Vulnerability And Adaptations Of Nigeria's Niger Delta Coast Settlements To Sea Level Rise

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Key words: Vulnerability, adaptations, sea-level rise, inundation, resilience building.

SUMMARY

The Niger delta Coastal settlements, which are already under stress of demographic pressure and unsustainable oil exploitation, are equally under the threat of sea level rise. Global projections of sea level rise put the area under future inundation of up to 100km in land. The implications are the loss of valuable Biodiversity, land, property, economic activities and livelihoods.

Though the impact is not expected to be uniform across board, the flora and fauna already enlisted as threatened will be more vulnerable. The poor, marginalized and economically week would be worst affected. The impact would not be spontaneous and as such economic activities and facilities will gradually be relocated and human population will migrate, creating environmental refugees.

The burden, which will be more social than economic will be heavy on the government, the community and other stakeholders. In addition increasing scarcity of land will accelerate the stress on available resources and conflict could ensue.

Many adaptation measures are in place to contend the negative impact of sea level rise. These have there financial and environmental cost implications. Because of the prohibitive cost of protection, many developing countries such as Nigeria may not be able to afford such measures. This is more so that there are many issues the nation have to tackle. The most probable and affordable approach is through resilience building and vulnerability reduction. This can be achieved with the collaboration of all the stakeholders in a participatory (bottom-top) rather than by imposition (top-bottom) approach.

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1. INTRODUCTION

The Niger Delta, which falls between the barrier lagoon coast, the transgressive mud coast, and strand coast (Ibe and Awosika, 1996 in French et al (1995).
covers about 70,000 km^2,, consists of barrier islands, estuaries, mangroves, creeks and freshwater swamps (Okeke, 2005). This area has not received much empirical focus in terms of its physical and socio-economic vulnerability to climate change-induced sea level rise. However it is considered to be highly vulnerable to sea level rise. It is estimated (French et al, 1995) that with sea level rise, inundation along the Niger Delta coast would extend perhaps 100km up the Delta, bringing serious consequences to the people and the economy.

A current environmental problem in the Niger Delta is flooding which comes from the high rainfall and runoff from rivers and urban chains, and tidal movement and wind (Okeke, 2003). With this problem already common, the issue of sea level rise occasioned by global climate change will exacerbate it. In addition is the potential to cause permanent inundation, beach erosion and saline. This will concomitantly lead to the displacement of millions of people, destruction of property and infrastructure and the loss of considerable proportion of biodiversity.

The intensity and gravity of the impacts cannot be the same for all facets of the bio-physical and socio-economic spectrum. There are therefore differential vulnerabilities and coping strategies (adjustments and adaptations). The concept of vulnerability as used here is akin to the views of (Cooper et al (2005) IPCC (2001), Ribbot, (1996, and 1995) the extent to which a natural or social system (coastal environment) is liable to sustain damage from environmental change (sea level rise). This is considered as a function of sensitivity and ability to adapt. The response of the systems which suffer from perturbations of climate-induced sea level rise will therefore be determined by their vulnerability (Kates, 1984). Bio-physical vulnerability is influenced by environmental and geographical factors such as elevation above mean sea level, distance from the shoreline, the effectiveness of natural and/or artificial barriers to protect or dissipate energy of surges and the adaptation ability/resilience of the flora and fauna. The socio-economic vulnerability is influenced by the ability of the system to adapt, such as resilience, involving the quality of physical infrastructure, the preparedness of communities poverty level and the ability of the system to recover from damage incase it occurs.

2. Sea level rise and the Niger Delta settlement: the why of this paper.

A major concomitant with global warming is the issue of sea level rise. Though there are conflicting reports and uncertainties as to the nature and magnitude of this rise and climate change, the scientific evidences and certainties of possible climate change-induced sea level rise imply that the present coastal problems, which could be exacerbated.

Reports on impacts, vulnerability and adaptations to climate change for Africa, released by the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) estimate that Africa's coastal infrastructure and settlements, particularly in the Gulf of Guinea, where the Niger Delta is located, could be inundated. To French et al, (1995), without consideration of oil wells in the Niger Delta, the greatest threat to land and settlement is inundation, and the greatest value at risk is along the barrier coast – ranging from just 1.3 U.S billion dollars with a 0.2m sea level rise to almost 14 billion U S dollars with a 2m rise. A 1m rise would flood many areas and flooding would destroy $18 billion of infrastructure including the cost of drilling oil wells.

The implication is that a rise in sea level and associated incursion will impact activities and infrastructure in many parts of area. As Sokona and Denton (2001) point out, the already deplorable state of the environment as occasioned by oil production and environmental degradation, coupled with other innumerable social and environmental problems imply that the rise in sea level and associated biophysical and socio-economic impacts will be much.

