The Implications of Rising Sea Level on the Coastal Lowlands of Cameroon

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Key words:

SUMMARY

The Cameroon coastal lowlands dominated by Barrier beaches, Barrier islands, Creeks and Lagoon formations runs from Limbe in the west to Tiko and Douala to the east along the Gulf of Guinea. The Cameroon coastal lowlands evolved during the last marine transgression of the Holocene, which occurred about 10,000 years ago with the drowning of the mouths of coastal rivers along the tropical coastlines. It is today dominated by a depositional sedimentary environment with peculiar geomorphic character of sandy, low lying swampy nature constantly influenced by saline water incursions from the Atlantic Ocean. The extremely faint slopes of the geomorphic features are easily inundated from sea incursions, which should be worsened by the impending global sea level rise. A crucial issue of importance to this paper against the background of adaptive strategies is the rising global sea level in the face of increasing high population density in the Cameroon coastal lowlands.

Coastal flooding from saline water incursion results in ecological stress through wetland loss, inundation and erosion, while the lagoon-creek complex is inflicted by hydro-geomorphic changes with adverse environmental consequences on the coastal settlements. Sustainable development in the rapidly urbanised built-up areas of Limbe and Douala becomes increasingly difficult along the Cameroon coastal lowlands as coastal flooding from inundation is expected to increase in magnitude while land loss become more devastating.

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INTRODUCTION

Global concern has shown a heightened interest in the vulnerability of coastal zones to natural and human-induced hazards in recent times. This is because of the increasing human population, which occupy the area today, a trend that is expected to continue at an even greater magnitude. The Population Reference Bureau (PRB, 2003) in acknowledging this has described the coastal environment as an area of intensive natural and anthropogenic processes, as home to a large and growing population and it is fast undergoing environmental decline. The coastal zone thus come under the influence of increased magnitude of global environmental change processes exhibited by flooding, saline water incursions, erosion, wetland loss and the threats of sea level rise with the much talked about global warming, and is today focussed upon as a disaster zone. The last three years has witnessed flood related hazards with the December 2004 Tsunamis which flooded South East Asia, the September 2005 Hurricanes Katrina and Rita which inundated the United States of America's cities of New Orleans and Houston which led to evacuations in the face of heavy death toll. This year 2007 has already witnessed severe flooding and inundation of the coastal zone of Mozambique in the southern part of the African continent.

THE PROBLEM

Global Warming and Accelerated Sea Level Rise

The global climate is known to have a natural variability upon which there is a discernible human influence. The current discussions inquire how this changing climate will alter in the future and what impacts it will have on the environment. The predictions following an avalanche of studies range considerably, however, the consensus is that the most important factor is that of global warming. In March 2006, a team of British scientists stated firmly that the planet earth is faced with increasing global warming capable of melting ice sheets of continental Europe. The next month of April 2006 incidentally witnessed a devastating flooding occurrence of the River Danube, the worst of its kind in a century which affected more than four countries with Serbia, Bulgaria and Romania as the worst hit.

The last two decades have seen a sudden surge of interest in climate change with increased global warming and sea level rise hazards. This has heightened the concern of nation states in the global warming saga resulting in the Kyoto convention embraced by the international community to reduce significantly emissions into the atmosphere, which has resulted in the fast depletion of the ozone layer, thus accelerating the global environmental change process. The global environmental change process initiated principally from the modification in the earth's atmosphere is due to increasing accumulation of carbon dioxide, methane and nitrous oxide from urban, industrial and agricultural activities. It is thought that the increasing concentrations of these gases could enhance the natural Greenhouse effect, whereby the

atmosphere intercepts some of the solar radiation reflected into space from the earth's surface, and so maintains global temperatures at a higher level than would otherwise prevail (Bird, 1993). The prospects is that sea level is expected to rise steadily as the earth gets warmer through global warming, with the consequence that most of the present world's shoreline could be submerged. A rise in sea level occurs when the volume of water in the ocean basins increases with far reaching impacts at the edge of the continental system. Since future emissions are not predictable and there are large uncertainties in forecasting future climates, this paper is focussed on impact of a rising sea level on a low-lying, swampy coastal area located in the southern part of Cameroon in the Littoral zone of the Gulf of Guinea.

