The Vulnerability of Eti-Osa and Ibeju-Lekki Coastal Communities in Lagos State Nigeria to Climate Change Hazards

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Abstract
The rapid growth of population and infrastructure along the Lagos Coast present many challenges especially in the face of the current threats posed by climate change. The predominance of rural communities whose livelihoods are closely linked with climate- sensitive resources makes it imperative that the inhabitants understand, address and reduce their vulnerability to and adapt to the challenges of climate change. This study therefore evaluated the vulnerability of communities in Ibeju-Lekki and Eti-Osa Local Government Areas to climate change in order to introduce effective climate change communication, mitigation and adaptation techniques. Distance from water bodies (sea, creeks and lagoons) and height above sea level were the major variables used to carry out a vulnerability analysis using digital terrain modelling. 50.5% and 49.4% of the 91 communities have very high levels of vulnerability with a total vulnerability index of 8.3 on a scale of 10 where 10 indicate the highest degree of vulnerability while the highest elevation in the area is 12metres above sea level. This calls for the urgent need for climate change communication that are place-specific and demographic appropriate.
Keywords: Vulnerability, Coastal communities, Digital Terrain Modelling, Climate change communication.

1.1 Introduction

The rate of population growth along the Lagos coast presents many challenges. One of these challenges is in ensuring the safety and security of a population that is continually threatened by natural hazards such as flooding, coastal erosion and storm surge. The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (2001) concluded that climate change is most likely to have important impacts on settlements in coastal or riverine locations especially where rapid urbanisation is occurring alongside economies that are dependent on climate –sensitive resources. Storm surge is an environmental hazard that leads to the loss of habitat in estuarine ecosystems, the loss of beaches and damage to properties and natural resources (IPCC, 2007). Furthermore, the development of official and residential estates along the coast of the Atlantic Ocean in Lagos state is a major problem that circumvents basic environmental principles which should be adopted in the planning of coastal towns and cities. (Adelekan, 2009). Elsewhere in the world such areas are at best developed for hotels, gardens, parks, swimming pools and less frequented facilities. The coastal shelf of Victoria Island is at present barely two metres (six feet) above sea level. A remarkable percentage of 15 million *Lagosians* see Victoria Island and its satellite peninsula, Lekki, as the best part of the State to invest in, and obtain superlative returns in real estate. Yet rising at a pace of one-metre per 50 years, ocean surge may herald *Armageddon* for the city but the general populace seems not to be aware of this very important fact.

Inhabitants of the Lagos state coastal communities live in a low-lying coastal environment with fragile coastal ecosystems and a high reliance on tourism, agriculture and industry for economic activity- all of which are vulnerable to the impacts of a changing climate.

Consequently, this study evaluated the vulnerability of coastal communities in Lagos State to climate change hazards. This is to fill the gap in knowledge as it relates to climate change communication and the implementation of effective, relevant and culture- and demographically-compliant adaptation policies. Ignoring this aspect of research might result in the unsuccessful implementation of policies in mitigating and adapting to climate change, waste of financial and human resources, the failure of the region to join the global community in combating climate change and the great loss of physical, social, human and economic resources due to the negative impacts and hazards of climate change, some of which can still be prevented. This is because one of the best ways to minimize the impacts from coastal hazards is through better preparedness and a more informed public.

1.2 Study Area

Eti-Osa local government area lies on the narrow coastal lowland of the south eastern part of Lagos state and is situated on about 129.5 square kilometres of landmass along the foreshores of featuring sandy beaches, swamps, mangroves and creeks. It is bounded in the north by the Lagos lagoon, in the south by the Atlantic Ocean while at its western and eastern boundaries are Ojo and Ibeju-Lekki local government areas respectively. Ibeju-Lekki local government area is bounded in the east by Epe local government while its southern end joins the Atlantic Ocean. It is about 75 kilometres long and 20 kilometres at its widest point.

With a total population of 283,791 persons(158,858 males and124,933 females), Eti-Osa local government area (including Victoria Island and the Lekki peninsula) is rapidly urbanizing with diverse economic activities like banking, retail and wholesale trading, commercial transportation and monumental real estate development for both residential and commercial purposes.

Ibeju-Lekki local government area is bounded in the east by Epe local government while its southern end joins the Atlantic Ocean. It is about 75 kilometres long and 20 kilometres at its widest point. According to the 2006 national census, the total population of Ibeju-Lekki is 117,793 consisting of 60,729 males and 57,064 females. Ibeju –Lekki is a rural community with eleven rural markets located at various villages and natural resource-based economic activities like fishing, agriculture, timber /saw-milling, mat/ raffia weaving, oil-palm processing and emerging eco-tourism.

