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Lagos Shoreline Change Pattern: 1986-2002

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Abstract: The increasing threats and disasters associated with coastal habitations have necessitated the need for an understanding of the changes that are taking place in this important natural environment. In the recent time there has been an increase in the intensity, rate and rapidity of occurrence of disasters associated with the coastal environments. Though there have been no major disaster along the Nigerian coast, the constant flooding and associated cut-off of the residents around Victoria Island, the general low heights of the coastal topography, as well as the dense population (with an estimated 12-15 million people) and the geological and morphological character of the area, necessitates a need to understand the changes that are taking place in the shoreline of the area. In this study, Satellite imageries covering 4 periods (1986, 1990, 1995 and 2002) were utilised. Shorelines of the different periods were extracted through the digitization features within the Arcview GIS software. The study showed varying annual loss of land to coastal erosion and the attendant environmental and socio-economic implications of the changes.

Key words: Accretion · change · erosion · pattern · shoreline · transects

INTRODUCTION

The Nigerian coast can be broken into four major shoreline types based on the morphology, vegetation and beach type, drainage system, immediate hinterland geology, material grain size, wave, climate and coastal dynamics and immediate shelf phsiography [1, 2]. The four geomorphic units are: the Barrier Island Coast, the Mahin Transgressive Mud Coast, the Niger-Delta Coast and the Strand Coast.

Lagos coast belongs to the Barrier Coast section of the Nigerian coastline and it comprises of the down drift side of the natural inlet into the Lagos harbour. It also includes the Marina section, the Lagos Bar beach section and the Lagos harbour. Before the construction of the breakwaters, the active bar beach at Victoria Island was almost in line with the Light House beach to the west of the inlet, both forming a contemporary barrier bar system and having a consistent west-east transport of sand bar across a tidal inlet. The presently observed more northern disposition of Victoria Island (Fig. 1) is attributed to the disruption of the west-east sand drift by strong flood-ebb currents which tended to concentrate sands preferentially to the west of the inlet. The recurred spits to the inlet suggest the dominance of flood currents, which would have been reinforced by sustained wave action at the inlet.

COASTAL EROSION AND CONTROL ALONG THE LAGOS COASTLINE

Generally, as in many other coasts, the explanation for the increasing shoreline erosion along the Nigerian coast would be related to a combination of various interrelated factors that create the conditions for erosion to take place than in a single cause. These factors can be grouped into natural and human-induced causes. The natural causes are associated with storm surges/high wave tide, sediment supply, erodible nature of sand, climatic change/sea-level rise and low coastal topography; while the human-induced factors are associated with population growth, urban and industrial development pressures, tourism activities, intensified fisheries and other economic activities, construction of artificial structures (harbour-protecting and jetties) and over harvesting of mangroves.

A fundamental naturally-induced cause of shoreline erosion in Lagos is from the incidence of storm surges