The socio-economic vulnerabilities/impacts will differ from the physical. Whereas impact on the later will be more direct, that of the former will be both direct and indirect. For instance, the impact on the later will lead further to a wide range of social consequences (Ribot, 1996; 1995).

Though this implies that these problems and impacts are mostly societal based, it is necessary to evaluate the differential vulnerability, as well as the appropriate adaptation strategies, which largely depends on the socio-economic and technological disposition/preparedness of the society. On this basis, the paper attempts to provide a compendium of the bio-physical and socio-economic vulnerability of the coastal settlement in the Niger Delta sea level rise. It also attempts to determine the most feasible adaptation strategy within the context of the socio-economic disposition of Nigeria.

3. THE STUDY AREA AND SCOPE OF THE PAPER

The Niger Delta area under consideration extends for about 450 km in the east-west stretch (Okeke, 2003). Its geographic location is between Aboh at $5^{O}33'$ 49"N, $6^{O}31'$ 38"E in the north and Palm point ($4^{O}16'$ 22"N, $6^{O}05'$ 27"E) in this south. The east-west limit is between Benin River estuary ($5^{O}44'11$"N, $5^{O}3'$ 49"E) in the west and Imo River estuary ($4^{O}27'16$'N, $7^{O}35'27$"E) in the east (NDES, 1997).

Both rural and urban settlement are found therein. The plethora of rural settlements dotted all over the areas are mostly agricultural and fishing camps, while the major urban areas include: Port Harcourt, Bonny, Degema, Ahoada, Brass, Yenegoa, Ugheli, Sapele and Warri. Although the main economic activities of the rural folk is farming and fishing, the presence of oil facilities in most of the areas creates opportunity for increased commercial activities. Manufacturing and major service provisions are concentrated in the urban areas, mostly Port Harcourt, Warri and Bonny.

Settlements and indeed the population distribution are largely controlled and conditioned by the availability of dry lands. In the continuously stretched mangrove swamps are dotted small settlements on the dry lands, but the larger islands are heavily settled. Settlements are also on the coastal beach ridges. The ridges however are narrow, limiting the land available for expansion and creating high population density. On the whole habitable land is more available in fresh water zone, where the Levees along the river beds are more preferred and inclined to habitation. On this basis of attractiveness, the fresh water zone is home to some of the largest settlements, such as part of Port Harcourt, Warri, Sapele, and Ughelli, others are Saghama, Koko, Bomadi, Oleh, Yenegoa, Bori and Ahoeda.

The Niger Delta is the fulcrum of Nigeria's oil exploitation, providing the economic hub of the country. The area therefore has a plethora of oil fields (above 500) and wells that strew the region. It is estimated (*NDES, 1997) that about 742 of these oil fields are onshore, and this implies that with sea level rise and land inundation, many of these facilities will become offshore fields. Major gas fields and processing firms are now many in the Niger Delta, most of which are also onshore.

A great deal of food is produced in this area, including fishing, aquaculture and crop cultivation. These economic activities are vulnerable to sea level rise effects such as salinization of farmlands.

The Niger Delta is at present influenced by marine water from the ocean. The coastal/or shore influence is mostly felt during the dry season and in high tides. The salinity boundary generally oscillates, following the season, being further in land during the dry season and reducing to the coastline during the rainy season. The present average limit is shown in figure 1. The movement of this boundary inland often reaches 30-50km (NDES, 1997).

The coastline is generally protected from the ocean by a chain of natural barrier. However, the narrow sandy beach ridge of the barrier islands and the coastal beach ridges are of low elevation, mostly within 1m range. This implies that a 1m rise in sea level could inundate this zone, which inhabits some of the settlements. Most parts of the vegetated tidal flat (mangrove swamps) and forests are also of elevation of less than 1m above sea level (ASL). The physical and socio-economic implications in terms of physical infrastructure and land loss, as well as demographic inconveniences arising from sea-level rise are obvious.

Although there is yet to be empirical evidence of a change in the climate regime of the Niger Delta, there is a general consensus among scientific communities that the global climate is changing (warming) beyond natural variability. This is expected to have potential impact on sea level rise and the possible acceleration of coastal problems in the Gulf of Guinea, where the Niger Delta is located.

The Niger Delta coast is currently faced with a gamut of environmental problems, including: Soil and coastal erosion; oil pollution; population pressure; and flooding. Flooding is one of the commonest, given the existing hydro-climatologic conditions. In this coastal area high tidal range, which causes diurnal flooding and the creation of brackish water is common (Oni, 2003). On the whole, economic activities can be truncated and infrastructure destroyed in an event of sea level rise caused by climate change, while the already common problems associated with the local rainfall regime and tidal influences, can be accentuated, thus increasing the physical and socio-economic vulnerability.

