The Douala Coastal Lagoon Complex, Cameroon: Environmental Issues

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Abstract

The Littoral zone of Douala in Cameroon depicts an interesting physiography dominated by hydro-geomorphic characteristics of immense sustainable potentials to its teeming urban human population growth. The Douala coastal lagoon complex is easily the dominant feature with richly endowed natural and socio-economic resources along the littoral zone of Cameroon. It is fed mainly by the River Wouri, evolving a maze of creeks and lagoons about 50km from the Atlantic Ocean, with its largest surface extent north of Bonaberi, to the north west of metropolitan Douala. The Douala lagoon system describes a major consequence of the Tertiary to Early Quaternary period, particularly of the Holocene marine transgressions, which witnessed the drowning of the estuarine system of the River Wouri. This expansive lagoon system of Douala today is being inflicted with hydro-geomorphic changes due to rapid urbanization on the fragile land-water ecosystem. The land-water ecosystem of lagoon-creeks inlets, tidal mud flats, estuaries, mangroves and wetlands, which provide critical coastal habitats for socio-economic activities now face destruction due to increased spatial growth of the Douala metropolitan area. Easily the most urbanized center in Cameroon, metropolitan Douala has witnessed extensive spatial expansion, which has provoked certain observable environmental problems on the lagoon complex and the wetlands. These are in form of reclamation for expansion of urban sprawls, wetland conversion for industrial infrastructure and development with resultant increased discharge of effluents. In spite of the limitations and restrictions imposed by the lagoon water surface and the difficult terrain of its marginal lowlands describing wetlands, it appears that the rate of interference would continue unabated. The effects of these has seen impaired water quality in the contamination of surface and ground water sources, public health hazards, wetland loss, subsidence, flooding etc.

1. INTRODUCTION

The issues and problems of land degradation are increasingly becoming apparent as the carrying capacity of the earth is undergoing accelerated decline. The consequences of this development is known to be far reaching, however it is the increasing poverty levels that has placed the international community in dire need to reverse the trend. This has necessitated the development of the millennium goals by the United Nations organization working through it several agencies. There is no doubt that the millennium goals strictly seek to address sustainable development strategies for the third world countries, particularly in the sub-Saharan region where most of the poorest countries of the world today are found.

At the dawn of the 21st century, global concern for the earth's carrying capacity in the face of increasing human population resulted in the Rio+ 10 conference on Sustainable

Development. This 2002 World Summit on Sustainable Development in Johannesburg, South Africa, primarily reviewed the progress and global response on environmental issues since the Earth Summit in Rio de Janeiro after 10 years. The general consensus was the need to more effectively utilise science knowledge in the management of the physical environment in policy issues of Governments worldwide. The general trend of decline in global environmental quality agreed to at the 2002 World Summit on Sustainable in Johannesburg, South Africa, has further heightened concern for effective conservation and management. This pressing need for environmental management worldwide indicate that natural resources exploitation and utilisation has left a generally degraded environment. Perhaps the most obvious locality of degradation is the coastal zone where the continental system disappears into the marine waters of the oceans. This locality 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, is today focussed upon as a disaster zone.

Global environmental change process affecting coastal zones worldwide today is by far centred on the tripartite problems of receding shorelines, loss of biodiversity and increasing human population. Presently, the coastal zone is in principle regarded as the degrading edge of the continental system, in contact with marine waters of the oceans. Huge cries from the maritime nations, culminated in the requirements of chapter 17 of the Agenda 21, agreed to at the end of the United Nations Conference on Environment and Development commonly referred to as the Earth Summit at Rio de Janeiro, Brazil in June 1992. According to it, coastal states are required to "commit themselves to integrated management and sustainable development of coastal areas and the marine environment under their national jurisdiction". Exactly 10 years later in 2002, the World Summit on Sustainable Development (Rio+10) reviewed the programme made in this vein and further called on nation states of the United Nations to prioritise policy actions on mitigating global environmental degradation. We in Cameroon cannot afford to ignore the implementation of this call, in order to achieve sustainable development in the resource utilisation of our coastal areas. As the entire coast of Cameroon now face one form or another of degradation process, the issue of sustainability makes our understanding, monitoring and management of the coastal areas not only desirable but also imperative.

