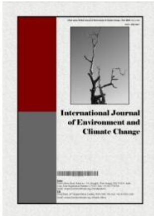

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Projected Impact of Sea Level Rise on Nigeria's Coastal City of Calabar in Cross River State

Joel Efiong[1*] and John O. Ushie[1]

[1]Department of Geography and Environmental Science, University of Calabar, P. M. B. 1115, Calabar, Cross River State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author JE conceived the idea and developed the methodology and spatial analysis for the study. Author JOU conducted the literature search and did field data collection. Both authors did the writing up and approved the final manuscript.

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ABSTRACT

This study projects the impact of sea level rise on Nigeria's coastal city of Calabar in Cross River State. Data for the study were obtained from both secondary and primary sources through the use of the internet and questionnaire administration respectively. The data were analysed using the geographical information systems (GIS), frequency tables and percentages. The results revealed that at 0.3 m rise in sea level, about 4.56% of the total land area will be covered with flood water. This would affect 159 houses, with approximately 1,431 persons. Further, at 3.0 m rise in sea level, about 10.10% of the area will be flooded, affecting 2012 houses with an estimated population of 18,108 persons. Again, the resilience of the residents to the vagaries of flooding by sea level rise is generally low due to very low income and lack of awareness. The study concluded that Calabar City is vulnerable to the impact of sea level rise which is primarily caused by climate change. Therefore, awareness campaign on the impact of flooding by sea level rise on coastal communities should be carried out by the appropriate agencies of government in the State.

**Corresponding author: E-mail: joel_efiong@yahoo.com;*

Keywords: Sea level rise; Nigeria's coastal city; Calabar; climate change; flooding; geographical information systems.

1. INTRODUCTION

Flooding has become a regular event in most part of the world, including Nigeria [1] with its attendant loss of lives and property [2,3]. Flooding can result from natural events or anthropogenic activities [4]. However, recent occurrence of flooding has been attributed to climate change [5,6]. It has been argued that climate affects virtually every activity on earth [7].

There are various dimensions of climate change and its impact on the environment. One dimension of climate change that scientists seem not to have an agreement is in relationship to sea level rise. Records have shown that sea levels have been rising over the centuries. However, sea level rise driven by increased earth's surface temperature will result in increased exposure of coastal communities to flood hazards. Specifically, sea level rise is not just predicted to have major effects on terrestrial and marine life, but also considered to bring about significant population displacement in the near future [8].

There are various estimates on the severity and pace of sea level rise around the world. For example, the Intergovernmental Panel on Climate Change [9] report estimated an upper limit of between 26 and 59 cm of sea level over the next century. In 2000, the United States Geological Survey (USGS) stated that, if the entire Greenland and Antarctic Ice sleets were to melt, then the sea level would rise to about 80m. With approximately 10% of the world's population living in coastal areas of 10m or less above the sea level, these projections are quite threatening. Recent scientific investigations reveal that sea level rises up to one metre are likely within the century [10]. This is supported by the possibility of the melting of Greenland and West Antarctic ice sheets by as much as 5 m.

While the reality of climate change is now being generally accepted, the impact of the actual and projected effects are still debatable. It is not still certain about local manifestation of global climate change and what necessary adjustments will be affected in both the natural and human systems [11]. This uncertainty characterizes the problem at the levels of the physical impacts and of the responses and adaptation in human settlements all over the world. For example, across the United States of America, there have been occurrences of extreme weather events and other disruptive incidents. These have led different US Presidents from 2000 to issue between 45 and 99 major disaster declarations annually. It is on record that eight weather and climate disaster events in the United States caused the loss of over $1 billion in 2014. These disasters impact communities in several ways by destroying critical infrastructure and natural resources, damage to human health and the local economy, human population displacement and disruption of environmental services. These losses are exacerbated in coastal communities.

In Nigeria, as at 2000, one quarter of the population of 100 million people lived in the coastal zone [12]. It has been reported that 1m rise in sea level by 2100 would threaten 18,000 km^2 of Nigeria's land and 3.2 million people would be at risk of flooding [13]. A 1-m rise in sea level would make over 800 villages uninhabitable in the Niger Delta region. Moreover, coastal erosion which is already a problem in the Niger Delta region will exacerbate with sea level rise. With sea level rise, there could be a potential loss of 17,000km^2 of wetlands in the Niger Delta [12]. This could result to a potentially massive "environmental refugee" migration.