4. METHODS

It must be noted that official map coverage of the Niger Delta has been poor (NDES, 1997). Most of the area does not have complete topo maps and where there are they are without contours, rendering digitization of the local environment using these maps, difficult. This restricted the study to the use of secondary information, supplemented by field observation.
In the case of the vulnerability of the regional physical and socio-economic systems, discussion is based on descriptive analysis using maps adopted from existing surveys.

The analytic techniques involved the application of descriptive and discourse approach. Discussion of impacts and vulnerability were based on the cartographic representation of the terrain (Thematic maps) and identifying the land at risk of inundation.

5. BIOPHYSICAL VULNERABILITY OF THE NIGER DELTA COAST TO SEA LEVEL RISE

It must be emphasized that because higher sea levels are expected to increase the chances of coastal flooding, storm damage, erosion of shorelines and contamination of fresh water supply. In addition, inundate coastal wetlands and barrier islands (UNEP, 2000; Green peace, 1997): The direct and multiplier consequences on the biophysical environment are expected to also be monumental.

The most obvious outcome of sea level rise, which is likely to cause more devastating effects, is permanent inundation of the coastal areas (Cooper et al 2005). This often times changes the position of the coastline and drowns natural as well as human habitats and structures.

The Niger Delta, being of low slope and flatter than other coastal areas is Nigeria, and majority of the area being below the two meter inundation zone, is likely to significantly suffer inundation. It is already estimated that with sea level rise inundation along the Niger Delta coast could extend about 100km up the Delta (French, et al 1997). This inundation could exacerbate flooding by allowing storm waves to act further in land.

Figure 1 (appendix I) shows the current extent of salt water incursion and the limits of fresh water swamps. The salt water area is home to the mangrove vegetation and brackish water organisms. The available estuaries are also home to a wide range of aquatic organisms. Within the fresh water systems are equally a gamut of flora and fauna, some of which are in the endangered species list. A rise in sea level and an extension of the salinity zone up to 100km projected inundation zone implies the high risk of the ecosystems. This will affect the present composition of the ecosystems with some habitat and species migrating and in some cases annihilation and extinction of some organisms.

Salt water will intrude further with great potential to contaminate surface fresh water and ground water aquifers. The penetration up stream into these environments will be inimical to the health of both aquatic organism and man. For man, the water becomes too saline for residential, agricultural and industrial uses (Major and Goldberg, 2001) in Cooper et al (2005). A major source of water supply in the Niger Delta presently is ground water, since most of the surface waters have been degraded by oil exploitation. Whereas in the areas close to the sea and within the present salinity limit, boreholes are drilled at considerable depths to avoid contamination, the water tables in the fresh water zone is quite high and most of the wells are shallow. These shallow wells stand the risk of contamination with a shift in the salinity limit and this implies additional cost of borehole drilling to considerable depths in the future.

Saline intrusion and inundation have significant effects on the vegetation, which will likely undergo changes in community composition, with many salt intolerant species migrating inland, while others stand the risk of amelioration. The Niger Delta contains the wet lands that are the spawning grounds for commercial shrimps and oysters, and bait fish for the large tuna industry. Inundation, submergence and drowning of this coastline will significantly affect these spawning activities and may lead to the further northward migration of these grounds.

The typologies of vegetation within the Niger Delta as shown in figure 2 (appendix 2) are considered to be very productive and rich in biodiversity. Some species found within this area are considered threatened by IUCN standard, and enshrined in the federal endangered species (control of international trade and traffic) Act, Decree 11 of 1985. Several large mammals such as the Chimpanzee, Elephant and Hippopotamus have been reduced to small and highly vulnerable populations in one or a few small areas (NDES, 1997). In the family of reptiles the Dwarf Crocodile (Alligator) popular in the fresh water swamp areas has been red listed and ranked vulnerable.

Because the Niger Delta contains several species of high international interest such as the sclater's Guenon, Delta Red Colobus and Crested Genet, with a good population of animals considered to be highly endangered, some conservation sites have been either established or proposed for some parts of the region. These reserves include: Upper orashi forest reserve; Ramos-Dodo, Pennington-Digatoro area; Andoni Game reserve, Taylor Greek forest reserve; and Apoi Creek forest reserve. Inundation of these areas as provided by sea level projections could cause these endangered species to be more vulnerable and can become extinct.

