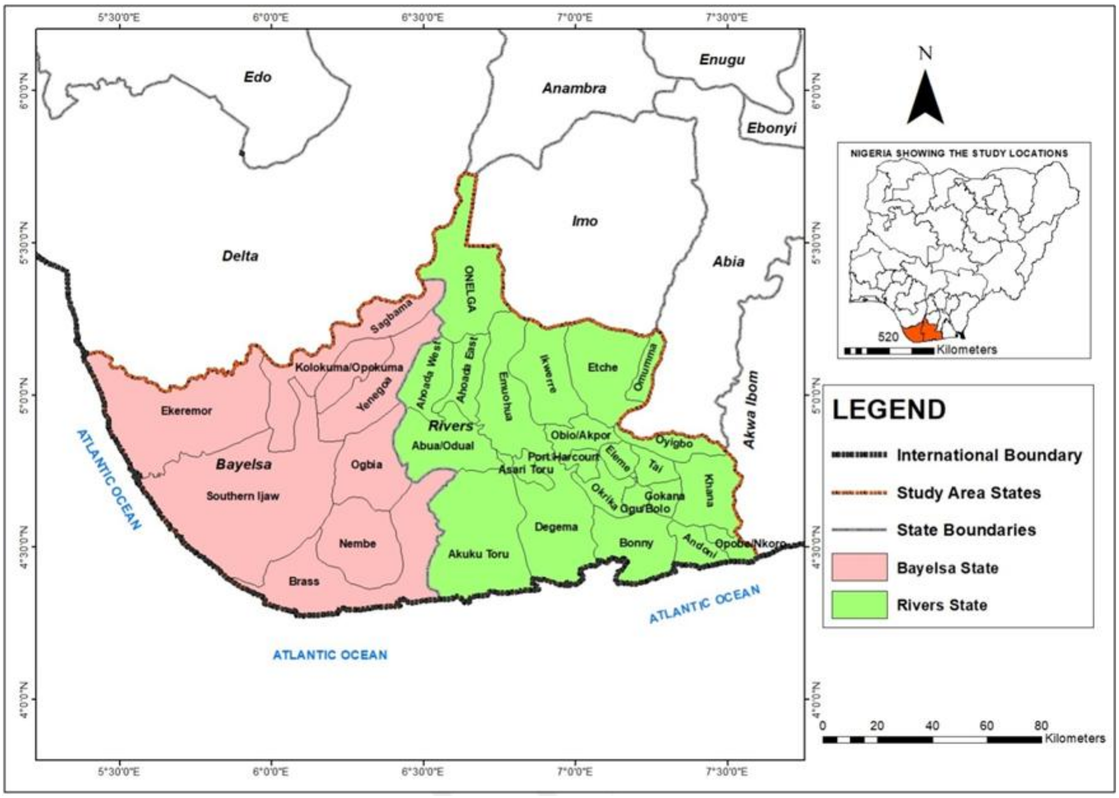

Fig. 1. Rivers and Bayelsa states showing the local government areas

Table 1. Wetland local government areas/communities in the study area

S/N	States	Local Government Area	2006 Population	2010 Population	2020 Projected population	Household Size	Sample size
1.	Bayelsa State	Sagbama	186869	209853	235669	39278	29
		Yenagoa	352285	395615	444283	74047	55
		Ogbia	179606	201697	226509	37751	28
		Kolokuma Opokuma	79266	89015	99965	16660	12
		Southern Ijaw	321808	361389	405846	67641	51
		Ekeremor	269588	302746	339989	56664	42
		Nembe	130966	147074	165166	27527	20
Total						**319,568**	
	Rivers State	Ahoada East	166324	190554	213995	35665	26
		Ahoada West	249238	285541	320668	53444	40
		Ogba/Egbema /Ndoni	283294	324565	364492	60748	45
		Abua - Odual	282410	323552	363355	60559	45
Total						**210,416**	**400**

Source: Researcher's preliminary studies (2018); Nigeria Population Commission (NPC) (2006)

for a better function than their standard specification and hence could be utilized for a variety of geospatial applications, such as coastal vulnerability mapping [23].