2. THE PROBLEM

Environmental issues and problems remain of global concern, despite the difficulty in reaching full consensus in signing agreements and treaties to pursue a common approach in implementing strategy to achieve a more sustainable world. The need for sustainable development was given its strongest support by the United Nations Organisation with the convening of the United Nations Conference on Environment and Development (UNCED) at the Earth Summit of June 1992, which included four main agreements: the Rio Declaration on Environment and Development; the Framework Convention on Climatic Change; the Convention on Biological Diversity; and the Agenda 21. All of these impact in someway or another on coastal environments. The Rio Declaration contains 27 principles relating to international behaviour in relating to development and the environment and requires all nations to co-operate in trying to achieve sustainable development. The Framework Convention on Climatic Change is directed towards reducing harmful emissions of greenhouse gases and specifically mentions regional programmes to lessen

the effects of climatic change and the need to incorporate climatic change into policies and actions. These are directly relevant to coastal sustainability in terms of global warming and sea level rise predictions. The Biological Diversity Convention which refers to ecosystem species and generic diversity is important in the sustainability of coastal systems, where there is greatest pressure of population growth and development today. Agenda 21 is a complex 800page action plan on global environment and development for the 21st century, which contains reference to the sustainable use of ocean and coastal resources. In order to follow up on Agenda 21 a commission on Sustainable Development was created within the United Nations and a World Summit on Sustainable Development convened in the Republic of South Africa after 10 years of the Rio Summit in 2002. It is clear that much has been achieved to improve and protect the environment for sustainable development in the last two decades. This is because it has been recognised that the growth and development of nations in the economic system is dependent on the ecological system. A major challenge facing humankind is therefore the achievement of sustainable development while utilising the natural resources that will also satisfy the needs of the increasing human population. This becomes even more pertinent as studies continue to reveal that the ecological system remain the base of the economic system in the fight against poverty in the pursuit of sustainable development particularly in sub Saharan Africa.

The quest for sustainable development to meet the yearnings of a fast growing global human population drew the attention of the international community and was considered by the World Commission on Environment and Development, which stated that it "seeks to meet the needs and aspirations of the present, without compromising the ability to meet those of the future… It is a process in which exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations". This is even more in the dynamic coastal environments, with their fragile morphological features, which are subject to flooding, saline water incursions, and ecological stress through wetland loss, erosion and eventual land loss. This becomes even more pertinent when it is realised that reasonably authentic figures suggests that, an estimated 75% of the global human population is expected to live within the narrow strip of 60km from the shoreline along the world's coastal areas. Sustainability therefore becomes crucial in the face of present day accelerated worldwide coastal zone deterioration and degradation. In the face of deteriorating environment, the continuous monitoring, detailed investigation and evaluation of procedure for natural resource exploitation and utilisation become imperative. The coastal zone with its fragile ecological system in its biophysical state has come under intense stress, with scientific evidence of degradation. Multi-disciplinary research along the coastal areas, continue to support the view, that the maintenance of biodiversity in coastal systems is an essential element for sustainability in the area. This locality under the influence of increased magnitude of global environmental change processes exhibited by inundation, flooding, erosion, wetland ecological stress and threats of sea level rise with the much-talked about global warming, is today focussed upon as a disaster zone. Over 250,000 people died in hazards affecting the coastal zone worldwide in 2004, with the most devastating being the Tsunamis, which flooded South East Asia. While the year 2005, witnessed the evacuation of New Orleans in the United States of America because of inundation caused by Hurricane Katrina from the Gulf of Mexico. It becomes more frightening, when it is realised that this zone has the greatest