Moreover, Calabar is often quoted as one of the Nigerians coastal cities that is vulnerable to the vagaries of sea level change due to its low-lying nature. However, no study has been undertaken to understand the extent to which the city could be impacted by sea level rise. Hence, this study was conducted with a view to predicting the impact of probable sea level rise on Calabar Urban in Cross River State of Nigeria.

2. BRIEF REVIEW OF PREVIOUS RESEARCH AND CONCEPTUAL FRAMEWORK

2.1 Brief Review of Previous Research

Several studies have been conducted on flood vulnerability. For example, [14] carried out a mapping on the exposure of socio-economic and natural systems of West Africa to coastal climate stressors. The study defined the coastal zone as a 200 km strip from the coastline inland. The study identified the Niger Delta Region – Southern Nigeria, of which the study area is located, as a particularly vulnerable area along the coast due to the activities of oil exploitation and the consequent environmental degradation commonly experienced in the area.

A study to estimate the physical and economic impacts of sea level rise on coastal zones around Africa has also been conducted [15]. Similarly, other authors estimated the exposure of the world largest port cities to coastal flooding due to storm surge using a population criteria of 1 million people in 2005 and identified 136 port cities all over the world, with 19 in Africa [16]. The study's findings ranked Africa as the third and fourth highest continent in terms of part city's population exposure and asset exposure respectively. However, the first quantitative analysis of Nigeria's vulnerability to sea-level rise was conducted and reported in [13]. It was found out that much of Nigeria's population and economic activities are located along the low-lying coastline, including the Niger Delta and the city of Lagos. The results of the study suggested that the potential social and economic costs to Nigeria could be significant. It was noted that a one-meter rise in sea level could flood as much as 18,000 km² of land, forcing as many as 3.2 million people to relocate from their homes and destroying infrastructure valued at over $18 billion, including vital oil producing facilities as at 1995. The recommendations of this research [13] showed that future studies using improve topographic data of the coastal zone is required and this therefore formed the basis of this current study.

Other studies on impact of sea level rise on coastal communities in Nigeria included those of [17,18,19,20,21,22,23]. However, most of these studies were either too generalized or do not cover the current study area. It is generally known that impact of sea level rise would not be the same across communities, hence the need for case-specific studies on all communities that are vulnerable to sea level rise impact.

On the aspect of awareness to flood risk due to sea level rise, [24] showed that it was higher among residents who had experienced flooding previously than those without any experience. However, building regional citizens' knowledge base about current and future flood risks and the benefits and consequences of options to reduce flood risk was quite inevitable [25].

2.2 Conceptual Framework

This study was underpinned by the concepts of vulnerability and resilience. Vulnerability describes the degree to which a system is susceptible to or unable to cope with adverse effects of climate risk. It include climate variation to which a system is exposed, its sensitivity and its adaptive capacity [26]. It has been shown that vulnerability increases as the magnitude of climate change or sensitivity increases, and decreases as adaptive capacity increases [27]. This concept is important for this study because coastal environments have a higher risk of being impacted by the effect of sea level rise than any other environments, hence their vulnerability level is expected to be higher than those for other areas. Aside proximity of the Atlantic Ocean and rivers flowing through the study area, the low elevation of most part of the study area could exacerbate the risk of high flood exposure due to sea level rise.

Contemporary studies on vulnerability include consideration of self-awareness of capacities as well as vulnerability [28,29]. People living with risk are now increasingly being seen as "powerful claimants with rights, rather than poor victims or passive recipients" [30]. It is also now well-established that people living with disabilities have valuable knowledge, experience, and skill to contribute to social protection and risk reduction [31,32]. Such could be adopted in the study to turn the weakness, from exposure to flooding due to sea level rise to strength.

The theoretical ecologist C. S. Holling was the first person to introduce the term resilience to the ecological literature in 1973 [33] and it was used in a way to help in the understanding of the non-linear relationship that were observed in ecosystems. He defined ecological resilience as the amount of disturbance that an ecosystem could withstand without changing self-organised processes and structures. Since then, several meanings have been provided for the concept. For example, some authors consider resilience as the return time of the ecosystem to a stable state after perturbation. Generally, resilience of a system have been defined in two different ways in ecological literature, each reflecting different aspect of stability [34]. These are, resilience in engineering systems defined as a return time to single global equilibrium, and resilience in ecological systems, which is the amount of disturbance that a system can absorb without changing the domains of stability.