The Intergovernmental Panel on Climate Change (IPCC, 1988) had in its widely publicised report, states that a rise in sea level would:

- inundate wetlands and coastal lowlands;
- erode shorelines;
- exacerbate coastal flooding;
- increase salinity of estuaries and aquifers and otherwise impair water quality;
- alter tidal ranges in rivers and bays;
- change the heights, frequencies and other characteristics of waves; and
- decrease the amount of light reaching the sea floor.

Through the study of historical weather records and future projections with General Circulation Models (GCM), there is strong evidence that human influenced climate change is taking place, and may accelerate in the future (IPCC, 2001). As Hosking and Moore (2002), stated the future extreme sea level scenario combines changes to mean sea level, tidal regime, local land movement and surges. The predicted increase in extreme events and rise in mean sea level would equally have a significant impact along the coastline. As coastal research advances, it is clear that these summarised consequences serve as indicators of a global environmental change process affecting the coastal zone. Some of these consequences are now noticeable particularly along sandy, swampy coastlines characteristic of the humid tropical environment.

In the most recent IPCC WGI Fourth Assessment Report published February 2007 on "Direct Observations of Recent Climate Change"; 'Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level". This report further states " Global average sea level rose at an average of 1.8 (1.3 to 2.3) mm per year over 1961 to 2003. The rate was faster over 1993 to 2003, about 3.1 (2.4 to 3.8) mm per year. Whether the faster rate for 1993 to 2003 reflects decadal variability or an increase in the longer-term trend is unclear. There is *high- confidence* that the rate of observed sea level rise increased from the 19th to the 20th century. The total 20th century rise is estimated to be 0.17 (0.12 to 0.22) m. However, the effect of changes in regional weather systems on sea level extremes has not been assessed.

The Littoral zone of Cameroon characterised by lowlands depicts an interesting physiography dominated by Hydro-geomorphic features of immense sustainable potentials to its teeming

human population and consequent urban spatial growth. The extremely faint slopes of the geomorphic features are easily inundated from sea incursions, which impact would be worsened by rising sea level. A unique feature of this zone and of importance to this paper is the fact that the locality of study describes the most densely populated area of the entire Cameroon coastal zone. Management for sustainable development becomes increasingly difficult along the Cameroon coastal lowlands against the background of adaptive strategies in the face of constant sea incursions and the scenario of rising global sea level. Coastal flooding is expected to increase in magnitude on the fragile nature of landform features in the area, the economic benefits or otherwise of which the present paper is focussed. It is expected that with global warming the frequency and vulnerability of events related to weather namely droughts, storms and floods would be greatly altered and obviously more frequent.

THE STUDY AREA

The coastal lowlands of Cameroon lie within the littoral zone washed by the Gulf of Guinea where the West African coastline changes abruptly into the central African coast. The Cameroon coastal lowlands evolved during the last marine regressions of the Holocene, which occurred about 10,000 years ago with the drowning of the mouths of coastal rivers along the tropical coastlines. It is today dominated by a low-lying depositional sedimentary environment that is highly influenced by the estuarine systems of the Mungo and Wouri drainage basins, bringing along massive supply of sediments, which constitutes fragile landforms. Its geomorphic character of sandy, low-lying swampy nature remains constantly influenced by saline water incursions from the Atlantic Ocean, a situation expected to aggravate with the observed sea level rise.