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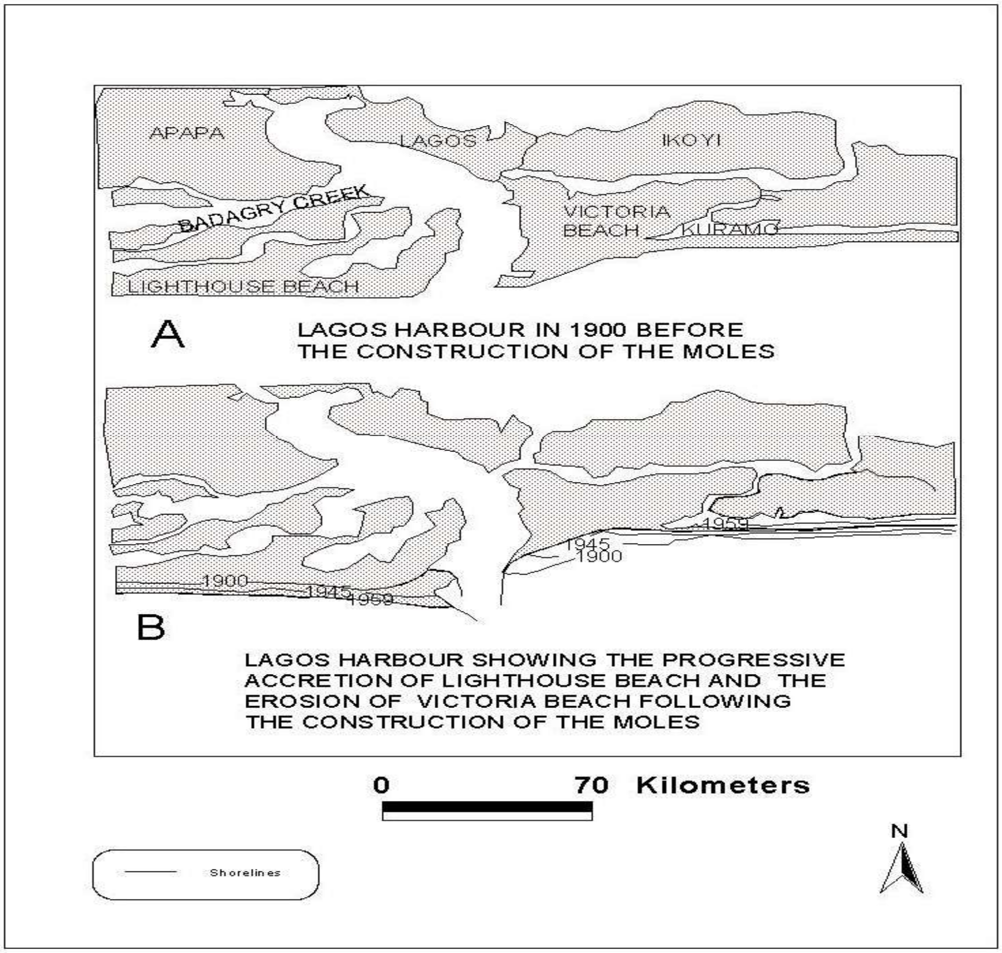

Fig. 1: Impact of the Construction of the Lagos Harbour on Accretion and Erosion Process along Lagos coast Source: Ibe [1]

coastal erosion process along the Lagos coast. According to Ibe [4] the Victoria Beach has eroded 2 km inland since the construction of the moles. Indeed, the construction of the moles seems to be the most important anthropological drivers of coastal erosion along the Lagos coast.

The 6 km section of the Bar Beach on Victoria Island has the highest erosion rates in Nigeria, averaging 25-30 m in a year. Awosika *et al*. [4] found erosion rates to be fastest close to the moles averaging 66.12 m during a survey carried out over a 14 months period between 1990 and 1991. This amounted to a mean monthly rate of 4.71 m during the 14 month period. These very high rates of shoreline erosion of the Lagos coast have been of serious concern both to the Federal Government of Nigeria and the Lagos State Government. The concern results from the very important position of Lagos as a former Federal Capital City and as the Capital of Lagos State, as well as its importance as the economic, industrial and commercial nerve centre of the nation. This is in addition to its position as home to about 15 million people.

To avoid a possible over-run of the city of Lagos by the incursion of the sea into Lagos through the shoreline erosion and the accompanying flooding of adjacent lands, many efforts have been undertaking (Table 1) and are still been undertaking. For instance, as late as January 2006, the Lagos State Government has just awarded a first phase of bar beach rehabilitation project (at a cost of 2.9 billion Naira) involving the massive sandfilling with boulders for stability [6]. Unfortunately, these measures have not been successful at managing the shoreline phenomenon. To further worsen the problem there are inadequate information concerning gathering historical data revealing the patterns of such shoreline change that could serve as basis for the determination and execution of effective shoreline erosion management plans. It is in the light of this concern that this study was undertaken.