MAP 1: STUDY AREA

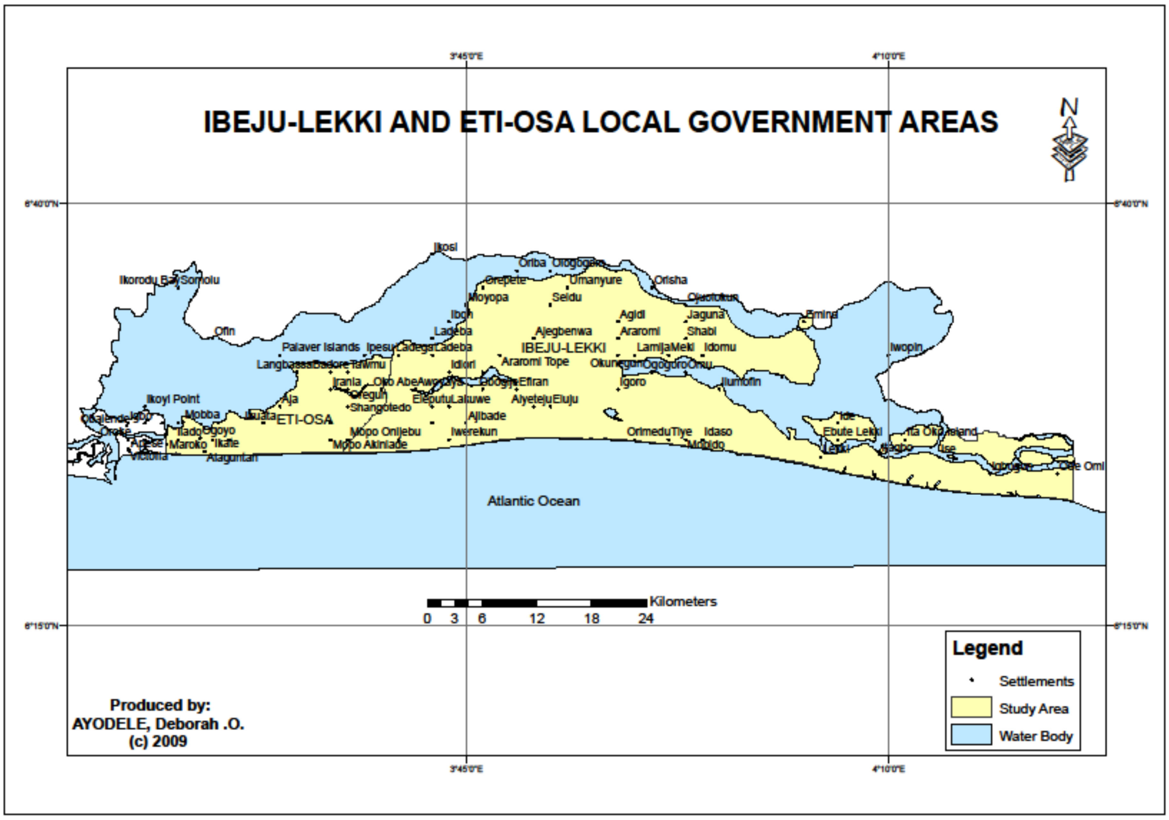


Figure 1: Map of Study Area

1.3 Conceptual Framework

The vulnerability of any system (at any scale) is reflective of (or a function of) the exposure and sensitivity of that system to hazardous conditions and the ability or capacity or resilience of the system to cope, adapt or recover from the effects of those conditions. Adaptations are manifestations of adaptive capacity, and they represent ways of reducing vulnerability. The basic vulnerability relationships are portrayed in Venn diagram format in Figure 1 (Smith and Wandel, 2006). The larger sets represent the broader stresses and forces that determine the exposure and sensitivity and shape adaptive capacity at the local or community level, denoted by the smaller embedded sets.

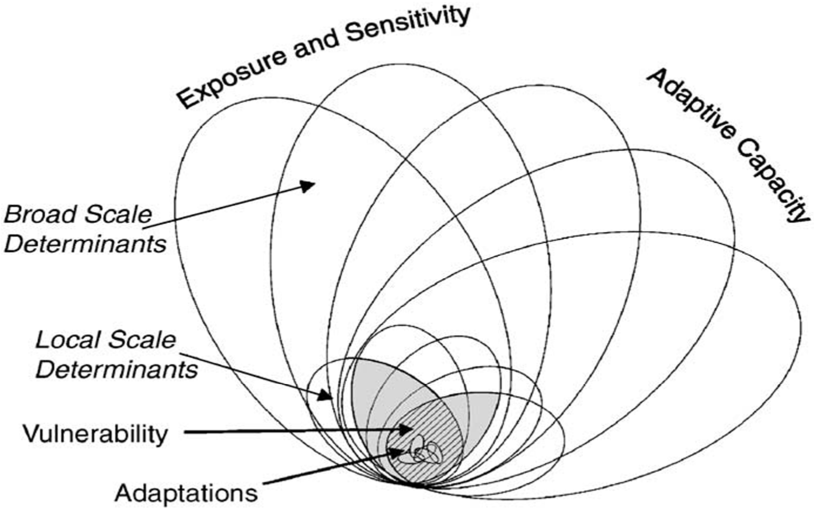


Figure 2: Basic vulnerability relationships (Smith and Wandel, 2006)