concentration of human population on earth. The coastal zone is easily the fastest growing geomorphic environment of human population on planet earth. 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 1976 official national population census figures put metropolitan Douala at 458,426 and with an annual growth rate in excess of 8% per annum, the estimated population of the area is at 2.5million enjoying the fastest growing rate of urbanisation in the Republic of Cameroon. Easily the most urbanized center in Cameroon, metropolitan Douala has witnessed extensive spatial expansion, which has provoked certain observable environmental problems on the lagoon complex and the wetlands. These are in form of poor land reclamation for expansion of urban sprawls, sand dredging, expansion of highways, wetland conversion for industrial infrastructure and development with resultant increased discharge of effluents. In spite of the limitations and restrictions imposed by the lagoon water surface and the difficult terrain of its marginal lowlands describing wetlands, it appears that the rate of interference would continue unabated. The effects of these has seen impaired water quality in the contamination of surface and ground water sources, public health hazards, wetland loss, subsidence, flooding etc. (World Commission on Environment and Development, 1987; Population Reference Bureau, 2003; Centre de Recherche et d'Etudes en Economie et Sondage, 1994).

3. THE STUDY AREA

The study area is the Douala coastal lagoon in the southern lowlands of the Republic of Cameroon within the depositional sedimentary formations. Except for the rocky shores in a portion of the Limbe coast, the Cameroon costal lowlands dominated by Barrier beaches, Barrier Islands, extensive creeks and Lagoon formations runs from the Bakassi islands in the west to Tiko and Douala in the central parts of the coastline and to the sandy beaches of the Kribi area to the south of the country. The Cameroon coastal lowlands is located within a geographical area of Africa which can be readily identified on the basis of the abrupt change in direction of the west African coast into the central African sub-region. The study area of the Douala coastal lagoon complex is an integral part of the 402km long shoreline of the Cameroon coast. The hydro-geomorphic characteristics of the littoral zone of Douala in 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.

The Republic of Cameroon today is estimated to have 4 million of its 15 million human population within 60km of its coastline, thus accounting for more than 25% of the population on the 6.5% area of coastal land in the country (Asangwe, 2002). Douala metropolitan area alone has a current estimate of 2.5 million people and the fastest growing rate of urbanization. With its environmental problem of scarcity of land in the face of abundant water dominated by its lagoon complex, management strategies become inevitable for its resource utilisation and infrastructure development.

The Douala lagoon system evolved during the last marine transgressions of the Tertiary to Early Quaternary period, particularly of the Holocene (wholly recent-used frequently for

the youngest epoch), which occurred about 10,000 years ago with drowning of the mouths of coastal rivers along the tropical coastlines. This period witnessed the inundation and submergence of coastal lowlands including estuarine river systems to form the broad embayment into the lagoon system from the Atlantic Ocean. The expansive lagoon system of Douala metropolitan area today is the consequence of such drowning of the River Wouri- the main river system feeding the lagoon far inland, thus giving its greatest spatial extent about 50km from the opening into the Atlantic Ocean. Asangwe (2002) in an earlier study noted "the area comes under strong influence exerted by tidal movements, episodic events of floods, storms with far reaching geomorphologic implications, which encourage further degradation". The expansive lagoon system of Douala today is under constant interaction of a fast growing urban population and the land-water ecosystem now suffer many uncoordinated large scale disturbances inflicted upon its character.

4. THE DOUALA COASTAL LAGOON ENVIRONMENT

The Littoral zone of the Republic of Cameroon presents an array of varying contrasting geomorphic attributes consisting of creeks, lagoons, sand and rocky beaches, coastal plains, wetlands and mangroves. These varying landforms show evidence of fluvial activities of sediment deposition, which has given the coastal lowlands of Cameroon a unique character, despite the imposing feature of the Cameroon Mountain. The sedimentary formation of the Camerooon coastal lowland is dominated by the lagoon-creek system within the Douala metropolitan area.