In the present study, resilience will be used to mean "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to and recover rapidly from flooding" [35] impact due to possible sea level rise at various scenarios. It should be noted that one way that communities can improve their capacity to cope with disasters such as flooding is to enhance their resilience. Resilience work can help protect the Calabar Urban from future disaster that could result from sea level rise.

3. RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Location and extent

The study area is Calabar Urban in Cross River State. Cross River State is one of the 36 States in Nigeria and within the Niger Delta region (Fig. 1). It is found in the South-South geo-political zone. Calabar urban lies within Longitudes 8º15' and 8º25' East of the Greenwich Meridian and Latitudes 4º40' and 5º05' North of the Equator (Fig. 2). It has a total land area of 106.586 km^2.

3.1.2 Drainage

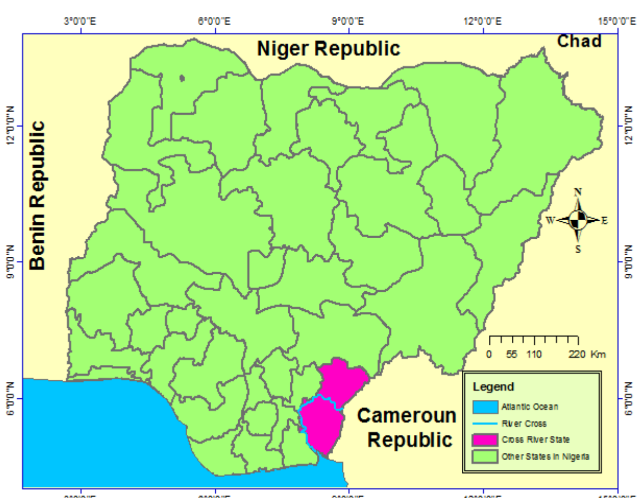
Calabar Urban is sandwiched between two main rivers: the Calabar River and the Great Qua River (Fig. 3). These Rivers join at the Cross River Estuary and empty into the Atlantic Ocean. This makes the study area to be vulnerable to the impact of sea level rise.

3.1.3 Elevation

The relief of Calabar is relatively low and generally flat. Elevation ranges between 0m in marginal areas of the Atlantic Ocean to 96 m in the northern area of the study (Fig. 4). The generally low elevation of the study area makes it vulnerable to flooding due to sea level rise. However, the level of exposure to vulnerability by the different parts of the area with respect to their elevations above sea level and the different exposure scenarios was the interest of the study.

3.1.4 Socio-economic activities

Most residents in the state capital originally engaged in farming and fishing activities. However, in view of the fact that Calabar is the Capital of Cross River state, a good number of residents are engaged in other activities such as civil and public service, business, crafts, tourism and recreation. In fact, the study area is the hub of recreational and tourism activities in Cross River State, playing host to the premier Tinapa Business and Leisure Resort, the Marina Resort, the Old Residency Museum and the Carnival Calabar activities organized every month of December. The study area can be accessed by air, land and water. There exist an International Airport (Margaret International Airport), a sea port with a Free Trade Zone. Major land routes are the Murtala Mohammed Highway, Calabar–Itu–Ikot Ekpene Highway, Calabar–Ikom highway and the Calabar-Ikang Highway. There could be serious socio-economic disruption if these activities and the infrastructures are impacted by flood due to sea level rise.



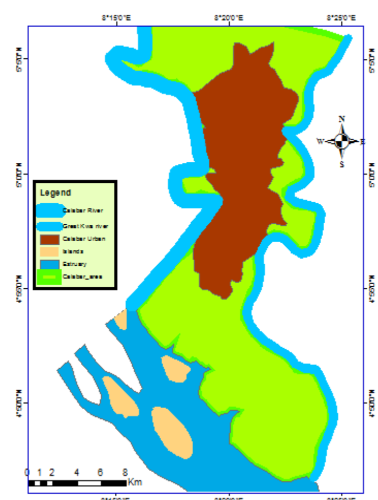


Fig. 1. Location of Cross River State in Nigeria **Fig. 2. Map of the study area**