The interaction of environmental and social forces determines exposures and sensitivities, and various social, cultural, political and economic forces shape adaptive capacity. The overlap recognizes that the processes driving exposure, sensitivity and adaptive capacity are frequently interdependent. The finer scale interaction of these elements represents local vulnerability, and adaptations are particular expressions of the inherent adaptive capacity. Generally, a system (e.g. a community) that is more exposed and sensitive to a climate stimulus, condition or hazard will be more vulnerable, *Ceteris paribus*, and a system that has more adaptive capacity will tend to be less vulnerable, Ceteris paribus. This conceptualization broadly indicates the ways in which vulnerabilities of communities are shaped in addition to being place- and system-specific.

Vulnerability is defined by IPCC TAR (2001) as 'The degree, to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremities. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. Levina and Tirpak (2006), found very different interpretations for vulnerability: one interpretation views vulnerability as a residual of climate change impacts minus adaptation, whilst another views vulnerability as a general characteristic or state generated by multiple factors and processes, but exacerbated by climate change.

2.1 Methodology

Table 1 shows the primary and secondary data sources sub- divided into spatial and attribute (non-spatial) data.

Table 1: Types / Sources of data

S/N	DATA	DATA TYPE	DATA CHARAC-TERISTIC	DATA SOURCE	SCALE	NO	DATE
1.	Map of Ibeju-Lekki and Eti-Osa	Secondary	Spatial data	Department of master plan, Alausa; Ibeju-Lekki Town Planning office and Ikoyi-Obalende LCDA	1:200,000	2	2003
2.	Topographic maps of Lagos	Secondary	Spatial data	Federal surveys	1:25,000	6	1967
3	Population figures	Secondary	Attribute data	National Population commission	-	2	2006

In order to identify the selected communities within high risk areas and to determine their level of vulnerability, Geographic Information System was used. A standard setback of 75 metres was used to create buffers around the water bodies using ArcGis 9 software. The Town planning standard setback from the Atlantic Ocean is 150 metres, from the lagoon is 75 metres and from the creek is 30 metres. Therefore, an interval of 75metres was used to divide the study area's distance from water bodies into 5 levels. These levels were then scored to be able to determine quantitatively the level of vulnerability of the communities. Also, topographic sheets of the study area were projected to the geographic coordinate, *Minna datum*, digitized and the 3D Analyst tool was used to create a digital terrain model of the area into vulnerability levels based on topography.

The values obtained from the two criteria are added to obtain a vulnerability index for each of the communities on a scale of 0-10, 10 depicting areas with the highest degree of vulnerability.

3.0 Results and Discussions

3.1 Identification of Study Area Communities within Areas of High Risk and the Determination of their Levels of Vulnerability Analysis

Map 1 shows the various communities' distance to surrounding water bodies such as the Atlantic Ocean, Omu creek and the Lagos Lagoon. Communities that fall within each level help determine the overall vulnerability of the region.

Level 1 comprises those areas that are between 0 metres and 75 metres from any water body. Level 2 comprises those areas that are between 76 metres and 150 metres from any water body.

Level 3 comprises those areas that are between 151 metres and 225 metres from any water body.

Level 4 comprises areas that are between 226 metres and 300 metres from any water body. Level 5 comprises those areas that are at a distance of above 300 metres from water bodies.

Table 2: shows the settlements in each of the various vulnerability levels according to their distances from water bodies.