Table 1: Erosion control measures applied from 1958 to 2003 to victoria beach (Lagos)

Period	Measures applied
1958	Construction of a groyne at the foot of the eastern breakwater, to avoid undermining of the breakwater.
1958-1960	Dumping of sediment dredged from the Commodore Channel of the extremity of eastern breakwater, for dispersal along the beach by waves.
1960-1968	Permanent pumping station built on the eastern breakwater, supplying an average of 0.66 Million m3 per annum of sediment from the Commodore Channel to the beach. In between in 1964, a 'zig zag' timber groin (palisades) running parallel to the coastline was driven in some 26 m from the shoreline.
1969-1974	Some artificial sand replenishment (but reliable records of quantities or frequencies are not available).
1974-1975	3 Million m3 of sand dumped and spread on the beach.
1981	2 Million m3 of sand dumped and spread on the beach.
1985-1986	3 Million m3 of sand dumped on the beach (before the work commenced, the Culvert to the main boulevard parallel to the shoreline was already being undermined at some points by waves action).
1990-1991	5 Million m3 of sand was dumped on the beach. Before the work started in August 1990. the entire sand dumped on the beach between 1985-1986 has been washed away in most places. The Lagos State Tourism fence along the main boulevard, as well as the main boulevard, Ahmadu Bello drive was already being undermined.
1995-1997	6 Million m^3 (2million m^3 per year) was dumped.
1998	A groyne was constructed at the back of the Federal School of Fisheries.
1999	2 Million m^3 of sand were dumped and spread on the beach using dredger.
2002-2003	Dredging of more than 2 Million m^3 of sand and refurbishment of Ahmadu Bello Way.

Source: Awosika *et al*. [5], Odofin [7]

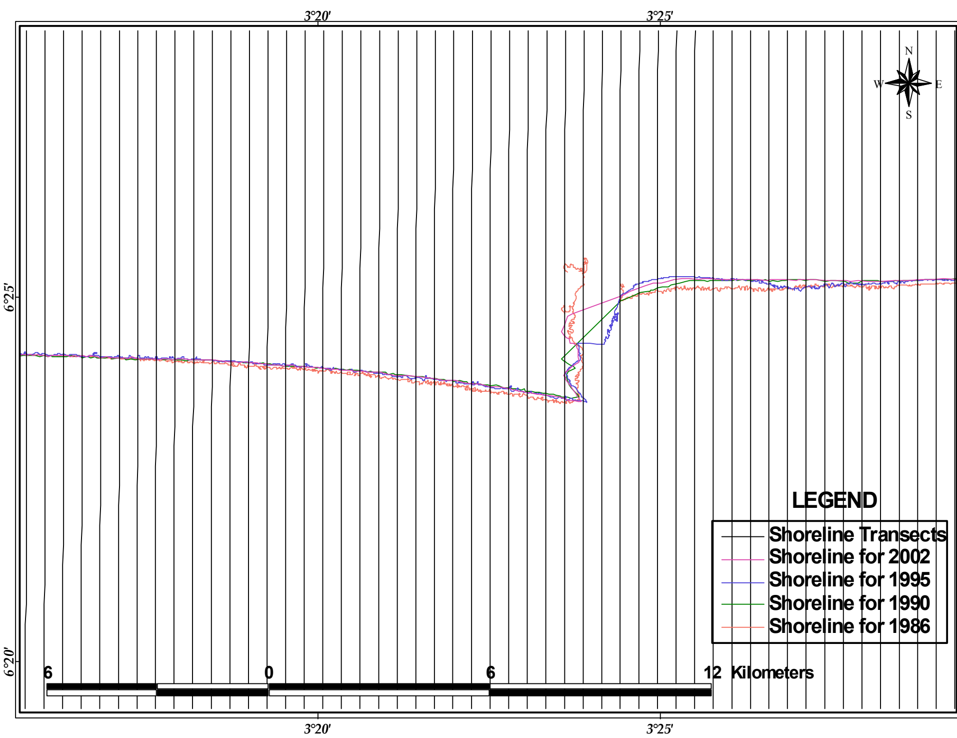

Fig. 2: Shoreline at different times/ shoreline analysis transects

METHODS

Sustainable management of shoreline requires up-to-date and continuous knowledge of features that comprise the shoreline and change detection procedures can be employed to determine the health of the shoreline [8]. New maps and data displaying long term and more recent trends of behaviour increase the capacity for sound decision-making and enhance public awareness of coastal change [9]. Four sets of remotely sensed imageries covering four periods (Landsat 1986, 1990, 2002 imageries and SPOT 1995) imagery were used in the study. Measuring and analyzing shoreline change involve three distinct phases or process:

Table 2: Shoreline transects change statistics in metres

1986-1990	1986-1995	1986-2002	1990-1995	1990-2002	1995-2002	Shoreline Change
	-26.91	-16.22			10.69	-32.44
31.79	-33.17	-10.69	-64.96	-43.86	22.48	-98.41
23.02	-31.17	-6.30	-54.81	-38.09	25.49	-81.86
30.15	-16.77	-4.42	-46.92	-34.57	12.35	-60.18
29.45	-45.70	-16.25	-75.15	-48.76	29.45	-126.96
9.98	-56.80	-22.11	-66.78	-32.09	34.69	-133.11
18.67	-49.24	-26.87	-67.91	-45.54	22.37	-148.52
33.95	9.65	-15.61	-24.30	-49.56	-25.26	-71.13
-1.93	-15.77	-28.16	-13.84	-26.23	-12.39	-98.32
0.97	26.71	-17.05	-27.68	-18.02	9.66	-25.41
11.26	-39.43	-33.96	-50.69	-45.22	5.47	-152.57
-29.29	-89.15	-4.06	-59.86	-15.77	44.09	-154.04
-34.92	-70.33	-66.46	-35.41	-31.54	3.87	-234.79
-77.44	-105.86	-103.02	-28.42	-25.58	2.84	-337.48
-53.52	-60.15	-63.47	-6.63	-9.95	-3.32	-197.04
-75.78	-104.46	-102.55	-28.68	-26.77	1.91	-336.33
-89.28	-89.17	-101.36	0.11	-12.19	-12.08	-303.97
-77.92	-67.50	-102.78	10.42	-24.86	-35.28	-297.92
-54.71	-63.24	-84.31	-8.53	-29.60	-21.07	-261.46
-65.36	-80.05	-72.24	-14.69	-6.88	7.81	-231.41
-93.55	-108.70	-109.89	-1.19	-16.34	-15.15	-344.82
-94.26	-83.86	-100.18	10.40	-5.92	-16.32	-290.14
-72.33	-78.41	-84.10	-6.18	-11.87	-5.69	-258.58
-74.13	-57.31	-81.00	16.82	-6.87	-23.69	-226.18
-120.40	-56.60	-125.99	63.80	-5.59	-69.39	-314.17
-129.10	-111.44	-155.73	17.66	-26.63	-44.29	-449.53
-84.18	-52.31	-85.28	31.87	-1.10	-32.97	-223.97
-110.83	-112.51	-116.06	-1.68	-5.23	-3.55	-349.86
-133.15	-145.89	-150.82	-12.74	-17.67	-4.93	-465.20
-125.99	-70.57	-130.50	55.42	-4.51	-59.93	-336.08
-158.41	-137.49	-139.60	20.92	18.81	-2.11	-397.88
-137.78	-85.68	-144.73	52.10	-6.95	-59.05	-382.09
-160.94	-115.03	-161.85	45.91	-0.91	-46.82	-439.64
-123.86	-100.65	-136.65	23.21	-12.79	-36.00	-386.74
15.84	-236.40	422.44	-252.24	406.60	658.84	1015.08
-53.94	-287.09	-318.40	-233.15	-264.46	-31.31	-1188.35
-89.47	-280.24	-292.10	-190.77	-202.63	-11.86	-1067.07
-191.05	-295.92	-65.13	-104.87	125.92	230.79	-300.26
-208.69	-271.05	-173.15	-62.36	35.54	97.90	-581.81
-211.56	-248.93	-136.83	-37.37	74.73	112.10	-447.86
-187.88	-164.20	-166.17	23.68	21.71	-1.97	-474.83
-232.74	-164.72	-285.77	68.02	-53.03	-121.05	-789.29
-208.41	-24.74	-232.63	183.67	-24.22	-207.89	-514.22
-160.25	11.84	-187.88	172.09	-27.63	-199.72	-391.55
-113.68	-57.23	-176.83	56.45	-63.15	-119.60	-474.04
-120.39	-60.95	-177.62	59.44	-57.23	-116.67	-473.42
-164.99	-86.44	-190.65	78.55	-25.66	-104.21	-493.40
-161.94	-114.07	-230.83	47.87	-68.89	-116.76	-644.62
-102.63	-80.34	-171.15	22.29	-68.52	-90.81	-491.16
-101.07	-94.41	-165.49	6.66	-64.42	-71.08	-489.81
-88.73	-86.52	-153.15	2.21	-64.42	-66.63	-457.63
-103.26	-76.73	-171.59	26.53	-68.33	-94.86	-488.24
-110.84	-79.57	-149.36	31.27	-38.52	-69.79	-416.81
-104.86	-92.84	-95.69	12.02	9.17	-2.85	-275.05
-124.40	-100.41	-151.88	24.01	-27.46	-51.47	-431.61
-109.26	-52.20			42.94	-118.52	