This coastal lowlands form part of a wider geologic environment known as the sedimentary basin of southern Cameroon evolved from intense work of deep chemical weathering and fluvial activities. The evolution of the coastal lowlands of Cameroon is influenced by the massive chain of the Cameroon Mountain volcanic line where deeply weathered parent materials of the migmatitic rocks consisting of granite, gneisses and metasediments has liberated ferruginous materials through fluvial activities further south into the sandstones, shale and limestone area of Tiko and Douala describing geomorphic attributes of a barrier island-lagoon environment.

As the Atlantic Ocean retreated, taking the form of marine regressions, a period of sedimentation witnessed an enormous quantity of liberated sediments from fluvial activities of coastal rivers utilised in the evolution of emerging foreshores and lagoons. It is evident that the notable aspects of drowning along the lower courses and estuaries of the coastal rivers in the study area support this view. Rivers Mungo, Wouri and Dibamba in the study area have today, several kilometres of their lower courses as inland extensions of the lagoons, which they feed. This is shown in the map below covering the most integral part of the Cameroon coastal lowlands in the Douala area.

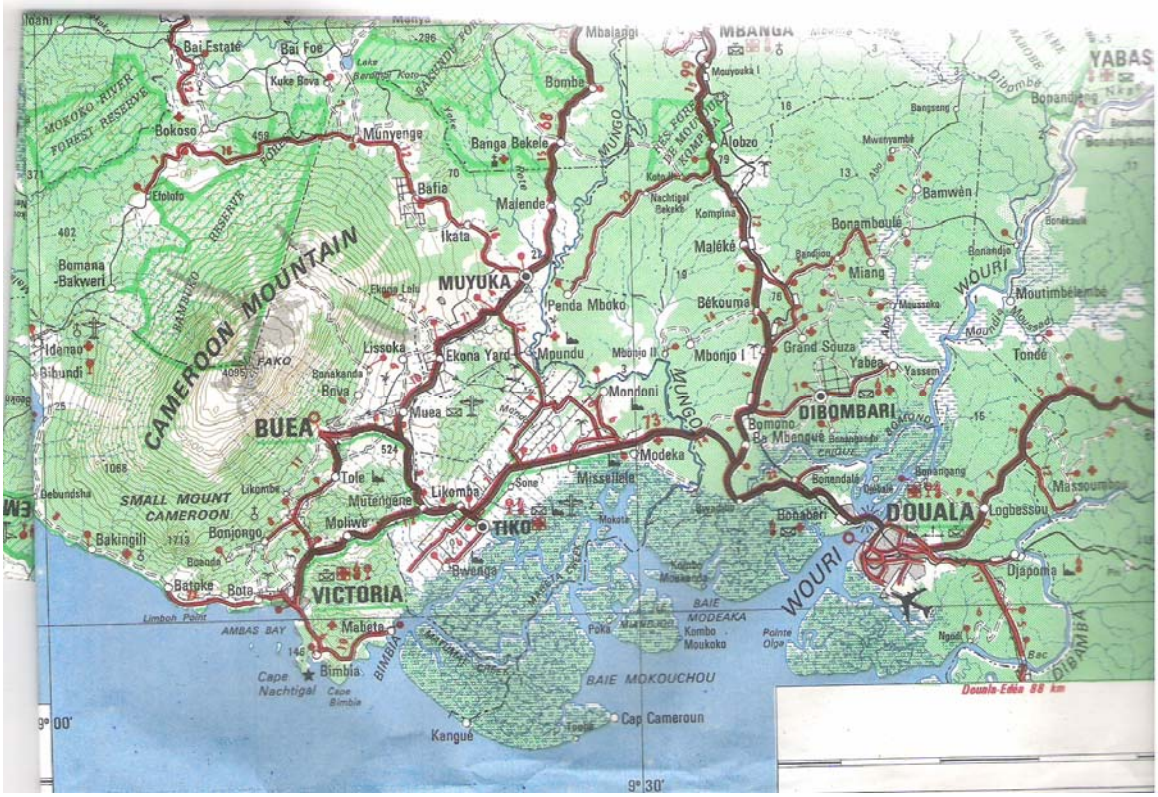

Figure 1: The Cameroon coastal lowlands.