Source: Produced by the author using Google Earth Map (2018) and Landsat 8 imagery

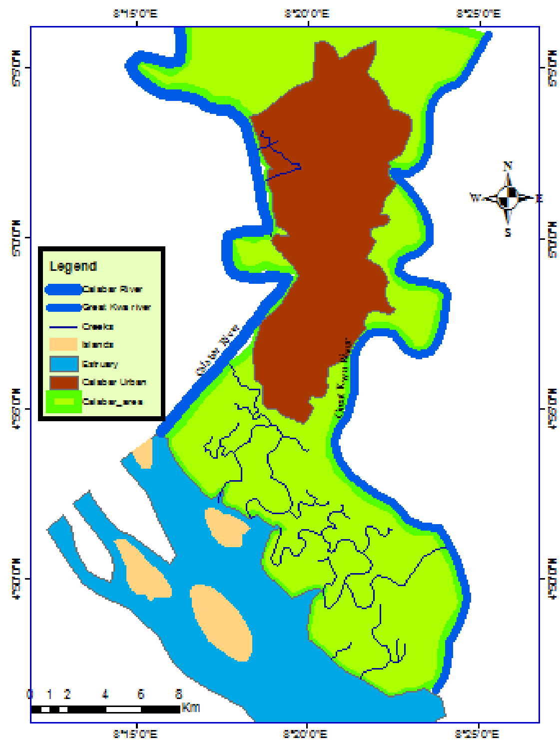


Fig. 3. Natural drainage the study area
Source: Produced by the author using Google Earth Map (2018) and Landsat 8 imagery

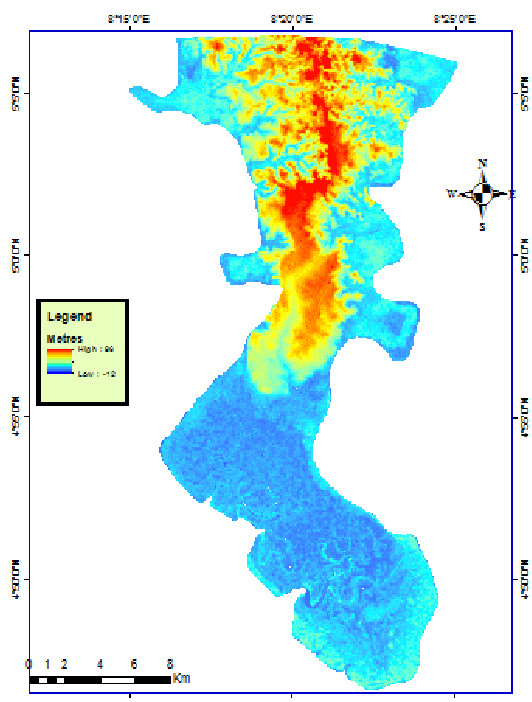


Fig. 4. Variations in elevation over the study area
Source: Extracted by the Author from the Shuttle Radar Topography Mission (SRTM) (2000). Available at: http://seamless.usgs.gov

3.2 Research Design

This study was based on the experimental design. Here the current mean sea level was used as the control against the different experimental levels of sea rises due to climate change. The adoption of this design allowed the researchers to observe the level of exposure of the study area to different scenarios of sea level rises. Also, the cross-sectional survey design was adopted to investigate the preparedness of residents of the study area for possible impact of flooding due to sea level rise. This design was also important in obtaining data that enabled the investigation of factors that may hinder residents' resilience to the impact of flooding to sea level rise.

3.3 Sources of Data

Both primary and secondary sources were consulted for the generation of data for this study. The primary source of data was basically the structured questionnaire that was developed by the authors. The secondary sources of data were remote sensing obtained through the internet and other published maps of the study area.

3.4 Sampling

Two locattions in the study area were selected for the administration of questionnaire base on the vulnerability to flooding by sea level rise of up to 3 m. These were the Edim Otop/Atimbo axis and the Jebs/Anantigha axis. A total of 582 houses were identified in the two areas (see Table 1) based on remote sensing technique for housing count and population estimation [36] using the Google Earth (Figs. 5 and 6). This also served as the study population. The minimum sample size for the two locations were determined using the formula [37]:

$$n = \frac{N}{1+N\,(e\,)^2} \qquad \text{Eq, (1)}$$

where: n = minimum sample size; N= population of study; and e = tolerable error limit of 0.05 percent

The sample size for each axis is shown in Table 1. The simple random sampling technique was then used to select houses for data collection.