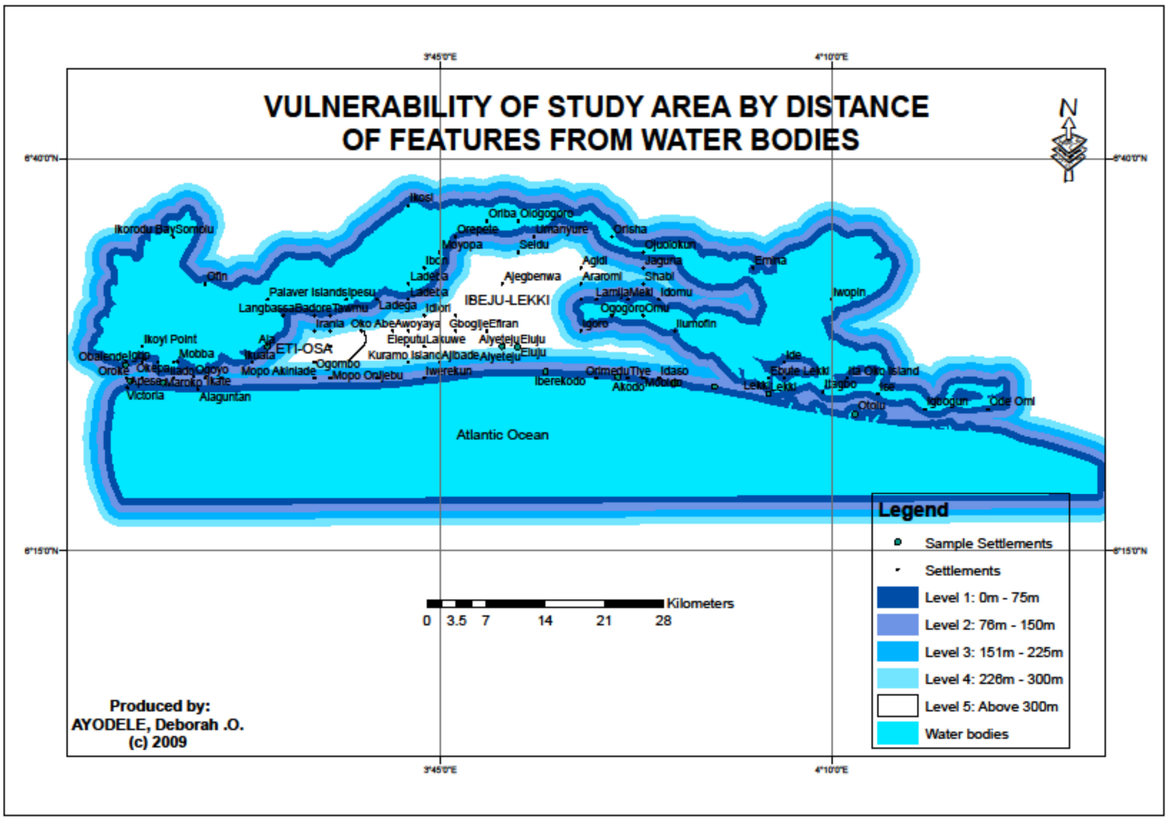
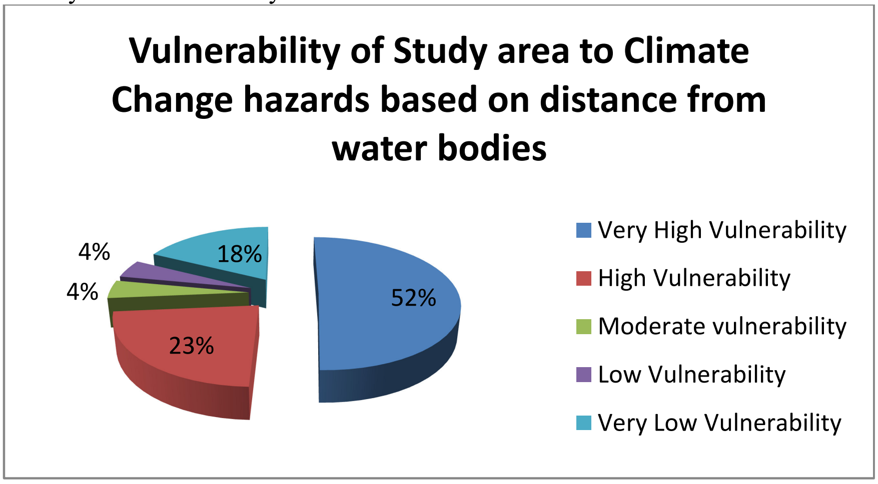


Table 3: Communities within each vulnerability level based on their distance from surrounding water bodies