The location of each community was derived from the base map produced by the survey department, ministry of lands and survey of individual states. This base map was geo-referenced using known ground control points derived via the hand held GPS and land marks in the study area. The geo-referencing of the base map was done using known ground points derived in the course of the field work and used to produce the maps required for the analysis. The tidal inundation range of the study area was carried out using the data derived from the WXtide 32 developed by the United States National Oceanic Service which gives tidal values in meters above sea level for the tidal water level for 9 rivers in the Niger Delta region study area inclusive. These data were crosschecked in the creeks and rivers of the study area by the author for reliability via groundtruting. Descriptive analysis was applied for the data analysis while maps and tables were used for the data presentation. Also Pearson's Correlation Statistics was used to model the relationship between the flood height and tidal inundation. Taro Yamane sampling methods was used to compute the 400 population sample required in this study for questionnaire administration as displayed in Table 1.

3. RESULTS AND DISCUSSIONS

3.1 Risk Levels of Flood Hazard in the Study Area

From the analysis using the digital terrain model, it is observed that majority of the coastal region in the study area is generally low lying and highly exposed to flood event as shown in red coloured areas of the map (Fig. 2). The range of the elevation as shown in Fig. 2 was between 0.01 m and 98m.There are some pockets hinterland and most parts of the coastal aligning the Atlantic Ocean are generally of low elevation.

3.2 Enumeration of the Communities at Risk of the Flood Hazard and Characteristics of their Vulnerability to Floods

The enumeration of communities at risk displayed in Fig. 3 revealed flood risk in the region ranged from high risk exposure to very high risk exposure across the study area. From the analysis, most communities in the Ogba/Egbema/Ndoni Local Government Areas are very highly exposed to flooding at the same time the coastal communities and as indicated with the green box. The high risk exposed communities included Ahoada, Azagbene, Eben, Kpopkie, Owenegbene, Bisagbene, Ekeni among others while the very risk exposed communities included Okpogo, Ebubu, Aboigbene among others. In enumerating the communities at risk in flood hazard the period of living in the flood prone areas was evaluated in this study as observed the number of respondents that have lived in these communities for more than 25 years is less. This is as recorded that 20%, 11% and 11% of respondents from Yenagoa, Sagbama and Ogba/Egbema/Ndoni respectively have lived in this LGAs for over 25 years others include Ekeremor which recorded (11.1%), Sagbama (11.1%), southern Ijaw (44.5 %) and Yenagoa (10%).