The Douala coastal environment describes a Barrier island-Lagoon formation with the Douala metropolitan area having developed on a number of such barrier islands. The Douala lagoon system is at its most extensive spatial attribute about 50km from the Atlantic Ocean and comes under the strong influence exerted by tidal movements. It is thus a flood tide dominated zone where mangrove-covered barrier islands proliferate adjacent to the shoaling lagoon and tidal inlets. The coastline of the Douala area has a broad embayment as it opens into the Gulf of Guinea of the Atlantic Ocean, which greatly enhances tidal movements, witnessing inflow of marine saline waters. Salinity varies little from a vertical perspective in the zone, however a very dynamic surface variation ranging from between 18ppt to 13 ppt in the creeks has been reported in this zone. This indicates that to a large extent, the thermohaline conditions are quite homogeneous. The variation in salinity gets pronounced as one move into the mud flats colonised by mangrove vegetation, since the silt grained composition of deposits here tends to concentrate salinity. At high tides, the marine waters surge into the creeks at a rate of about 0.5m/sec in some areas and 0.9m/sec in others. The low tide of marine waters retreat at an average of about 2.7m/sec, which occur once in the face of two high tides in a 24-hour period. There is the high magnitude monthly of seasonal tides, locally called "big water" which takes about 10 days to rise, with the waters attaining between 18 metres to 20 metres in depth. These tidal movements apart from inundating and flooding the area, further extends the mud flats and salt marshes as salinity extends further inland into the marginal areas of the Douala lagoon system to ensure proliferation of wetlands and mangroves. Progradation of muddy sediments usually occurs during prevailing low energy conditions (Chappell, 1995), which is well exemplified by the tidal movement of the Douala coastal lagoon system. Figure 1 below show a part of the mangrove and wetland of the Douala coastal lagoon at low tide. The depositional sedimentary character is further revealed by the predominantly muddy

consistency that supports mangrove proliferation and the fact that the Douala lagoon is a shoaling lagoon system.

Figure 1: Mangrove and wetland at low tide.

Coastal lagoons are shallow water bodies, running parallel to the coast, and connected to the open sea with an outlet. They are separated from the open sea by sand bars or barrier islands. According to Phleger (1969), important factors for the development of lagoons are that enough sand-size sediment is available (brought by rivers) and enough wave activity is present for the formation of a sand bar or a barrier island. Generally, lagoons are areas of shallow aquatic geomorphic attributes that have been almost completely sealed off from the marine waters of the sea or ocean by the full development of spits or barriers by oceanographic processes of wave action, tidal action, alongshore drift of materials etc. The evolution of lagoons is closely associated with sandy, swampy coastal areas of low topography, where sandy barriers, ridges or spits develop to seal off the brackish water zone of deposition by coastal rivers. The Douala lagoon system under the influence of the River Wouri and its tributaries is today colonised by mangrove swamps, wetlands, mudflats along the lagoon marginal depressions, creeks, tidal inlets etc. The massive input of sandy grained size sediments from the fluvial system of the Wouri has evolved a typical shoaling lagoon complex, which is presently the target of continuous land reclamation embarked upon to meet the demands of the rapidly urbanized Douala metropolitan area. The continued spatial growth of the Douala metropolis has invariably inflicted far reaching alteration on the hydro-geomorphic attributes of the lagoon marginal depressions which has witnessed increased residential housing structures and infrastructure development of highways, industries and wetlands conversion. In the process of carrying out these large-scale environment-disturbing programmes the natural land-water ecosystem of the lagoon complex has been unduly manipulated and this has aggravated the process of degradation in the Douala administrative region (Phelger, 1969).