SN	**Level 1** (0-75m)	**Level 2** (76-150m)	**Level 3** (151-225m)	**Level 4** (226-300m)	**Level 5** (Above 300m)
1	Tiye	Umanyure	Shabi	Seidu	Shangotedo
2	Ikorodu Bay	Tawmu	Maiyegun	Oregun	Oko Abe
3	Refuge Island	Oroke	Ajibade	Kuramo Island	Oguntedo
4	Palava Islands	Moshere Ikoga	Araromi (close to Agidi)	Iranla	Ogombo
5	Orisha	Mopo Onijebu	-	-	Lakuwe
6	Orimedu	Mopo Akinlade	-	-	Idiori
7	Oriba	Maroko	-	-	Gbogije
8	Orepete	Magbon	-	-	Eluju
9	Omu	Ladeba (2) close to Idiori	-	-	Eleputu
10	Ologogoro	Jinadu	-	-	Efiran
11	Okunegun	Jaguna	-	-	Awoyaya
12	Okepa	Ogoyo	-	-	Araromi Tope
13	Ojuolokun	Ilado	-	-	Arapagi Oloko
14	Ofin	Ikuata	-	-	Ajegbenwa
15	Ode Omi	Ikate	-	-	Aiyeteju
16	Moyopa	Igoro	-	-	Agidi
17	Mobido	Idomu	-	-	-
18	Meki	Ide	-	-	-
19	Lekki	Idaso	-	-	-
20	Langbasa	Badore	-	-	-
21	Lamija	Victoria Island	-	-	-
22	Ladeba (close to Ibon)	-	-	-	-
23	Ladega	-	-	-	-
24	Iwopin	-	-	-	-
25	Ita Oko Island	-	-	-	-
26	Itagbo	-	-	-	-
27	Ise	-	-	-	-
28	Ipesu	-	-	-	-
29	Ilumofin	-	-	-	-
30	Ikoyi point	-	-	-	-
31	Ikosi	-	-	-	-
32	Iwerekun	-	-	-	-
33	Igbogun	-	-	-	-
34	Igbo	-	-	-	-
35	Ibon	-	-	-	-
36	Emina	-	-	-	-
37	Ebute Lekki	-	-	-	-
38	Bamgbose	-	-	-	-
39	Aja	-	-	-	-
40	Ogogoro	-	-	-	-
41	Obalende	-	-	-	-
42	Alagutan	-	-	-	-
43	Araromi (2) close to Bamgbose	-	-	-	-
44	Victoria	-	-	-	-
45	Apese	-	-	-	-
46	Mobba	-	-	-	-

The above results show that 50.5% (more than half) of the study area has very high vulnerability to the exacerbated coastal hazards resulting from climate change, 23.1% has high vulnerability, and 4.4% has moderate vulnerability, while 17.6% of the area has very low vulnerability. This is illustrated in Figure1 below.
Source: Authors' GIS analysis

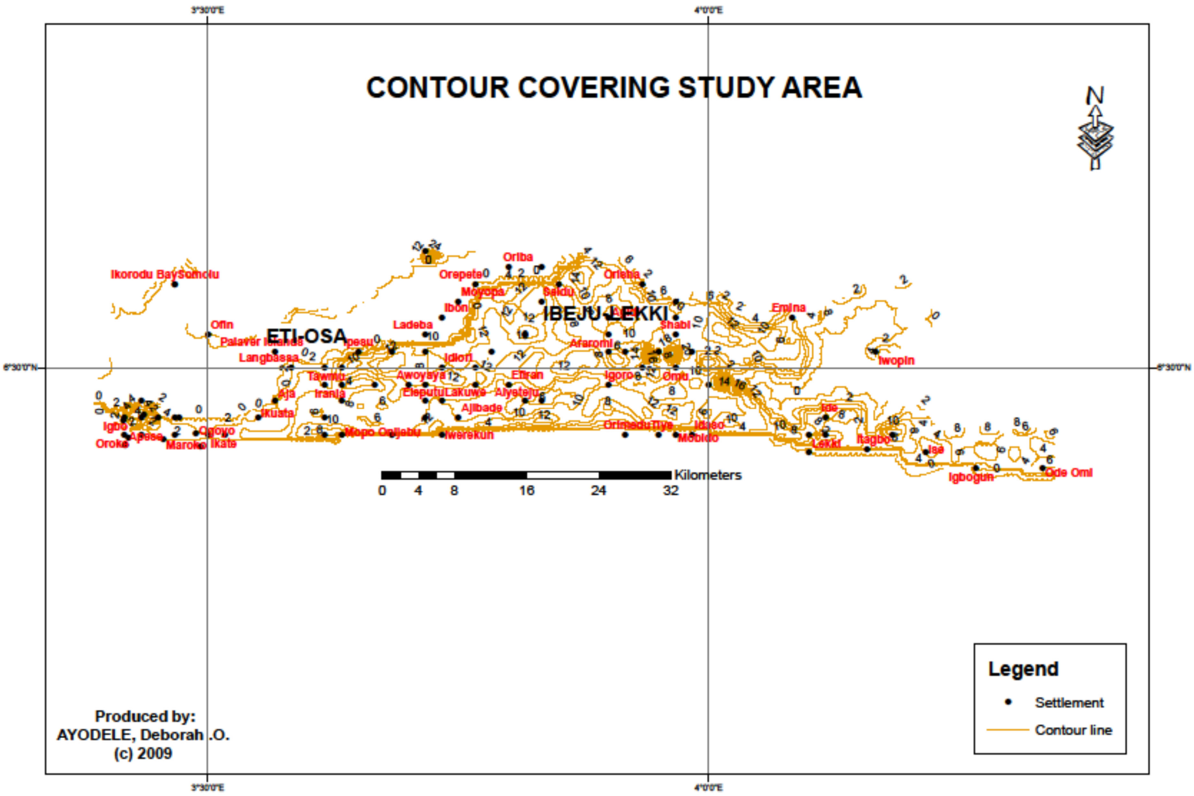
Figure 1: Vulnerability levels in the study area based on the distance of the communities from water bodies