3.5 Procedure for Data Collection

Data collection for this study was done in two phases. The first phase involved data collection from secondary sources through the internet. Here the Shuttle Radar Topography Mission (SRTM–3 DEM) elevation data set and Google Earth were explored. The SRTM data was obtained from [38]. The tiles that contained data for the study area were mosaicked using Erdas Imagine 2014 software and the area of interest extracted in the case of SRTM-3DEM [35].

Fig. 5. Satellite image of Edim Otop/ Atimbo axis
Source: Google Earth (2019)

Fig. 6. Satellite image of Jebs/Anantigha axis
Source: Google Earth (2019)

Table 1. Sample selection

Location	Total affected houses	Number of houses selected
Edim Otop/Atimbo	89	73
Jebs/Anantigha	493	221
Total	482	294

The second phase of data collection involved face-to-face administration of questionnaire. The face-to-face method was adopted to ensure that all administered copies of the questionnaire are returned to ensure that the minimum sample size is maintained. The questionnaire administration was used to obtain data on socio-economic characteristics of residents within the identified areas of possible sea level rise impact of up to 3metres. Other data obtained included current experience of flooding, severity of flooding and flood coping strategies and resilience. The questionnaire was sampled on one household head per selected residential building. The number of houses were counted from the Google Earth imagery using a hand lens.

3.6 Techniques of Data Analysis

Data obtained for the study were analysed using both the graphical and statistical techniques. Graphical techniques involved the use of geographical information systems (GIS) and cartographic methods while statistical techniques made use of tables and percentages. For the graphical techniques, the elevation data in the form of digital elevation model (DEM) was imported onto the GIS environment for spatial analysis to show areas that are expected to be flooded at different scenarios of sea level rise. Scenarios were created for sea level rise at 0.3, 0.5, 1, 2, 3, 4, 5, 7, 10, 15, 20 and 40 m.

The DEM was used to re-classify the area using Boolean (crisp) set approach [39]. This approach allows the use of only binary membership function of either 'yes' or 'no', or 'true' or 'false', which can be expressed mathematically as '0' and '1'. The membership function for flooded and non-flooded areas in the study area were expressed as:

$$MF^{B}(z) = 1 \quad \text{if } b_1 \leq z \leq b_2 \quad \rightarrow \text{for flooded area} \quad - \quad \text{Eq, (2)}$$

$$MF^{B}(z) = 0 \quad \text{if } z < b_1 \text{ or } z > b_2 \quad \rightarrow \text{for non-flooded area} \quad - \quad \text{Eq. (3)}$$

Where: MF= Membership function; z= elevation value: and b_1& b_2 = define the boundaries between flooded and non-flooded areas.

The extent of the flooded and non-flooded areas was read of from the attribute table generated during the spatial analysis. Data obtained from questionnaire were analysed using percentages and are presented in tabular form.

4. RESULTS AND DISCUSSION

Table 2 shows extent of the flooded area, number of houses and estimated population that would be impacted for a given level of sea rise on the urbanized area of Calabar in Cross River State of Nigeria. It reveals that at 0.3 m rise in sea level, about 4.56% of the urban land area will be affected by flood. This will in turn affect a total of about 159 houses with an estimated population of 1,431 persons. Similarly, at a sea level rise of 0.5 m, about 5.28% of the total urban landmass will be flooded; affecting 237 houses with an estimated population of 2,133 persons. Other scenarios of possible impact are also shown in Table 4 up to 40 m rise in sea level. At 40 m rise in sea level, about 50% of the entire area will be affected by flooding. This could bring untold harm and hardship to about 61,461 persons. This could result in more environmental refugees, a situation that is currently being witnessed all over world and in particularly in some areas of Nigeria.