5. ADMINISTRATIVE ISSUES OF THE DOUALA COASTAL SPACE

The Douala region constituting the built-up area as well as the marine and coastal space is administered under the Wouri Division of the Littoral province of the Republic of Cameroon. The Douala region, despite its urbanized growth, displays both the urban and rural landscape over the land-water ecosystem of its coastal space. This proximity to the marine environment of the Gulf of Guinea has greatly influenced the administrative setting of both the Douala metropolitan area and its rural landscape. The pertinent environmental issues faced by these two varying landscapes no doubt influenced the administration of the Douala marine and coastal space. The Douala region has a broad embayment as it opens into the Gulf of Guinea in the Atlantic Ocean, which now has the metropolis expanding on both sides of the lagoon inlet, while the rural area remain on the creeks to the north and south of the lagoon complex. Today, six sub-divisions under a Divisional Officer each administer the Douala region, while a Governmental Delegate governs the metropolitan area under the urban council. Presently five of the six divisions, which make up the Wouri Division are considered as strictly within the urban council and thus has the influence of the Government Delegate. It is the lagoon-creek environment to the south from Youpwe into the marine environment, which now cover the only division that is rural in the Douala area. The Douala region has grown on a typical marine and coastal space where the old barrier islands were colonised by the Bonandjo, Akwa, Deido, Bepanda Bassa, Bonamoussadi and the Bonaberi districts, which today support the high population density in the area. Except for the Akwa, Bepanda and Bassa districts, the Douala lagoon complex still directly influences all the other aforementioned districts. The Douala area therefore has the crucial problem of abundant aquatic terrain in the face of scarcity of land, which poses a serious challenge of coastal zone degradation in the pursuit of urban spatial growth in the area.

The Douala coastal lagoon complex continues to extend over the depositional environment of the Cameroon southern lowlands with the dynamic estuarine system of the River Wouri which ensure sediment supply into the lagoon. This is responsible for the fast silting up process evolving the shoaling lagoon character and of course the proliferation of mangroves and wetland forests. The spatial growth of the Douala metropolis necessitating the bridge over the lagoon system in order to link the metropolis to the Bonasama and Bonaberi districts led to the effective demarcation of the lagoon system into two to the north and west of the city. To the north of the metropolis the lagoon system is characterised by clusters of mangrove and wetlands forests, the other to the west where the Douala port complex is located cover a larger area depicting a shoaling lagoon which has necessitated massive sand dredging to keep the harbour facilities operational.

Douala is the economic centre of the Republic of Cameroon. The entire Central African sub-region today is influenced by the Douala coastal space. The Douala harbour directly serves the land-locked countries of Chad and the Republic of Central Africa, while countries like Equatorial Guinea and Gabon continue to use the marine and coastal space for socio-economic activities like fishing, transportation etc. The economic status of the Douala metropolitan area has further influenced its administrative status to the highest level of the presidency of the Republic of Cameroon. This is because Douala as the financial and investment base of the country serve as headquarters to a number of government establishments like the Department of Customs and the only Stock Exchange

in the country- the Douala Stock Exchange amongst others. The ecological approach to planning and management of the Douala area has witnessed conflicts with economic issues, with the political authority leaning on the economic consideration to the detriment of environmental issues. The office of the Government Delegate at the helm of decision taking concerning the Douala marine and coastal space is this political authority, which of course subjects itself to the administrative bureaucracy of the central government entailed in developmental process in sub-Saharan Africa. As environmental deterioration is a slow process of degradation, the cumulative effects towards the attainment of the state of disaster also come unnoticed and extremely difficult to reverse.

6. ISSUES OF RAPID URBANIZATION IN THE DOUALA MARINE AND COASTAL SPACE

The issue of rapid urbanization is not a new phenomenon in the developing countries, which constitutes the bulk of the third world nations. This is because these countries have had a long-term situation of primate cities, which performed purely urban functions of administrative, economic, religious and cultural centres from the early contacts with Western Europe. By far one of the most crucial contemporary problems of the Douala area is that of rapid urbanization. It has continued to grow up fast to accommodate large human population increases as a result of the attractions offered as a nodal growth centre to the rural hinterland. Douala metropolitan area within the last three decades has grown not only in spatial extent, but also in its internal and area-wide functions. The expansion of the Douala urbanized area has been achieved largely through an uncoordinated programme of land use management based on internal filling up of aquatic undeveloped terrain and the absorption of rural settlements. It is indeed common to find such areas having large concentration of people who have to cope with the inadequacies and problems of poorly managed environments in the Douala area. The Mabanda, Ondobo and Bonandale localities in the Bonaberi district present such poor physical locations with difficult terrain conditions.