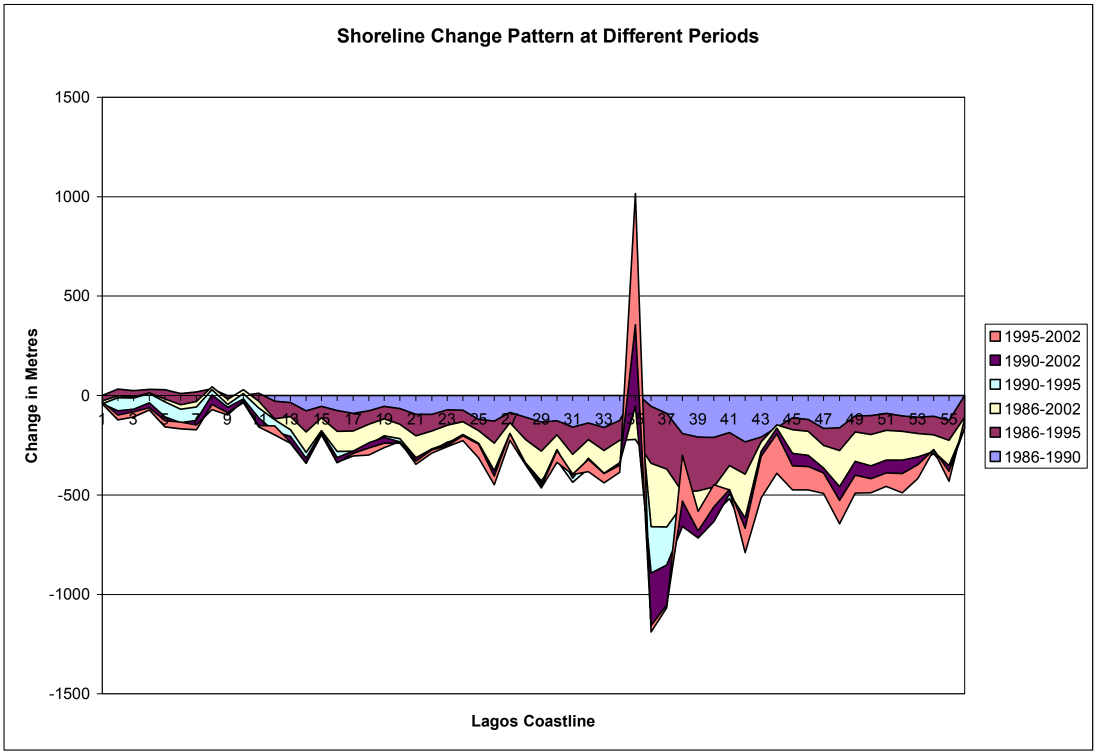

Fig. 3: Shoreline change pattern at the different periods

Table 3: Shoreline erosion, accretion and net change/summary of statistics in metres