6. SOCIO-ECONOMIC VULNERABILITY OF THE NIGER DELTA COAST TO SEA LEVEL RISE

The Niger Delta is the economic hub of Nigeria, with a high concentration of population, infrastructure and suprastructure, and many of the inhabitants engaged in a variety of economic activities. It is a region rich in oil and gas and productive ecosystems. Over the years the region has attracted so much development strides and the influx of migrants from other parts of Nigeria. Population explosion and the desire for spatial transformation to carter for the teaming population has resulted in serious modification of parts of the coast, making the area more and more vulnerable to flooding and inundation.

Many settlements strew the area, some of which are major and others comprising of fishing camp (see figure 3, appendix 3). There are quite an array of oil, and gas fields and wells, as well as other beneficiary and support facilities. Today, it is estimated that more than 500 oil fields exist, majority of them onshore. It addition, a surge in development in the area of residential accommodation, industrial facilities and tourism-based efforts has accompanied the influx of people.

Agriculture and fishing are the mainstay of the economy of this region, with a great deal of food is produced here. Sea level rise and the inundation and saline incursion into cultivable land and fishing settlements will result in the displacement of the people, reducing agricultural land in the delta and creating conflict between resource users and uses. The displacement of the fishing industry will also have grave consequences on the livelihood of the communities and the beneficiaries of the products.

Because the expected sea level rise would inundate much of the coastal lowlands, damaging croplands and displacing millions of people, many communities may experience adverse conditions that may aggravate existing problems of dense population dependent on limited resources. To this and, many of the communities may be forced to migrate to more favourable clines that are not originally the abode (UN Atlas of Ocean, 2001), and this is likely to alter their way of life. According to French et al (1995) there is a potential for massive environmental refugee migration from the many villages in the low lying areas, estimated to be above 3.2 million people. People are therefore to migrate from threatened coastal areas as the result of economic decisions, resulting in slow depopulation of the

vulnerable region as coastal livelihoods become less viable (Hall and Nicholls, 2006). In addition, the destruction of marine habitats by inundation may undermine livelihoods based on fishing and other marine resources, thus increasing poverty and food insecurity. This will then require intervention from the government and other stakeholders and depressing local economic activities.

Already the Niger Delta coastal systems are subject to much stress due to demographic pressure and this will be increasingly affected by sea level rise. As pointed out by French et al (1995), assuming the current population patterns and development levels, the Nigeria's coast, 60 percent of which is the Niger Delta, there is a potential for flooding that would destroy $18 billion of infrastructure, including the cost of drilling oil wells.

In the Niger Delta, majority of the oil exploitation activities are concentrated in lowlands under 2m inundation zones. With this huge investment in the Niger Delta that are based on the available oil and gas resources, a rise in sea level and inundation could result in the destruction and increased costs of exploitation of these resources. For instance, many of the oil fields and wells that are presently onshore will become offshore with the submergence of the parts of the coastal area where they are located. The result is increased cost of maintenance and exploitation. Already the difficult terrain makes exploration and exploitation difficult and expensive.

It should however be noted that timescales required for sea level rise in excess of 1m to occur are long. However that of the systems, which make up a large proportion of the assets is infinite (Hall and Nicholls, 2006). On this basis, it might be clearly stated that economic activity would migrate away from areas at risk of a rise above 1m without severe economic consequences at the longer run. In most cases therefore, the economic impacts could spread over time and so this will be much wider than the social cost of relocation of settlement and their livelihoods.

7. OPTIONS FOR RESPONDING TO SEA LEVEL RISE IN THE NIGERIA DELTA

The potential impacts of sea level rise on the biophysical and socio-economic systems within the Niger Delta are likely to be monumental. These effects are not likely to be the same for all facts of the biophysical and socio-economic spectrum hence differential vulnerability. The high vulnerability of most parts is because the region is already under stress of demographic and environmental constraints, the later being the result of unsustainable human activities.

Generally, a gamut of response strategies exists and have been reported widely. Their applicability differs between regions depending on the socio-economic and technological disposition as well as political will of the regions. However, because there is a complexity of sensitive environmental, economic, social and cultural values, at stake in the course of sea

level impacts, it is not possible to avoid trade offs (UNEP, 2000), implying that no particular response is optimal and mutually in isolation. However whatever plan for coastal protection should include research and decision of measures that take into consideration of the available resources. This is largely because the ability of coastal systems to adapt to the changes in sea level will depend on management and the nature of systems vulnerability and resilience of the community.

The current available responses include; protection, accommodation/adaptation, planned retreat/relocation and abandonment. Because none of these approaches is considered most effective, some scholars, example Brooks et al (2006); UNEP, (2000); Aggarwall and Lal (2001) believe that the best is to adopt integrated coastal zone management, which incorporates multiple approaches.