The Douala lagoon complex located north of the city into the Bonasama-bonaberi districts cover an area of 85sq. km and the marginal areas are colonised by mangrove forest swamps where human settlement continue to encroach. The high magnitude runoff from the River Wouri estuarine system into the land-water interface all years round ensure that the water table remain high and thus effect constant inundation of the heavily encroached marginal depressions, with severe consequence of environmental deterioration. Flooding is a major consequence of this scenario exhibited by the dynamism of the River Wouri estuarine system on the Douala metropolitan area. The Cameroon coastal lowlands of the Douala region is characterised by low lying geomorphic features with faint slopes almost at sea level. Though the newly built up areas of Bonammousadi, Makepe and Logpom are about 50km away from the Atlantic Ocean, it is just over 16 metres above sea level, while the rapidly growing districts of the metropolis, like Bonaberi which includes Mabanda, Ndobo are between 3-7 metres above sea level. The runoff from the Wouri River into the lagoon system account for the bulk of the flooding menace the Douala area is subjected to annually at the peak of the wet season. The low lying nature of the city provoking floods is observed in the general lack of flowing drains in the core built up areas like Akwa, resulting in stagnant water due to constantly high water table which has a further consequence of increasing high rate of subsidence and tilting of residential housing

structures, particularly along the lagoon environment. This is pronounced where poor reclamation has been employed in increasing land availability using domestic and timber industry wastes on the loose sandy deposits of the lagoon margins. This frequently inundated hazardous area, which offer spaces for the development of spontaneous settlements of slum nature now suffer subsidence of residential housing structures. This study revealed that over 75% of residential buildings along the lagoon fronts of marginal depressions that have been poorly reclaimed now experience varying degrees of subsidence in the Mabanda and Bonandale localities of Bonaberi to the north and the Youpwe locality to the south of Douala. Figure 2 here show the lagoon margin where residential buildings undergo perennial flooding and inundation.

Figure 2: Residential building at the lagoon margin

7. ENVIRONMENTAL DETERIORATION OF THE DOUALA MARINE AND COASTAL SPACE

Environmental degradation of coastal areas continues to receive heightened focus worldwide, since this zone accounts for the bulk of global human population. The advancement of technological, investment and financial development is occasioned by need to enhance global energy sources for economic development. Crude oil is the world's single most important source of enhanced global energy source for now and this trend is expected to continue for quite a while. The implication is that modern industrialization depends on crude oil and its products. It has been suggested that on a daily basis people now use over 4,000 oil-derived products for routine hygiene, health and socio-economic pursuits.

Cameroon is a crude oil producer of an economic scale and runs a state owned refinery in the coastal city of Limbe with proximity to the oil rich area of Ndian division in the southwestern part of the country. Douala is however the energy utilisation centre since it has the largest concentration of industries and serves as the depot for processed or refined oil products which powers the nation economy. The utilisation of these products within the designated industrial zones and illegal locations for such activities has made the proper discharge of effluents resulting from production processes a serious environmental problem to the teeming human population of Douala. With over 70% of the industries in Cameroon located in the Douala metropolitan area, petroleum products effluents have become an integral part of the state of the environment. Petroleum products effluents are generally any processes or unprocessed liquid, viscous and gaseous evacuation of agricultural and industrial constituents that contain petroleum input into the environment. These effluents are discharged during processing, transportation and utilisation as hydraulic fluids, solvents, fertilizers, sludge etc into the predominantly aquatic terrain of Douala. They all end up in this coastal environment of Douala that is very sensitive to deterioration, particularly of the aquatic terrain leading to contamination and eventual pollution of surface water with consequent health hazards to the people. These different sources of petroleum effluents including agricultural such as fertilizers, chemical or industrial, contain enormous quantities of contaminants ranging from hydrocarbons to trace metals. Some of these trace metals include; zinc, copper, cadmium, lead, mercury, nickel, vanadium, phenol, cyanide, arsenic etc. Table 1 below presents common petroleum products and their utilisation in the Douala area.