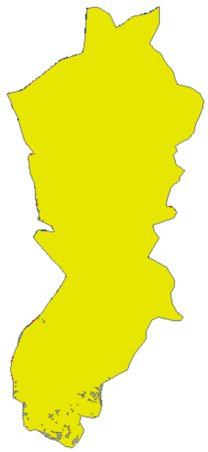
The specific locations that would be impacted by flooding due to sea level rise are shown in Figs. 7–18; corresponding to projected sea level rise shown in Table 2. The results reveal threatening impact of possible sea level rise on the study area. The results agrees with previous study [11] on the impact that sea level rise could pose on coastal communities. This is becoming more worrisome as recent reports [22] reveals that the polar ice is melting at rate faster than what was earlier predicted.

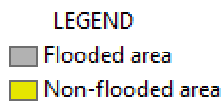
Tables 3-5 show data on socio-economic variables of respondents in areas that could be affected by sea level rise up to 3 m. Table 2 has already shown that about 18,108 persons could be affected by a sea level rise of 3 m in the study area. From the responses in Table 3, 92.86% of household heads in the two sampled areas were males while the remaining 7.14% cent were females. Hence, there are more male household heads than females in the sample.

Table 4 presents variations in number of persons per household in the study area. About 3.40 per cent of the households in the study have less than 3 persons constituting the household while 14.97% have more than 10 persons making up a household. Most of the households (56.12%) have between 9 and 10 persons in a household with 19.37% having between 6 and 8 members. Hence, the average membership per household in the study area was estimated as 9.

Table 2. Projected sea level rise, flooded area and affected population in Calabar Urban

Projected sea level rise (M)	Flooded area		Non-flooded area		Houses affected	
	Km ^{2}	%	Km^{2}	%	No, of houses affected	Estimated population (no. of houses x 9)
0.3	4.861812	4.56	101.724188	95.44	159	1431
0.5	5.628191	5.28	100.957809	94.72	237	2,133
1	7.742196	7.26	98.843804	92.74	449	4041
2	10.765786	9.68	95.830214	90.32	1024	9216
3	12.768196	10.10	93.817804	89.90	2012	18108
4	15.905384	14.92	90.680616	85.08	3711	33399
5	16.368191	15.36	90.217809	84.64	4012	36108
7	20.329963	19.07	86.256037	80.93	4740	42660
10	24.264318	22.77	82.321682	77.23	5213	46917
15	27.223181	25.54	79.362819	74.46	5782	52038
20	34.417679	32.29	72.168321	67.71	6231	56079
40	51.953869	48.74	54.632131	51.26	6829	61461





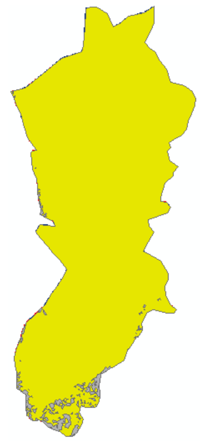
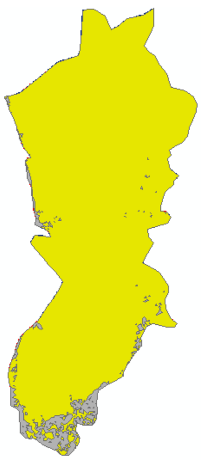
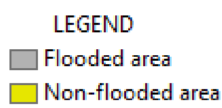


Fig. 7. Areal coverage of flood at 0.3 m rise in sea level

Fig. 8. Areal coverage of flood at 0.5 m rise in sea level





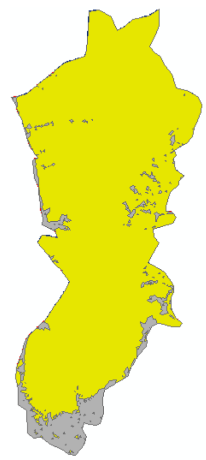
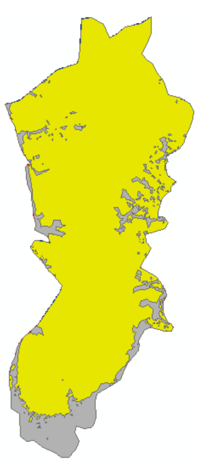
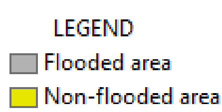