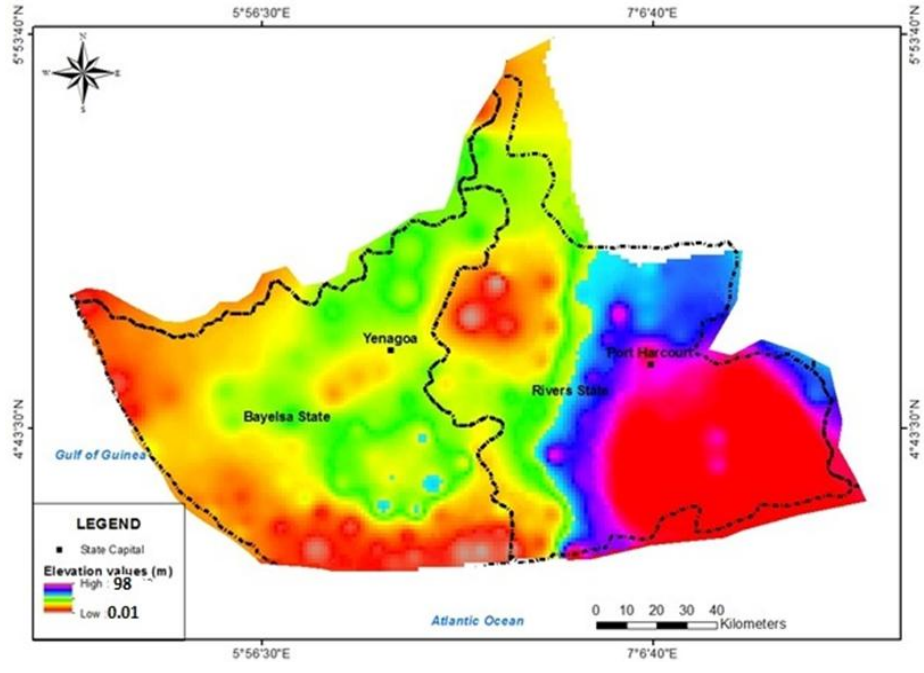

Fig. 2. Digital terrain map of the study area

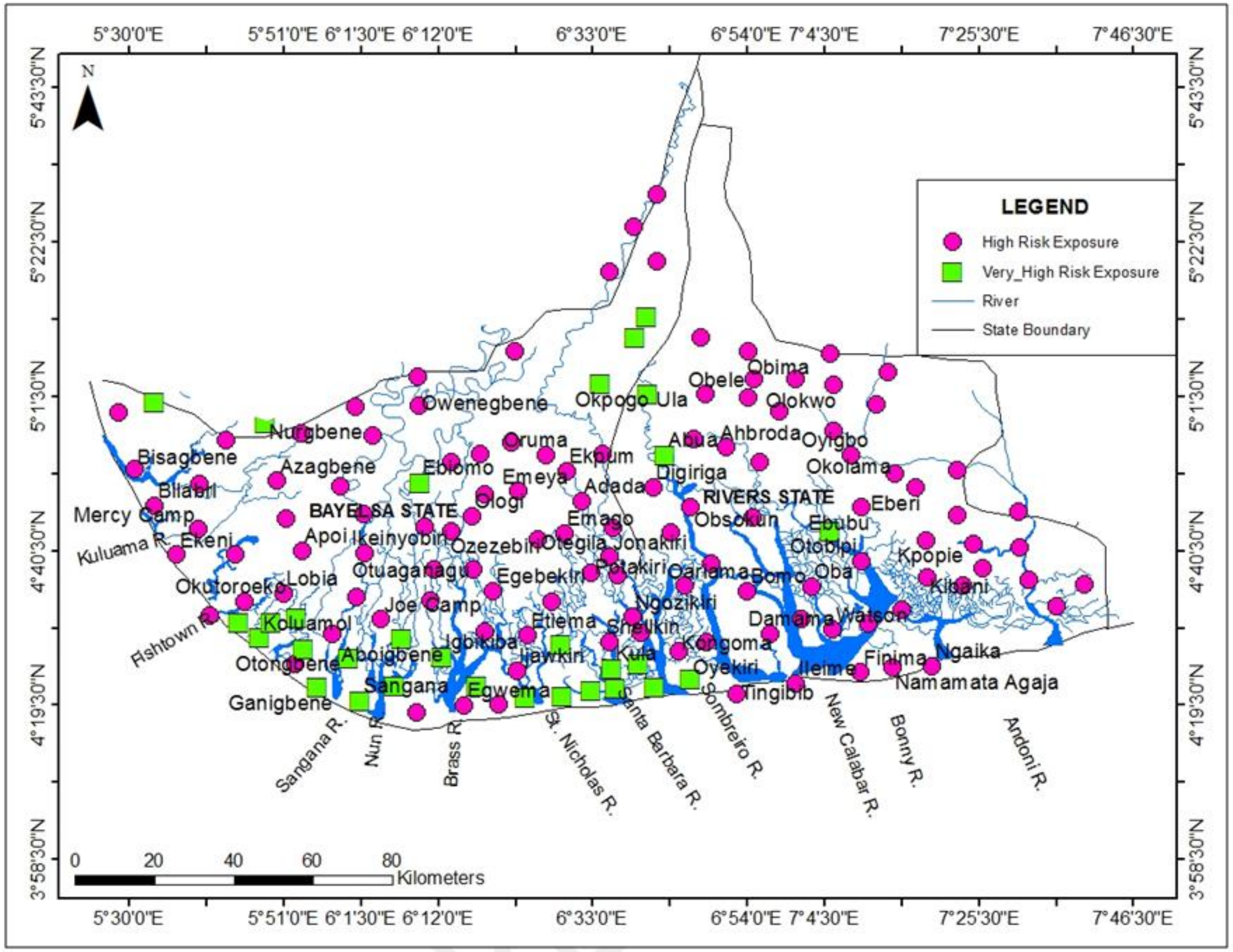

Fig. 3. Flood risk exposure across the study area

Table 2. Descriptive statistics of tidal water level and flood height in the study area

	Mean	Std. Deviation	N
Tidal Height	0.9301	0.36249	414
Flood Height	5.76	1.635	414

Table 3. Correlations between Tidal Water Level Increase and Flood Height across the Flooded Communities

		Tidal height	Flood height
Tidal Height	Pearson Correlation	1	0-.178(**)
	Sig. (2-tailed)		0.000
	N	414	414
Flood Height	Pearson Correlation	0-.178(**)	1
	Sig. (2-tailed)	0.000	
	N	414	414