Table1: Petroleum products and their utilisation
(Source: Fieldwork, 2006)

PRODUCTS	UTILISATION
Natural gas	Power engines and raw material for plastics production
Gasoline	Power motorized engines and raw materials for plastics
Diesel	Power automobiles, engines
Ethanol	Solvent used in manufacturing paints, cosmetics and dyes
Residue	Processed into fuels, candle wax, greases and asphalts
Petroleum gas:	- **Butane:** Used for making chemicals and fuel for industrial heating - **Ethanol:** Used for making chemicals and fuel for industrial heating - **Propane:** Used for making chemicals and fuel for industrial heating - **Kerosene:** Low energy flash fuel for domestic use - **Naptha:** Making plastics, automobile and engine fuel and chemicals - **Bitumen:** Road construction.

The sources and quantity of effluents generated over the terrestrial environment of the Douala metropolitan area was minimal at the early stages of industrial development during the seventies. The locations of the designated industrial zones of Bassa and Bonaberi districts afforded easy draining of generated effluents into streams, rivers and eventually into the Atlantic Ocean. The streams and the Rivers Wouri and Dibamba were therefore very effective in removing the wastes from the immediate terrestrial environment occupied by the human population. However, with the phenomenal increase in population, rapid urbanization, industrialization and agricultural expansion especially in the third world countries, which concentrate these various aspects in one urban centre, it is obvious that humanity's continued generation of the effluents will continue to pose degradation problems. In the Douala area these effluents end up in water bodies from city drains, spillways, into the land-water interface of the lagoon complex, with resultant damage to aquatic life, contamination of surface water for human consumption, crops and livestock.

The Douala metropolitan area as the economic hub of the Republic of Cameroon has grown with the concept of industrial agglomeration where maximum benefits are optimised by deliberate Government policy. Presently, the Douala area has two designated industrial zones namely the Bassa and the Bonaberi industrial zones. These two zones account for the bulk of industrial activities in the country, but however depict contrasting features in terms of physical landscape. While the Bassa industrial zone evolved on well drained landscape, the Bonaberi industrial zone evolved almost entirely on the aquatic terrain of the lagoon marginal depressions necessitating extensive land reclamation to obtain firm on which industrial had to be built. Furthermore while the Bassa area terminated into the estuarine-creek formation of the Dibamba River to the east of the city, the Bonaberi industrial zone complex has encroached into the lagoon itself. It becomes clearly evident that this situation most likely provoked increased discharge of effluents into the Bonaberi districts and as the fastest growing district in the Douala metropolis in terms of population density and spatial extent, the consequences becomes of disaster magnitude.

A survey of industries within the Douala metropolitan area involved in petroleum products effluents discharge into the lagoon show that contamination and eventual pollution of the

aquatic media has reached advanced degradation state. Table 2 below show a number of manufacturing and marketing companies whose operation contributes significantly in the environmental deterioration and degradation in the Douala marine and coastal space.

Table 2: Producers of petroleum products effluents in Douala
(Source: Fieldwork, 2006)

COMPANY	PRODUCT	CONTAMINANT
CIAC and PLASTICAM	Producers of plastic buckets, paints and tyres	Hydrocarbons, Tubes,
SAPCAM	Paint production	Combustible fuel oils
CONFITEX	Textiles	Acid waste oils
TOTALFINAELF	Crude oil exploitation and marketing oil products	Hydrocarbons and lead (Pb)
SCDP	Oil products storage and distribution	Oil dumps (contains lead, Arsenic, copper etc.)
SHELL/TEXACO	Aviation, petrol, diesel fuel and wax	Hydrocarbons, lead, cadmium, copper, zinc and other trace metals
CEP/Chemicals	Paints, detergents, vanish	Acid mercury, copper, lead, phosphates, trace metals etc.