Although the integrated management approach is the best option, some of the methods within it, such as the engineering approach to coastal protection, could be beyond the affordable power of developing countries. In practice, if that is to be carried out, it must be along the entire coastline as studies have shown that increasing coastal defenses in certain areas results in diminished beach volume and increased erosion in other areas (Hall et al, 2003) in Brooks et al (2006). Other management approaches have their limitations including financial, institutional, legislative, social and cultural frameworks.

All the strategies therefore have different costs and impacts borne by different sections of the society. Generally however, it is likely that the financial and social cost of sea level rise would be more in areas that are substantially developed. On the other hand, it is possible that these areas may have the financial and technological prowess to offset the negative outcomes than poor undeveloped areas that depend directly on the resources of the coast. As pointed out by Hall et al (2006) in Brooks et al (2006) some countries with large low-lying areas and high population density may find it more economically feasible in terms of both cost effectiveness and ability to pay to protect coastlines than smaller poor low-lying areas and islands.

A widely recommended strategy is adaptation and within this is resilience building and vulnerability reduction. Adger et al (2005) in Brooks et al (2006) defines resilience as

> "*the capacity of linked social-ecological systems to absorb recurrent disturbances such as to retain essential structures, processes and feedbacks . . . (reflecting) the degree to which a complex adaptive system is capable of self organization and the degree to which the system can build capacity for learning and adaptation*" .

This can be achieved through human capacity building and empowerment.

Since vulnerability is related to the wider socio-economic status of the society, including poverty, marginalization and access to resources, the prospective for reducing vulnerability and enhanced adaptation are strongly rooted in the wider socio-economic and political

environment (Brooks and Adger, 2005) in Brooks et al (2006). Vulnerability can thus be reduced through strong and effective formal and informal institutions, robust governance systems, efficient early warning systems, diversify in resource use and livelihood strategies (Adger et al, 2005) in Brooks et al (2006).

Adaptation through resilience building and vulnerability reduction is highly recommended for Nigeria as it involves the Niger Delta coast. This should however be pursued through participatory approach in which all the stakeholders are involved.

8. CONCLUSION

The potential impact of sea level rise on the coastal settlement of the Niger Delta could create alteration of the composition of the Biophysical and socio-economic systems. The multiplier effects would be quite monumental and this calls for steps at protecting this fragile coastal system and enhancing capacity building. The severity will however be spatially variable, depending on the nature of elevation and geomorphology of the coastline. The problem is likely to be more severe in the barrier islands and areas with sandy beaches. It will also be more in areas with high population density and the concentration of infrastructure while the poor whose means of livelihood are limited are more at risk and more vulnerable.

The ability of the coastal systems to adapt to the changes in sea level will depend largely on their management. It will also be dependent on the extent to which coastal protection will inhibit their migration and the nature of biophysical and socio-economic resilience and vulnerability of the communities as determined by the socio-economic status.

In reality, though human response to change in sea level will vary, the adoption of a particular strategy will depend on the socio-economic disposition of the society. In many cases, one response strategy is not likely to be in isolation, with a mixture of responses depending on the economic, social, and ecological consideration. However, enhancing socio-economic and ecological resilience will play a key role in minimizing the vulnerability of coastal communities in the Niger Delta.

Indeed, Nigeria, given the multiplicity of developmental needs may not afford some of the sophisticated adaptation responses such as sea defenses. On this basis, it is important for the development of policies that are well informed and relevant to the nation's needs and available resources. There is therefore the need to first of all carry out biophysical and socio-economic vulnerability mapping to determine the extent to which land and livelihoods could be affected. Assessment of adaptation strategies relevant to the region need to be made. Physical mapping of the area is imperative, given the fact that presently, most topographic maps of the region are without contours. Such mapping will give an idea of the probable areas of inundation, as the elevations in the region will be determined.

REFERENCES

Aggarwal, D. and Lal, M. (2001). Vulnerability of Indian Coastline to sea level rise. Presented to the Centre for atmosphere Science, Indian Institute of Technology, New Delhi.

Brooks, N. Hall, J. and Nicholls R. (2006). Sea level rise: Coastal Impacts and responses. Report submitted to WBGU-Expert for NBGU on Ocean and Global change.

Cooper, J. P., Beevers, M. D. and Oppenheimer, M. (2005). Future sea level rise and the New Jersey Coast. Assessing potential impacts and opportunities. Science, Technology and environment policy program. Princeton University, Woodrow Wilson School of Public and International affairs.

French, G. T. Awosilla, L. F. and Ube, C. E. (1995) Nigeria: More than 3 million may have to move from lowlands in Nigeria. Climate Alert 8 (2) March-April, 1995.

Green Peace organization (1997). The threats of sea level rise. Archive. green peace.org/comms/97/artic/climate/seachange.html.

IPCC (2001). Climate change 2001: Impacts adaptations and Vulnerability. UNEP/WMO.