Fig. 9. Areal coverage of flood at 1 m rise in sea level

Fig. 10. Areal coverage of flood at 2 m rise in sea level





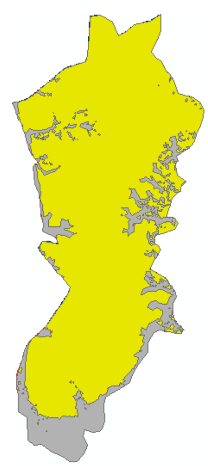
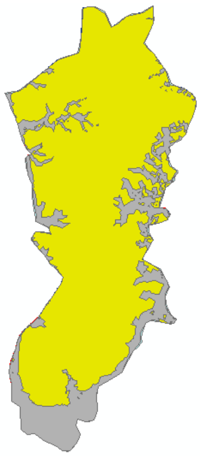
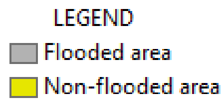


Fig. 11. Areal coverage of flood at 3 m rise in sea level

Fig. 12. Areal coverage of flood at 4 m rise in sea level





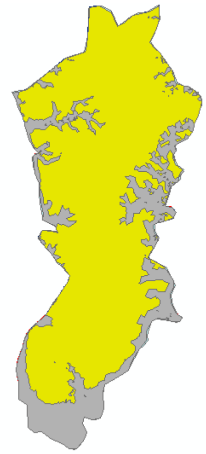
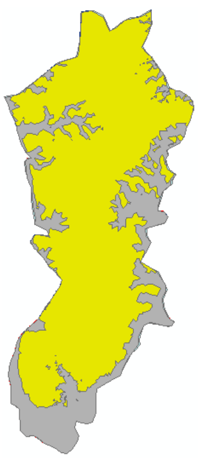
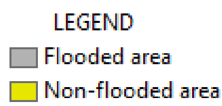


Fig. 13. Areal coverage of flood at 5 m rise in sea level

Fig. 14. Areal coverage of flood at 7 m rise in sea level





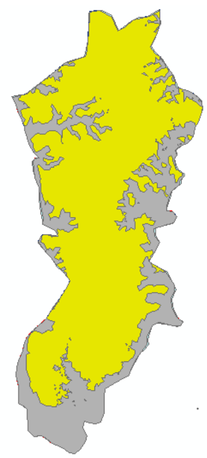
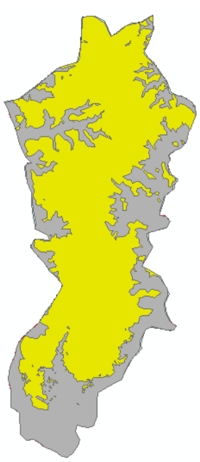
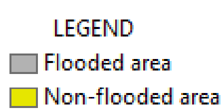


Fig. 15. Areal coverage of flood at 10 m rise in sea level

Fig. 16. Areal coverage of flood at 13 m rise in sea level





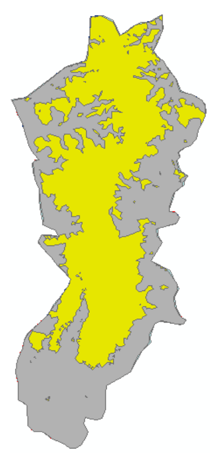


Fig. 17. Areal coverage of flood at 20 m rise in sea level

Fig. 18 Areal coverage of flood at 40 m rise in sea level

Table 3. Distribution of respondents by gender

Gender	Location				Total	
	Edim Otop/Atimbo axis		Jebs/Anantigha axis			
	Frequency	%	Frequency	%	Frequency	%
Female	64	87.67	209	94.57	273	92.86
Male	9	12.33	12	5.43	21	7.14
Total	**73**	**100**	**221**	**100**	**294**	**100**

Table 4. Variations in number of persons per household

Number	Location				Total	
	Edim Otop/ Atimbo axis		Jebs/Anantigha axis			
	Frequency	%	Frequency	%	Frequency	%
< 3	2	2.74	8	3.62	10	3.40
3 – 5	9	12.33	12	5.43	21	7.14
6 – 8	11	15.07	43	19.46	54	18.37
9 – 10	39	53.42	126	57.01	165	56.12
> 10	12	16.34	32	14.48	44	14.97
Total	**73**	**100**	**221**	**100**	**294**	**100**

The ability of residents to cope with the impact of flooding by sea level rise and their resilience could be effected by their income. Table 5 shows the income distribution of respondents in the study area. About 44.22 % of respondents receive income below N18,000.00 per month. This is about $50,00 which is far below the poverty level of $1 per person per day. If this amount is divided among members of the household based on the average number of person per household, the amount would not be up to the minimum bench mark required for at least two members of the household in a month. This level of poverty as shown in the study area portends great danger to the population in the areas and could hinder residents' resilience to the vagaries of sea level rise, thereby worsening the impact.