*** Correlation is significant at the 0.05 level (2-tailed)*

Table 4. Flood impact mitigating measures

Names of LGA		Damage compensation	Governmental relief funds	Insurances	Total count & percentages
Abua/Odual	Count	12	12		24
	% of total	50	50		100
Ahoada	Count	24			24
	% of total	100			100
Ekeremor	Count	8	32		40
	% of total	20	80		100
Kolokuma	Count		16		16
	% of total		100		100
Nembe	Count	20	4	4	28
	% of total	71.4	14.3	14.3	100
Ogbia	Count	20			20
	% of total	100			100
Ogba/Egbema/Ndoni	Count	32			32
	% of total	100			100
Sagbama	Count	32	8		40
	% of total	80	20		100
SouthernIjaw	Count		36		36
	% of total		100		100
Yenagoa	Count	12	24		36
	% of total	33.3	66.7		100

3.3 Relationship between tidal water Level Increase and Flood Height across the Flooded Communities of the Study Area

There is a significant relationship between tidal water level and flood height in the study area after being tested using Pearson's correlation statistics. The analysis is displayed in Table 2 and Table 3 whereby the correlation coefficient between tidal water level increase and flood height across the flooded communities of the study area was -0.178 which means that the correlation was negative but low. Since the p value was p=0.000, thus it was greater than 0.05 significance levels. It therefore shows that the null hypothesis is rejected while the alternative hypothesis is accepted.

3.4 Flood Abatement and Mitigation Measures

Approaches to tackling the negative impact of flooding are manifold and can compromise action

Table 5. Flood abatement or flood prevention measures among residents

Names of LGA		Dams/ reservoirs	Reforestation	Restoring meanders in brooks and rivers	Retention of upstream attachment	Wave breakers	Wetlands conservation/ rehabilitation	Coastal wetlands protection	Total count & percentages
Abua/Odual	Count		4	12	12			16	44
	% of total		9.1	27.3	27.3			36.3	100
Ahoada	Count			16	8	4	4	8	40
	% of total			40	20	10	10	20	100
Ekeremor	Count				40			28	68
	% of total				58.8			41.2	100
Kolokuma	Count				12			8	20
	% of total				60			40	100
Nembe	Count	4			36			8	48
	% of total	8.3			75			16.7	100
Ogbia	Count				20				20
	% of total				100				100
Ogba/Egbema /Ndoni	Count			4	28			4	36
	% of total			11.1	77.8			11.1	100
Sagbama	Count				36		4		40
	% of total				90		10		100
SouthernIjaw	Count				40				40
	% of total				100				100
Yenagoa	Count				40				40
	% of total				100				100

Table 6. Flood defense and control measures put in place by respondents

Names of LGA		Embankment construction/ rehabilitation	Flood barrier	Mobile flood wall	Coastal sand supply	Bypasses to safeguard wetlands	Connect Rivers to existing lake	Dredging rivers	Embankment relocation and realignment	River bed widening	Total count & percentages
Abua/Odual	Count	20						4			24
	% of total	83.3						16.7			100
Ahoada	Count	20		4					8		32
	% of total	62.5		12.5					25		100
Ekeremor	Count	40									40
	% of total	100									100
Kolokuma	Count						16				16
	% of total						100				100
Nembe	Count	32	4		4				8		48
	% of total	66.7	8.3		8.3				16.7		100
Ogbia	Count	16							16		32
	% of total	50							50		100
Ogba/Egbema/ Ndoni	Count	32							28		60
	% of total	53.3							46.7		100
Sagbama	Count	32							8	4	44
	% of total	72.7							18.2	9.1	100
Southern Ijaw	Count	40									40
	% of total	100									100
Yenagoa	Count	32							20		52
	% of total	61.5							38.5		100

before, during and after the flood event but the most common is actions taken after the flood which includes damage compensation, government relief funds while insurance can be taken as action before flooding which only 14.3% of responses were obtained from Nembe to that effect and majority of the respondents enumerated the action taken after flooding which are the damage compensation and government relief funds as shown in the Table 4 Explicitly, it was gathered that 50% of respondents in Abua/Odual LGA, 100% in Ahoada, 20% in Ekeremor, 71.4% in Nembe, 100% in Ogbia, 100% in Ogba/Egbema/Ndoni, 80% in Sagbama, and 33.3% in Yenagoa LGA believed in damage compensation. Similarly, 50% of respondents in Abua/Odual LGa, 80% in Ekeremor, 100% in Kolokuma/Opokuma LGA, 20% in Sagbama LGA, 100% in Southern Ijaw and 66.7% in Yenagoa LGA believed in government relief funds. The analysis thus revealed that the two major ways of tackling the negative impact of flooding were damage compensation and government relief funds while the case of insurance remained unpopular in the study area.