PERSPECTIVES OF IMPACT OF RISING SEA LEVEL ON THE COASTAL LOWLANDS OF CAMEROON.

The resultant effect of the evolution and configuration of the Cameroon coastal lowlands between Douala and Tiko is the extensive spatial coverage of areas liable to inundation and flooding. The socio-economic effects of this is known to have far reaching consequences on the teeming human population that continue to occupy the coastal lowlands. Cameroon has a surface area of 475,000 square kilometres with an estimated human population of 16million, however only 6.5% accounts for the coastal land in the country, which is home presently to more than 4 million people. The bulk of the close to 4 million people occupying this 6.5% coastal land in Cameroon are in the fast growing Douala metropolitan area accounting for at least 2.5million people, while the others are shared by the Limbe, Tiko areas to the west and the Kribi, Sanaga-Maritime areas to the south of Douala.

Cameroon with a coastline of 402 kilometres in length dominated by low-lying, swampy geomorphic features of beaches, extensive creeks and lagoon formations, the phenomenon of rising sea level is expected to be far reaching on this teeming population and thus of heightened interest for study. Asangwe (2006) in earlier study on Douala stated that this hydro-geomorphic characteristics of the littoral zone of Cameroon has remained of "immense sustainable potentials to its teeming urban population growth, as it is richly endowed with

aquatic and terrestrial resources within the brackish and saline water environments". Rising sea level in this area of coastal lowlands is expected to enhance more spatial extent of the aquatic media while the terrestrial media will be further driven inland to encroach on better drained land. The Cameroon coastal lowlands are a flood tide dominated zone where mangrove-covered barrier formations have evolved within the intricate network of creeks, tidal inlets, and shoaling lagoon formations. The drowning of the mouths of the major coastal rivers like the Mungo Wouri and Sanaga today describes a broad embayment along the Cameroon coastline as it opens into the Gulf of Guinea, which greatly enhances tidal movements with consistent inflow of saline waters. The immediate effect is the proliferation of the brackish water environment where the mangrove vegetation thrives on the mud flats further inland.

The Mangrove forest vegetation constitutes the dominant coastal lowlands ecosystem of the humid tropical coasts. The Mangrove forest vegetation ecosystem in Cameroon cover more than 2500 square kilometres in area, though this has witnessed considerable reduction in quantity due to exploitation by the rapidly encroaching human population and settlement in the wetland zone. This has been the global trend particularly along the tropical coastlines where considerable human-induced destruction of mangroves is still being carried out. In 1987 some 13.9 million hectares of mangroves were estimated to remain in the 22 countries containing the world's major mangrove stands. Of this total only 10% occur in developed countries, the remainder being found in tropical developing countries where development pressures have resulted in an accelerated rate of habitat loss.

A mangrove swamp forest is an association of halophytic trees, shrubs and other plants growing in brackish to saline tidal waters of tropical and sub-tropical coastlines and according to Maltby (1986), supports over 2,000 species of fish, invertebrates and epiphytic plants. Maltby (1986) further described the mangrove forest as an impenetrable maze of woody vegetation with unconsolidated peat, and many adaptations to the double stresses of flooding and salinity. The mangrove forest strives best in areas, which, are brackish, swampy, waterlogged, have the influence of tide incursions at least twice daily and in which sedimentary deposition occurs. Deposition occurs either from marine and/or river processes. A change in water levels on a periodic or seasonal basis influences the proliferation or retreat of the forest. This is because the changes have an influence on the several factors, which determine the type of species, which abound in the area, and also maintains the wetland characteristics of the environment. Factors such as tidal currents and levels, the intensity of the waves, the salinity concentration and the sediment depths have formed and maintained an arrangement or zonation pattern of the species of mangrove forests found in the Cameroon coastal lowlands. This has evolved mainly 3 zonal pattern arrangements of the mangrove species in the Cameroon coastal zone namely:

– The Rhizophora racemosa (red mangrove), which occupy the accreting tidal mudflats of the embayment into the Cameroon coastal lowlands in the Douala area, as well as the Tiko creeks. This specie occupies 90% of the Cameroon mangrove swamp forest at the coast.