Table 5. Income distribution

In N	Location				Total	
	Edim Otop/ Atimbo axis		Jebs/Anantigha axis			
	Frequency	%	Frequency	%	Frequency	%
0 – 18,000	29	39.73	101	45.70	130	44.22
19 ,000 – 30,000	12	16.44	40	18.10	62	21.09
31,000 – 50,000	8	10.96	28	12.67	36	12.25
51,000 – 100,000	5	6.85	19	8.60	24	8.16
101,000 – 150,000	5	6.85	15	6.78	20	6.80
151,000 – 200,000	2	2.74	11	4.98	13	4.42
> 200,000	2	2.74	7	3.17	9	3.06
Total	**73**	**100**	**221**	**100**	**294**	**100**

Table 6. Current experience of flooding

Response	Location				Total	
	Edim Otop/ Atimbo axis		Jebs/Anantigha axis			
	Frequency	%	Frequency	%	Frequency	%
Yes	34	46.58	102	46.15	136	46.26
No	39	53.42	119	53.85	158	53.74
Total	**73**	**100**	**221**	**100**	**294**	**100**

Table 7. Nature of current flooding

Response	Location				Total	
	Edim Otop/ Atimbo axis		Jebs/Anantigha axis			
	Frequency	%	Frequency	%	Frequency	%
Not severe	5	14.70	23	22.55	28	20.59
Just severe	8	23.53	30	29.41	38	27.94
Very severe	13	38.24	36	35.29	49	36.03
Extremely severe	8	23.53	13	17.75	21	15.44
Total	**34**	**100**	**102**	**1000**	**136**	**100**

Table 8. Awareness of sea level rise

Response	Location				Total	
	Edim Otop/ Atimbo axis		Jebs/Anantigha axis			
	Frequency	%	Frequency	%	Frequency	%
Unaware	37	50.68	89	40.27	126	42.86
Just aware	23	31.51	68	30.77	96	30.95
Very aware	13	17.81	64	28.96	77	26.19
Total	**73**	**100**	**221**	**100**	**294**	**100**

Tables 6-8 show data on current experience of flooding, nature of current flooding and awareness of sea level rise by residents. Table 6 shows that about 46.26% of the residents usually experience flooding, particularly during the rainy seasons. Also, over 50% of current flooding is at least very severe (Table 7). The situation would certainly worsen with sea level rise. Moreover, over 40% of residents are not aware of possible sea level rise (Table 8). From these results, it can be observed that even those who claimed to be aware of possible sea level rise may only have related it with the general ebb and tide regime experienced in coastal areas and not necessarily sea level rise which is primarily driven by global warming and climate change.

5. CONCLUSIONS AND RECOMMENDATIONS

This study has shown that there is the probable impact of sea level rise due to flooding of Calabar Urban based on projections made in the study. The findings of the study are unique in that they have provided readily available maps with precise locations of possible impact of sea level rise from different scenarios considered during the study. Hence, it is concluded that Calabar Urban would not be spared from the severe impact of flooding due to sea level rise. This will affect several houses/households depending on the level of sea rise. The resilience of most of the residents in the affected areas is generally low, due to poor income which is grossly below $1 mark per person per day. Also, awareness on the negative impact of sea level rise is generally low among residents. This should be the starting point for combating the cause of the problem which is global warming. Therefore, based on these conclusions from this study, the following recommendations are made:

1. Awareness campaign on possible impact of sea level rise on coastal communities should be carried out by the appropriate agencies of government, including the Federal Emergency Management Agency and their State counterparts.
2. Residents should avoiding building houses in flood prone areas and approval of building plans in such areas should be denied by the approval agency of government. The maps produced in this study should guide such approval, particularly for areas that could be impacted by up to 1m rise in sea level.
3. Human activities that encourage global warming and climate change, such as deforestation, gas flaring, bush burning, etc, should be discontinued or done in a sustainable manner.
4. Other case-specific studies should be conducted in other coastal communities, particularly in Africa, where vulnerability of sea level rise is high with low resilience.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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