The government of the Republic of Cameroon has over time particularly since becoming a member of the United Nations Organisation at independence in 1960 has always enacted legislations for the protection and management of the environment. This has come mainly through international conventions, multilateral and bilateral agreements especially when the developed countries are coming in to invest in Cameroon. The Crude oil exploration and exploitation industry, which is carried out in the coastal zone, significantly contributed to the legal framework and requirement in handling petroleum effluents discharge, accidental discharge of oil spills, blowouts, protection of aquatic terrain for socio-economic activities of fishing etc. The Ministry of Mines, Water and Energy Resources in the Republic of Cameroon is the supervisory authority of government in the legislation on petroleum effluent discharge into the marine and coastal space of Douala. The Cameroon legal code has a law relating to safe and proper discharge of petroleum effluents into the Marine and Coastal space of Douala, in recognition of the city's physical landscape and status as the economic centre of the country. The law no 96/12 of 5th August 1996 states clearly the enforcement of safe practice in the discharge of effluents in the land and aquatic ecosystems of the Douala marine and coastal space under the supervision of the Ministry of Mines, Water and Energy Resources. In recognition of the unavoidability of some of the contaminants getting into the lagoon through the drainage systems, which started as a safe way of getting rid of them in the first place, the law permits high values of concentration of zinc (5mgl). This as expected has continuously been flouted with greater content of discharge as well as uncontrolled effluent discharge into the lagoon system. This increases viscosity forming solid oil aggregates, which now cover extensive portions of the land-water interface at the lagoon margins where population is rapidly growing. These aggregates distort the penetration of solar radiation to the lagoon bottom thus inhibiting the growth of plankton and other micro life forms for increased fish production for the socio-economic pursuits of the people in this locality. These aggregates are in form of petroleum

lumps and tar balls on surface water and display light grey, brown or black sticky lumps with varying sizes. The surface serves as a substrate for developing bacteria, unicellular algae and other harmful microorganisms. The presence of green algae and a host of other organisms, which proliferate due to decomposition of the effluents on the lagoon waters, are indicators of heavily contaminated water not safe for human consumption due to its impaired quality.

8. CONCLUSION

Perhaps the greatest force that has influenced the Douala marine and coastal space is the rapid urbanization imposed on the metropolitan area due to its function as the economic centre of the Republic of Cameroon. This force on it lies primarily in the policies and actions of the government to concentrate most of the projects for socio-economic development in the Douala area, which thus attract increased population. Therefore the competition for land in this largely aquatic terrain adds more to intensify the concomitant problems associated with rapid urbanization resulting in fast degradation of the Douala environment. This paper has heightened awareness of the adverse consequences in the Douala marine and coastal space and hereby calls for urgent strategies at reverting this trend. It would be noted that from the foregoing account, that the process of rapid urbanization must have to be put under some control in order that the existing Douala metropolis may be better managed and that the quality of both its immediate and area wide environments may be preserved. The paper calls for such controls that can best be achieved through well though out land use planning which involves institutional, legal and high technological inputs. The continued undue demands on the limited land resources in the Douala coastal lagoon area necessitates a detailed mapping procedure within a technical framework that would classify stable and unstable lands imposed by the character of the area. Detailed Geographical Information System (GIS) will provide archival data on both the land and water space from which pollution hot spots from manufacturing industries could be easily monitored and controlled, effects on fish catch, impaired water quality can be controlled from time to time. It becomes clear that the ecological system of the Douala metropolitan area will be better understood and thus enhance sustainable management strategies. This is in view of preserving and maintaining environmental quality while permitting the intensive use of the lagoon system.

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