Height of the area above sea level

This involves using topography as a factor that increases the vulnerability of the coastal community under study to coastal hazards. The area under study is on the average below sea level. Digital terrain modelling was used to determine the topography of the area i.e. the height of different places above sea level. Maps 3 and 4 below show the contour of the study area which was used to generate the region's digital terrain model; and the digital terrain model of the area which divides the region into 5 levels based on heights above sea level.

Map 3: Contour covering study area



Map 4: Digital terrain model of the study area

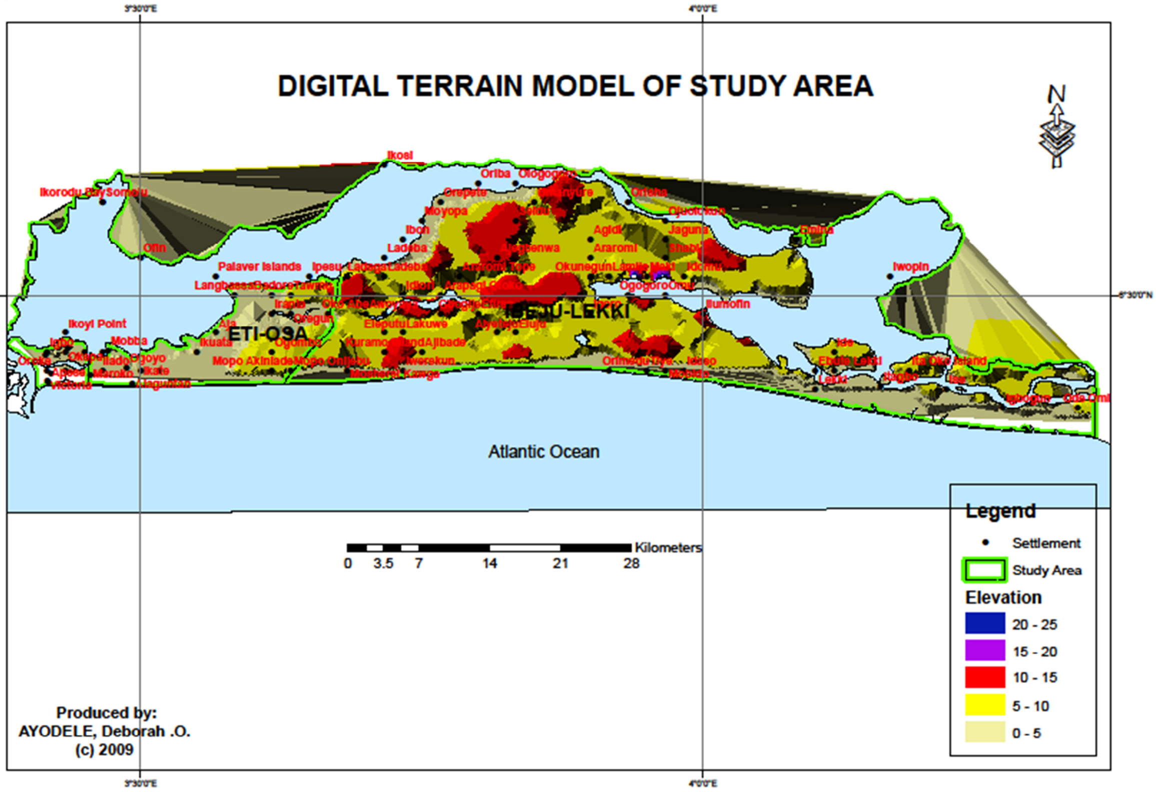


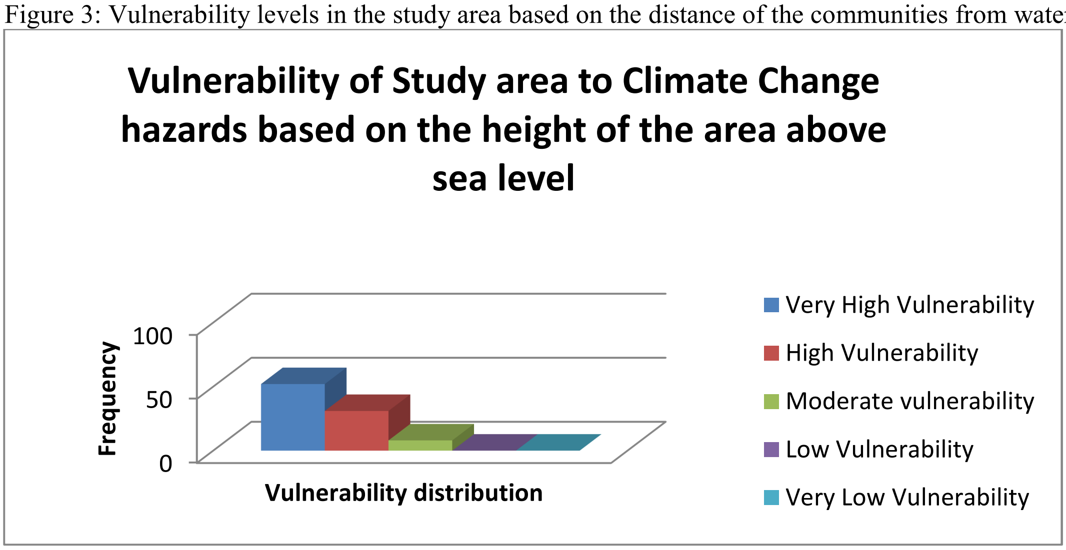
Table 3: Communities within each vulnerability level based on their height above sea level

Sn	Level 1 (0m-5m)	Level 2 (5m-10m)	Level 3 (10m-15m)	Level 4 (15m-20m)	Level 5 (20m-25m)
1	Victoria	Umanyure	Seidu	-	-
2	Tiye	Tawmu	Ogogoro	-	-
3	Ikorodu Bay	Ojuolokun	Iluomofin	-	-
4	Shangotedo	Ogombo	Ikosi	-	-
5	Refuge Island	Ode Omi	Arapagi Oloko	-	-
6	Palaver Island	Mopo Akinlade	Ajegbenwa	-	-
7	Oroke	Meki	Aiyeteju	-	-
8	Orimedu	Lamija	Agidi	-	-
9	Oriba	Lakuwe	-	-	-
10	Orepete	Ladega	-	-	-
11	Ologogoro	Shabi	-	-	-
12	Oko Abe	Orisha	-	-	-