Methods put in place to mitigate or prevent the extent of flood across the study area include restoring meanders in brooks and rivers which account for 40%, 27.3%, and 11.1% in Abua/Odual, Ahoada and Ogba/Egbema/Ndoni respectively while more than 50% of the respondents in the LGA sampled are of the opinion that the best way to prevent flooding is the retention of upstream attachments while others are in support of coastal wetland protection with the peak at Ekeremor (41.2%); finally 10% of the respondents from Ahoada are in support of wave breakers. From the same analysis, it can be observed that only 9.1% of respondents agreed to reforestation in Abua/Odual LGA while 27.3% each agreed on restoring meanders in Brooks and Rivers and retention of upstream attachment while 36.3% believed in coastal wetlands protection at the means of flood abatement or prevention measures among the residents in Abual/Odual LGA (Table 5).

In Ahoada, 40% agreed on restoring meanders in the brooks and rivers, and 11.1% in Ogba/Egbema/Ndoni. Furthermore, majority believed in retention of upstream attachment whereby 20%, 58.8%, 60%, 75%, 100%, 77.8%, 90%, 100% and 100% of respondents from Ahoada, Ekeremor, Kolokuma/Opokuma, Nembe, Ogbia, Sagbama, Southern Ijaw and Yenagoa LGAs respectively attested to. Similarly, 20%, 41.2%, 40%, 16.7% and 11.1% of respondents in Ahoada, Ekeremor, Kolokuma/Opokuma, Nembe and Ogba/Egbema/Ndoni LGAs respectively agreed on wetland protection as the flood abatement or prevention measures among the residents.

From the questionnaire survey carried out findings revealed that there are series of defense and control measures employed by the respondents across the study area and that most common among the LGA are embankment construction, construction/rehabilitation with most the respondents from the various communities affirming to it at a high percentage. Other measures enumerated include flood barrier, mobile flood wall, coastal sand supply and relocation/realignment as presented in the Table 6. In a nutshell, it is found from the analysis that 83.3% of respondents in Abua/Odual LGA, 62.5% in Ahoada, 100% in Ekeremor, 66.7% in Nembe, 50% in Ogbia, 53.3% in Ogba/Egbema/Ndoni, 72.7% in Sagbama, 100% in Southern Ijaw and 61.5% in Yenagoa LGA agreed on the embarkment construction/rehabilitation measures. Also, 12.5% of respondents in Ahoada believed in mobile flood wall and only 8.3% of respondents in Nembe LGA believed in flood barrier as flood control measures. In the same vein, it is believed that 100% of respondents in Kolokuma/Opokuma LGA believed in connecting rivers to existing lake while 16.7% of respondents in Abua/Odual LGA believed in dredging rivers. Similar to embankment construction/rehabilitation is embankment relocation and realignment whereby 25% of respondents in Ahoada, 16.7% in Nembe, 50% in Ogbia, 46.7% in Ogba/Egbema/Ndoni, and 18.2% in Sagbama LGA agreed to it. Only 9.1% of respondents in Sagbama LGA believed in riverbed widening as the only way for flood control.

4. CONCLUSIONS AND RECOMMENDA-TIONS

The study can be concluded that the coastal region in the study area is generally low lying and highly exposed to flood event. Most communities in the Ogba/Egbema/Ndoni LGA are very highly exposed to flood which included Ahoada, Azagbene, Eben, Kpopkie, Owenegbene, Bisagbene, Ekeni among others. Damage compensation and government relief funds were the major ways used to tackle the negative impact of flood. The popular method of flood abatement in the study area were restoring meanders in brooks and rivers and coastal wetlands protection. Based on the findings in this study, the following recommendations are suggested:

1. The use of dam for flood abatement and prevention should be adequately established in the study area
2. Apart from embankment, other flood defense and control measures such as flood barrier, mobile flood wall, coastal sand supply, bypasses to safeguard wetlands, connect rivers to existing lake, dredging rivers, and river bed widening should be adequately put in place to reduce the levels of flood impact in the study area.
3. Special relief funds should be released to victims that their household properties are destroyed during the flood
4. Majority of the residents should be given more orientation programmes on flood preparedness and mitigation measures to always reduce the impact of flooding on the livelihood of individuals and corporate establishments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Crichton D. UK and global insurance responses to flood hazard. Water Int. 2002;27:119-131.
2. Kron W. Flood Risk-A Global Problem. In Proceedings of the ICHE 2014-11th International Conference on Hydroscience & Engineering, Hamburg, Germany, 28 September–2 October. 2014;9–18.
3. Dang NM, Babel MS, Luong HT. Evaluation of food risk parameters in the day river flood diversion area, Red River Delta, Vietnam. Nat. Hazards; 2010. DOI:10.1007/s11069 – 010 – 9558 – x
4. Akinola, Suleiman, Francii. A review of flood risk analysis in Nigeria; 2015. DOI:0.3844/ajessp.2015.157.166, American journal of environmental Sciences.
5. Komolafe AA, Adegboyega SA, Akinluyi FO. A review of flood risk analysis in Nigeria. American Journal of Environmental Sciences. 2015;11(3): 157–166.
6. Coppock JT. GIS and natural hazard: An overview from a GIS perspective, In: A. Carrara and F; 1995.
7. Clark MJ. putting water in its place: A perspective on GIS in hydrology and water management, hydrological processes. 1998;12:823–834.
8. Smith AB. 2017 U.S. billion-dollar weather and climate disasters: A historic year in context; 2018. Available:https://www.climate.gov/news-features/blogs/beyond-data/2017-us-billion-dollar-weather-and-climate-disasters-historic-year
9. Shrubsole Dr. Dan. Flood Management in Canada at the Crossroads. Institute for Catastrophic Loss Reduction. 2000;5.
10. Hausmann P, Weber M. Possible contributions of hydroinformatics to risk analysis in insurance, In:Proc. 2nd International Conference on Hydroinformatics, Zurich, Switzerland. 1988;9–13 September, Balkema.
11. Smith LC. Satellite remote sensing of river inundation area, stage and discharge: A review, Hydrological Processes. 1997; 11:1427–1439.
12. Menzinger I, Brauner C. “Floods are Insurable!,” Swiss Reinsurance Company, Zurich; 2002.
13. Blong Russell. “A New Damage Index’, Natural Hazards,” Kluwer Academic Publishers, Netherlands. 2003;30:1-23.
14. Carter NT. Flood Risk Management: Federal Role in Infrastructure. CRS Report for Congress; 2005.
15. Werritty A, Houston D, Ball T, Tavendale A, Black A. Exploring the social impacts of flood risk and flooding in Scotland. Scottish Executive Social Research; 2007.
16. Miller G. The tsunami’s psychological aftermath. Science. 2005;309(1030).
17. Duan M, Zhang J, Liu Z, Aekakkararungroj A. Use of remote sensing and GIS for flood hazard mapping in Chiang Mai Province, northern Thailand. In International Conference on Geospatial Solutions for Emergency Management and the 50th Anniversary of the Chinese Academy of Surveying and Mapping. Beijing, China. 2009;14–16.
18. Forkuo EK. Flood hazard mapping using Aster image data with GIS. International Journal of Geomatics and Geosciences. 2011;1(4):932–950.

19. Bapalu GV, Sinha R. GIS in flood hazard mapping: A case study of Kosi river basin, India. GIS Development Weekly. 2005; 1(13):1–3.
20. Fava PR, Fritz S, Castellano A. The use of geographic information systems for disaster risk reduction programmes in Africa -User Manual. 2010;94. Available:http://www.coopi.org/repository/pagine/gis.manual_26.04.2010.pdf.
21. Jha AK, Bloch R, Lamond J. (Eds.). Cities and flooding: A guide to integrated urban flood risk management for the 21st century (Part 1). World Bank Publications; 2012.
22. Umeuduji JE, Aisuebeogun A. Relief and Drainage. In C. U. Oyegun and A. Adeyemo, (eds.): Port Harcourt Region, Port Harcourt: Department of Geography and Environmental Management University of Port Harcourt; 1999.
23. Karwel KAEI. Estimation of the Accuracy of the SRTM terrain Model on the Area of Poland. Paper presented at the The XXI ISPRS Congress; 2008.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/103444