Periods	Accretion value	Erosion value	Net change	Annual rate of erosion
1986-1990	205.08	-5019.96	-4814.74	22.29
1986-1995	48.20	-5373.38	-5325.18	10.56
1986-2002	0.00	-5942.33	-5942.33	6.63
1990-1995	1163.40	-1577.80	-414.41	1.53
1990-2002	692.48	-1806.03	-1113.55	1.72
1995-2002	1375.74	-2007.82	-632.08	1.61

1. digitizing shorelines for the various years
2. drawing of transects of equal distance along the extent of the Lagos coast and
3. Measuring change in shoreline locations between the compared periods where each transect crosses the shorelines.

These three broad activities were carried out within the Arcview GIS in this study.

DISCUSSION OF FINDINGS

The result of the analysis is as shown on Table 2. Fifty nine transects of equal distance were built across the entire coastline under study (Fig. 2). However, because of the interference of the Lagos harbour, between 54 and 56 of the transects were effectively measured. Figure 3 shows the graphical representation of the land area that is being subjected to the different erosion and accretion processes.

In the study, it was found out that there are more eroding portions than accreting portions for all the periods across the entire coastal area. It was also found out that the accreting portion is associated with the 6 km Bar Beach section of the coastline where many beach nourishment activities had taken place in the past (Table 1). As it is well known, attempts at stabilizing the shore can greatly influence the rates of shoreline change as beach nourishment artificially causes rapid, temporary shoreline accretion. From Table 3, which shows the net change summary, it is seen that varying annual erosion rate (between 1.53 and 22.29 m) was derived from the analysis. While the highest annual rate of 22.29 m was recorded for the 1986-1990 period; the least annual erosion rate of 1.53 m was associated with the 1990-1995 period. This sharp contrast may be connected with the periods of beach nourishments.

A combination of correlation and *t*-test statistics was carried out to test the hypothesis on the significance of the change in shoreline overtime. 15 pair periods were possible and used in the statistical analysis. In 14 of the

15 paired period, the critical value of 1.66 at 0.05 significant levels was higher than the calculated values. It is only in one of the periods that the table value of 1.66 is lower than the calculated value of 1.835. This shows that though the shoreline is changing overtime, it is not statistically significant. Also, based on the summary table (Table 3) dividing the change characteristics into accretion and erosion, the significance of erosion as against accretion was also examined. The correlation result (0.481) shows a positive relationship between accretion and erosion. However, as earlier discussed, the statistical significance of the shoreline erosion may have been influenced by the various beach nourishment activities that have been carried out in the area.

Thus, caution must be exercised on the statistical results, as the erosion processes may be more important in reality than revealed, considering the fact that this section of the Nigerian coast is associated with the highest rate of human occupation, houses the greatest number of commercial and industrial concerns. Again, it must be remembered that two interpretations are possible from the result of shoreline change detection analysis: either that the change results from error in compilation and delineation or the change is actually true in reality. For instance, Li *et al*. [10] in their study of shoreline change observed these two possibilities. One is that the shoreline actually changed in the real world. The other possibility is that the differences were introduced as shoreline mapping errors. However, in this study, the result is atypical of the experiences of reality that has been taking place in the area.

CONCLUSIONS

This study has been able to provide a baseline statistics on the shoreline changing patterns along the Lagos coast that could serve as baseline information for further studies in the future. Such database has the potential to improve decisions concerning coastal management, residential and commercial development and coastal research by making shoreline data comprehensible and available to a wide audience [9]. In addition, such data would assist the Federal, State and Local Governments to manage and regulate coastal developments effectively as against the current practice that is based on inadequate and non-reliable information.

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