13	Okepa	Omu	-	-	-
14	Ofin	Okunegun	-	-	-
15	Mayopa	Oguntedo	-	-	-
16	Moshere Ikoga	Ladeba (2)	-	-	-
17	Mopo Onijebu	Kuramo Island	-	-	-
18	Mobido	Jaguna	-	-	-
19	Mobba	Ita Oko Island	-	-	-
20	Maroko	Igoro	-	-	-
21	Maiyegun	Idomu	-	-	-
22	Magbon	Idiori	-	-	-
23	Lekki	Ide	-	-	-
24	Langbasa	Gbogije	-	-	-
25	Ladeba	Eluju	-	-	-
26	Jinadu	Eleputu	-	-	-
27	Iwopin	Efiran	-	-	-

28	Iwerekun	Awoyaya	-	-	-
29	Itagbo	Araromi Tope	-	-	-
30	Ise	Araromi (2)	-	-	-
31	Iranla	Ajibade	-	-	-
32	Ipesu	-	-	-	-
33	Ilado	-	-	-	-
34	Ikuata	-	-	-	-
35	Ikoyi Point	-	-	-	-
36	Ikate	-	-	-	-
37	Igbogun	-	-	-	-
38	Igbo	-	-	-	-
39	Idaso	-	-	-	-
40	Ibon	-	-	-	-
41	Emina	-	-	-	-
42	Ebute-Lekki	-	-	-	-
43	Bamgbose	-	-	-	-
44	Badore	-	-	-	-
45	Araromi	-	-	-	-
46	Apese	-	-	-	-
47	Aja	-	-	-	-
48	Victoria Island	-	-	-	-
49	Alaguntan	-	-	-	-
50	Ogoyo	-	-	-	-
51	Obalende	-	-	-	-
52	Oregun				

The above results show that 49.4% (almost half of the total area) of the study area very high vulnerability to the exacerbated coastal hazards resulting from climate change, 23.6% has high vulnerability and 4.5% has moderate vulnerability as shown in Figure 4.15. No values were computed for low vulnerability and very low vulnerability because the highest point in the area is about 12 metres above sea level.