Izreal, Y. A. Hashimoto, M. and Yegart, W. J. M. (1990). Potential impacts of climate. Report from the working groups 11 to IPCC.

Justice, D., Turner, R. E. and Rebalais, N. N. (2004). Impacts of climate Variability on coastal fisheries in Low Oxygen environments.

Kates, R. N. (1984). The interaction of Climate and Society. In SCOPE 27 – Climate Impact Assessment.

Niger Delta Environmental Survey (1997). Phase I report. Volume 1. Environmental and Socio-economic Characteristics.

Okeke, I. C. (2003). Coastal Challenges and the Challenges of Coastal education in Nigeria. Paper Presented to Conek International, Lagos.

Oni, S. I. (2003). Owards Sustainable Coastal hazard management in Nigeria. Paper submitted at the International Conference on Estuaries and Coasts. Nov. 9 – 11 2003, Hargzhow, China

Ribot, J. C. (1996) Climate Variability, Climate Change and Vulnerability: Moving forward by looking back. Presented to centre for population and development studies, Harvard University.

Ribot, J. C. (1995). The Causal structure of Vulnerability: Its application to climate impact analysis. Geojournal 35 (2) 119-122.

Sokon, Y. and Denton, F. (2001). Climate Change impacts. Can Africa cope with the challenge? Daker, ENDA Tiers Monde.

UN Atlas of the Ocean (2001). Climate Variability and Change; Impacts and adaptations. Coastal settlements. http://www.oceanatlas.org/cas-static/en/coastal-settlements-en-2345-all-1.html? Status = NDOyMZQIJj…

United Nations Environment Program (UNED) (2000). Climate change information sheets 11: Sea levels, Oceans, and coastal areas http://unfccc.mt/cop3/fcc/climate/fact//.htm

Watson, T. R. Marufu, C. Z and Richard, H. M. L. (1997). The Regional Impacts of Climate Change. An assessment of vulnerability. Survey for policy makers. A special report of IPCC working Group 11.