– The inter-tidal flats, which have seasonal inundation at the peak of the wet season in the area, has the colonisation of the Rhizophora harrisoni, Rhizophora mangle and Pandamus candelabrum.
– The Avicennia nitida and Acrosticum aureum commonly called the black mangrove are found on firmer grounds away from inundated zone, though influenced by brackish waters where they are restricted to lagoon inlets and wetlands.

It is expected that with rising sea level, the mangrove swamp forest of the Cameroon coastal lowlands will be modified. As the coastline remains largely structure-free from engineering construction like concrete dykes and walls, a process of hinterland extension of the mangrove is imminent. The abundance of sediment supply to the coastal lowlands of Cameroon is expected to economically enrich the proliferation of the mangrove forest in the event of rising sea level. The scenario here is that as sea level rises there will be sufficient fine-grained sediment (mud) accretion on the low-lying depositional coastal environment of the Cameroon coastal lowlands to maintain the seaward edge while the mangroves spread landward. With the most extensive spatial extent of the lagoon system in Cameroon located at 50 kilometres from the saline water environment of the Gulf of Guinea, north of Douala metropolis and the lower courses of the Rivers Sanaga and Mungo to the east and west of Douala respectively, describing wetlands of tidal inlets of lagoon-creek formations, the more economical Rhizophora racemosa will become more abundant and extensive.

Today, Cameroon has an estimated 40% of total mangrove swamp forest vegetation lost over 4 decades since independence in 1960, a situation that has worsened the socio-economic status of the largely fishing population of the coastal area. With more landward colonisation of the mangroves with the continued rising sea level, the trend will certainly be reversed. With this scenario the total economic value of the mangrove swamp forest thus becomes greatly enhanced in the locality. The coastal population can then subsequently derive the indirect and direct benefits of the mangrove swamp forest by practising the large-scale conservation procedure called for in the pursuit of Agenda 21 and the millennium goals of the United Nations.

The rapidly urbanised coastal settlements of the Cameroon littoral zone like Douala, Tiko ,Limbe and Kribi, though faced with the natural influence of oceanographic processes of the Gulf of Guinea through flooding, inundation and erosion, continue to function as coastal resorts. Coastal tourism along tropical coast is by far the leading foreign exchange earner in most countries, particularly in south East Asia like Malaysia, Indonesia, and Thailand. These countries are known to have benefited tremendously from Beach restoration, coastal ecosystem and wetlands restoration programmes to attract tourist and foreign investment. The most urbanised centre of Cameroon, which is Douala, is currently engaged in urban renewal programme, which emphasise the coastal nature of the metropolitan area. The project is expected to culminate in the tourism incentive of beach restoration, construction of resort centres far into the lagoon system connected by concrete jetties, coastal wetland ecosystem conservation. The initial stages has already witnessed the destruction of illegal housing construction on drains for effective discharge of runoff into the lagoon system to avoid flooding and inundation of the city. While this is expected to restore the beauty of the city, it