Figure 3: Vulnerability levels in the study area based on the distance of the communities from water bodies



Using the scoring system, it is possible to rank the vulnerability of each of the individual settlements in the study area with reference to the two criteria already discussed above. The settlement with the highest rank number shows the most vulnerable community. This analysis is outlined in Table 4. In order to use both criteria to determine the level of vulnerability, Levels 1 are given a score of 5 because they have the highest level of vulnerability given both distance from water bodies and height above sea level, Levels 2 are scored 4, Levels 3 are scored 3, Levels 4 are scored 2 and Levels 5 are scored 1.

Table 4: The Vulnerability Indices of the study area

		Distance from water bodies	Height above sea level	Score / Vulnerability index
1	Victoria	5	5	10
2	Tiye	5	5	10
3	Ikorodu Bay Somolu	5	5	10
4	Refuge Island	5	5	10
5	Palaver Island	5	5	10
6	Orimedu	5	5	10
7	Oriba	5	5	10
8	Orepete	5	5	10
9	Ologogoro	5	5	10
10	Okepa	5	5	10
11	Ofin	5	5	10
12	Moyopa	5	5	10
13	Mobido	5	5	10
14	Mobba	5	5	10
15	Lekki	5	5	10
16	Langbassa	5	5	10
17	Ladeba (near Ibon)	5	5	10
18	Iwopin	5	5	10
19	Iwerekun	5	5	10
20	Itagbo	5	5	10
21	Ise	5	5	10
22	Ipesu	5	5	10
23	Ikoyi Point	5	5	10
24	Igbogun	5	5	10
25	Igbo	5	5	10
26	Ibon	5	5	10
27	Emina	5	5	10
28	Ebute-Lekki	5	5	10
29	Bamgbose	5	5	10
30	Apese	5	5	10
31	Aja	5	5	10
32	Alaguntan	5	5	10
33	Obalende	5	5	10
34	Oroke	4	5	9
35	Orisha	5	4	9
36	Omu	5	4	9
37	Okunegun	5	4	9
38	Ojuolokun	5	4	9
39	Ode Omi	5	4	9
40	Moshere Ikoga	4	5	9
41	Mopo Onijebu	4	5	9
42	Meki	5	4	9
43	Maroko	4	5	9
44	Magbon	4	5	9
45	Lamija	5	4	9
46	Ladega	5	4	9
47	Jinadu	4	5	9
48	Ita Oko Island	5	4	9
48	Ilado	4	5	9
50	Ikuata	4	5	9
51	Ikate	4	5	9
52	Idaso	4	5	9
53	Badore	4	5	9

54	Araromi (near Bamgbose) 0	5	4	9
55	Victoria Island	4	5	9
56	Ogoyo	4	5	9
57	Umanyure	4	4	8
58	Tawmu	4	4	8
59	Ogogoro	5	3	8
60	Mopo Akinlade	4	4	8
61	Maiyegun	3	5	8
62	Ladeba (2) near Idiori	4	4	8
63	Jaguna	4	4	8
64	Ilumofin	5	3	8
65	Ikosi	5	3	8
66	Igoro	4	4	8
67	Idomu	4	4	8
68	Ide	4	4	8
69	Araromi (close to Agidi)	3	5	8
70	Shabi	3	4	7
71	Oregun	2	5	7
72	Iranla	2	5	7
73	Ajibade	3	4	7
74	Shangotedo	1	5	6
75	Oko Abe	1	5	6
76	Kuramo Island	2	4	6
77	Seidu	2	3	5
78	Oguntedo	1	4	5
79	Ogombo	1	4	5
80	Lakuwe	1	4	5
81	Idiori	1	4	5
82	Gbogije	1	4	5
83	Eluju	1	4	5
84	Eleputu	1	4	5
85	Efiran	1	4	5
86	Awoyaya	1	4	5
87	Araromi Tope	1	4	5
88	Aparagi Oloko	1	3	4
89	Ajegenwa	1	3	4
90	Aiyeteju	1	3	4
91	Agidi	1	3	4

Assuming that in the vulnerability index column, 0 - 5 represents moderate vulnerability and 6 - 10 represent high vulnerability; then it can be deduced that 83.5% of the study area are presently highly vulnerable to climate change hazards while 16.5% are moderately vulnerable. Therefore on the average, with a mean value of 8.3 the study area is highly vulnerable to climate change hazards.

4.0 Conclusion

The vulnerability analysis of the area carried out based on the proximity of the communities to water bodies and the topography of the area showed that the average vulnerability of the study area is 83.5%, with some communities having vulnerability levels of 100%. The inhabitants of these low-lying coastal communities are therefore highly vulnerable to exacerbated coastal hazards resulting from climate change.

Further research is needed to examine the awareness, perception and sensitivity of the inhabitants of these coastal communities about this vulnerability. Therefore, given their high degree of vulnerability, there is an urgent need for proactive measures to be introduced in communicating climate change to the people.

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