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Appendix1

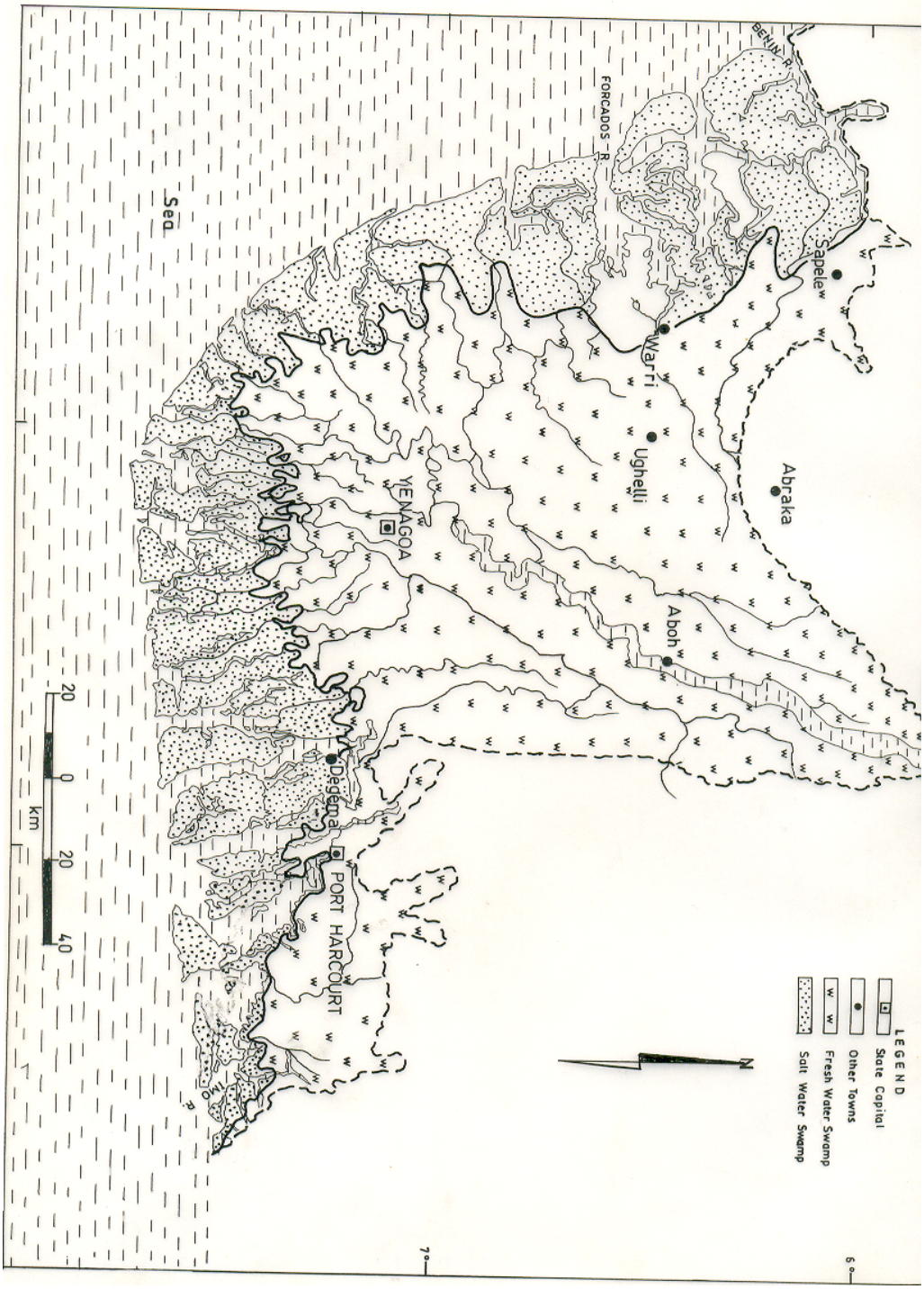

Fig. 1Estimated limits of saline and fresh water swamps.
Source: Adopted from Nigerian Geological Surveys (1984), NDES (1997).

Appendix2

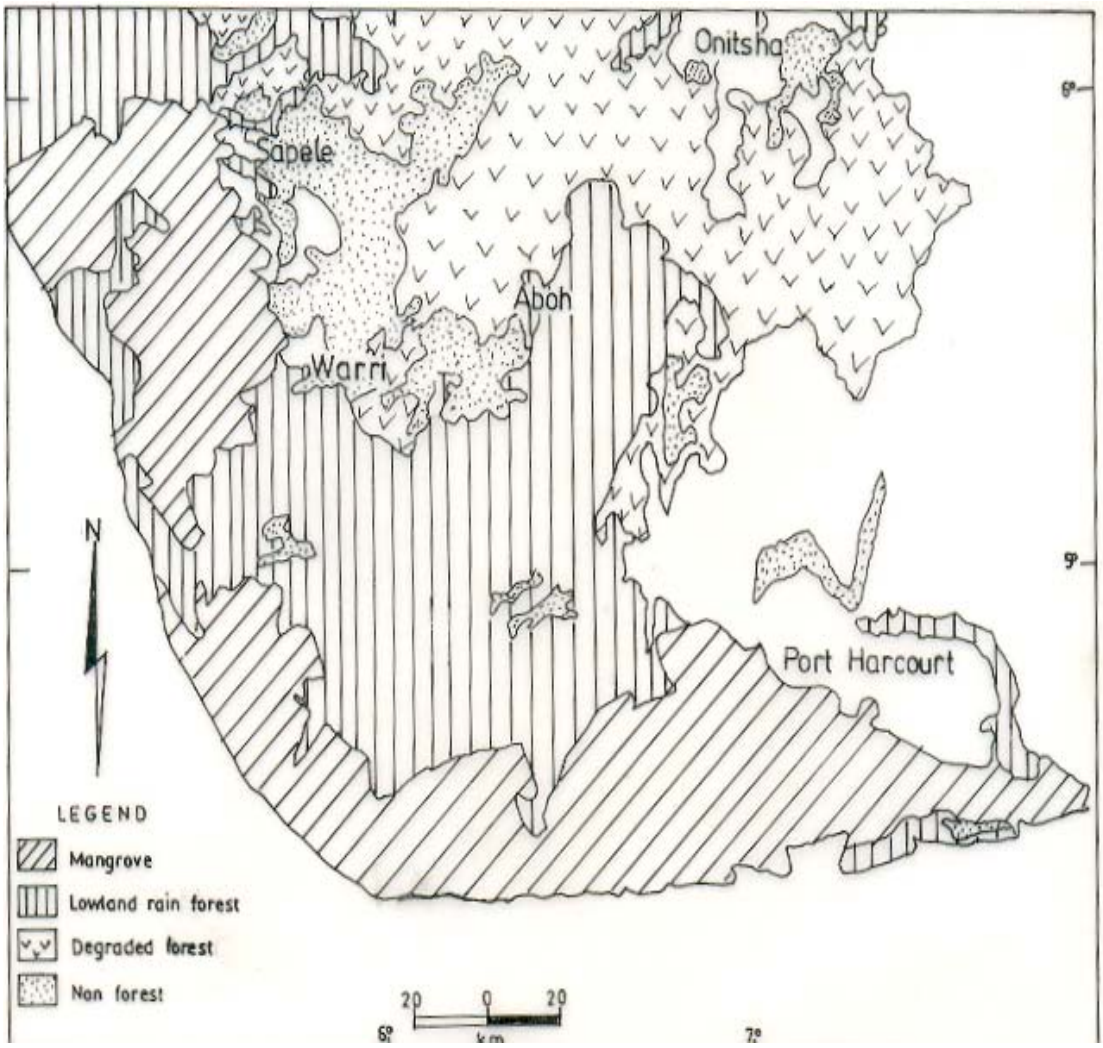

Fig. 2 Vegetation Zonation in the Niger Delta
Source: WRI (1995) NDES (1997)