is expected that with rising sea level, the coastal nature of the Douala metropolitan area will be preserved as the largely aquatic terrain will be maximally utilised for coastal tourism.
The progressive rise in sea level will enhance the spatial extent of wetlands in the coastal lowlands of Cameroon. The immediate impact is the growth in the distribution and ecology of the fauna community of fish and shrimps in the Cameroon coastal zone. It is interesting to note that the country got its name from the first contact with the European explorers from Portugal who gave the name "Rio dos Cameroes" meaning River of Pawns on observing the tremendous quantity of shrimps and fish at the mouth of the River Wouri estuary in the Douala area. The last few decades however have seen the decline in fish catch and earnings due to unprecedented reclamation for commercial/industrial buildings harbour and ports in the Limbe, Tiko and Douala areas. The fishing community here is predominantly foreign involving nationals of Nigeria which form the bulk with well over 80%, while others namely Benin, Togo, Ghana and of course Cameroon account for the rest. A continuous rise in sea level and the proliferation of the mangrove swamp forest enhancing the growth of the fauna community will encourage private sector investment fish and shrimp production. Investment in the preservation and storage of the variety of fauna species can only further enhance the socio-economic status of the coastal population in the Cameroon coastal zone. Cameroon is an economic giant in the CEMAC zone, which is the economic integration body of Central African sub-region as it directly serves two landlocked countries of Chad and Central African Republic. This location advantage of Cameroon as a coastal state is expected to be economically beneficial with the proper management of its coastal resources, expected to be modified with the rising sea level.

The lagoon-creek formations dominating the character of this coastal lowland under the threat of flooding from saline water incursion results in ecological stress through wetland loss, inundation and erosion inflicting hydrogeomorphic changes with adverse environmental consequences on the coastal settlements. Agriculture and human health of the coastal population suffer from flooding/inundation and pollution in terms of water quality, sanitation and Eutrophication. The deadly malaria parasites are expected to thrive in such a situation and with the seemingly no end in sight for the treatment of malaria, the tropical coastal population worldwide including Cameroon will be adversely affected.

Global warming and the anticipated rising sea level will increase storminess along tropical coastlines as have been experienced in the last few years, with the multiplicity of devastating storms in Mozambique, Gulf of Mexico in the United States of America and in south East Asia. Storminess will affect tourism, coastal residences and infrastructure as well as agriculture and coastal ecosystems. The economic damage of such scenario of environmental pressure and impact is obviously great necessitating detailed understanding of coastal processes at micro scale in order to implement adequate management procedure. Data bank of measured phenomena on coastal zone parameters specifically on changing attribute of sea level and coastal features in terms of heights, slope and configuration become imperative to avert or reduce significantly the damage in economic terms. Asangwe (2002) noted, "In a state of coastal instability as with other environmental changes, it is often not the change but rather the rate of change that poses the problem". This rate can therefore be continually monitored with a high degree of accuracy with the new technology involving spatial data

acquisition and analysis of remotely sensed imageries of the Earth's surface and Geographic Information System (GIS).

CONCLUSION

The expected environmental consequences and probable human responses of the much talked-about global sea level rise in coastal areas continue to attract concern for study, monitoring and management. The impending hazards in the event of continued global warming with the anticipated phenomenal sea level rise remain an environmental problem for coastal planners, developers, managers and conservationists. With the coastal zone estimated to account for almost 75% of the global human population in just a few decades from now, it becomes imperative that literature should move away from generalised and speculative studies to intensive micro-scale observations from localized to regional inferences.

The Cameroon coastal lowlands is expected to be impacted with the rising sea level as the paper has highlighted in detail, however it is not all a gloomy event as a lot of socio-economic benefits are anticipated for the mounting coastal human population. That a rise in sea level along a predominantly low-lying coast will aggravate sea incursions resulting in flooding, inundation and erosion is but a natural sequence of events, which necessitates adequate knowledge for mitigation and indeed management**.** The adaptive strategies for the continued utilisation of the Cameroon coastal lowlands in the face of rising sea level is to consider the costs and benefits to the range of stakeholders within the complex nature of property rights regimes that exist with many coastal resources. The government of Cameroon by law own the land and territorial waters of the country, however the resources within the coastal locations remain under conflicting utilisation. This situation is not unconnected with the fact that much of the coastland in this part of the world are often considered as waste land due to its inaccessibility and largely aquatic terrain.

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BIOGRAPHICAL NOTES

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