Appendix3

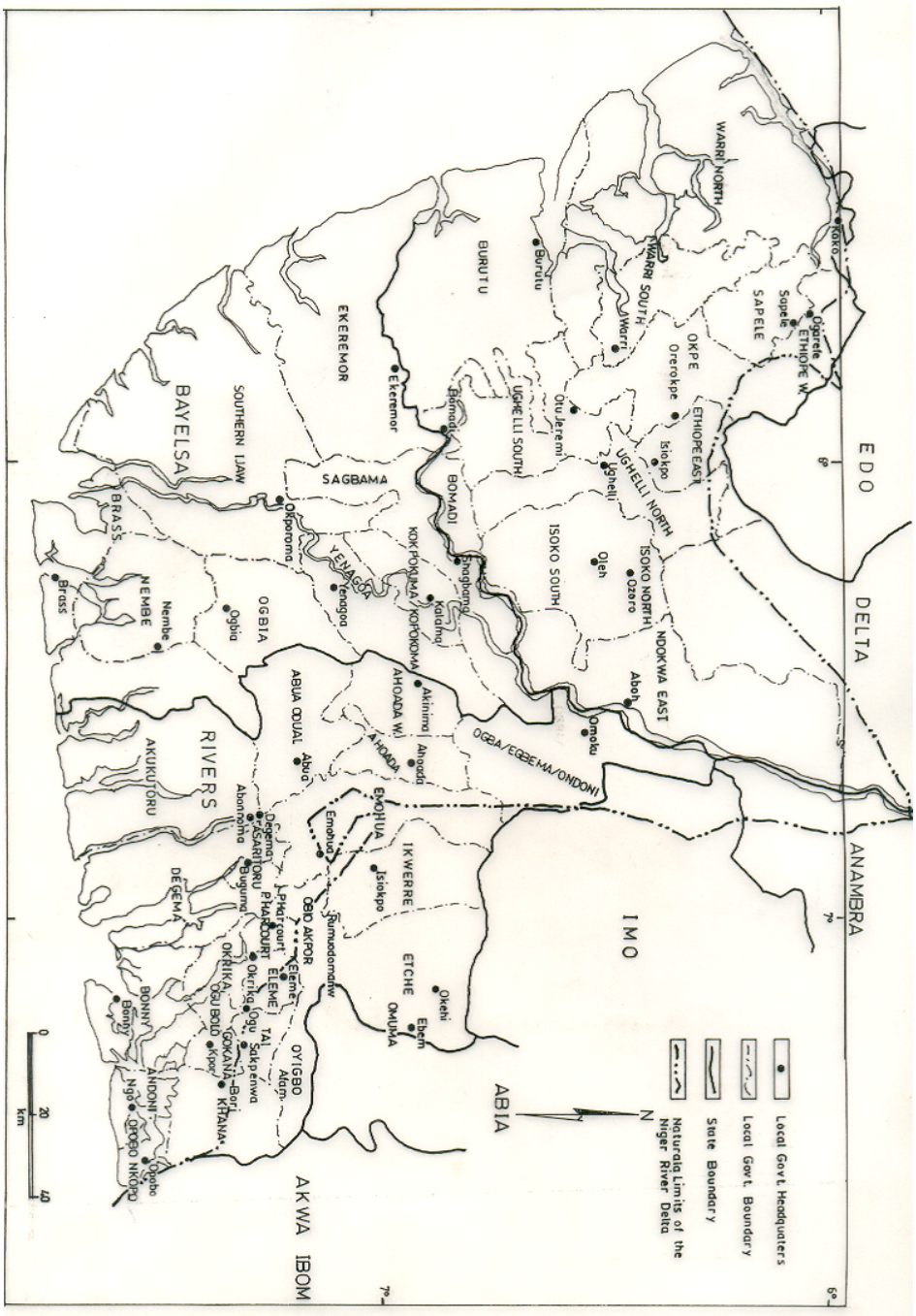

Fig. 3 Some settlements in the Niger Delta
Source: Ministry of Lands and Survey, 2007