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The Dynamism between Urbanization, Coastal Water Resources and Human Health: A Case Study of Douala, Cameroon

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Abstract
Current statistics show that more than half of the world's population now lives in urban areas (Lederbogen et al., 2011) with approximately 50 percent living within 200 km of the coast (Alcala & Russ, 2006). Nowadays, the increasing proportion of people in "coastal-urban" areas is undoubtedly an eminent challenge not just in specific countries but to the world at large (Le et al., 2013). Therefore, profound studies are needed in order to understand the dynamics within the "coastal-urban" space such that resources are deployed in a sustainable manner. This work, based on administrative consultations and field reconnaissance, therefore, portrays the changing dynamics between urbanization, coastal water resources and their related impacts on human health. It posits that, the fast degradation of the Douala coastal water resources due to urbanization, attest the gaps in current urban-public policies. Moreover, the degradation of the biophysical milieu has shouldered with waterborne diseases such as diarrhea, cholera, dysentery etc. As such, for a sustainable coastal environment to be attained, timely endeavours encompassing all stakeholders are needed to clearly circumscribe the challenges, and address them with state-of-the-art policies.
Keywords: Urbanization, Coastal water resources, Human health, Douala, Cameroon

1 Introduction

Coastal zones are convergent hot spots for human settlement since they are rich in resources. However, the increasing concentration of people in these areas has come with costs. For instance, a surge in pollution from ships and oil platforms, industrial pollution, inundations as due sea level rise and climate change, overfishing and problems of domestic waste management among others (Brown, 2014). According to Nicholls et al. (2007) rapid population growth, coupled with the increasing demand for coastal resources exert additional harmful effects on coastal ecosystems. The degradation of the coastal ecosystems is more noticeable in poor countries with limited technology rather than rich nations. This disparity is also affirmed by the prevalence of diseases on the coastal stretch of many developing nations when compared to developed countries (Elliott, 2012). The challenge for policy/decision makers and coastal resource managers is therefore to find to a balance between rapid urbanization, coastal ecosystem health and anthropogenic well-being. Therefore, focusing on human actions is essential to achieving such a balance and hence, gear towards environmental sustainability.

This paper, therefore, seeks to address the link between urbanization, coastal water resources degradation and their retroactions on human health in Douala, Cameroon. Nowadays, the progressive degradation of the coastal water resources of Cameroon comprises one of the main ecological challenges. Despite the mounting public apprehension and growing political rhetoric, most endeavours have been relatively unproductive in dealing with this challenge. The coastal morphology of Douala is altering at a fast rate and as the population rises, so does the impending threat to its fragile coastal ecosystems. Nefarious impacts of urbanization on coastal water resources have become problematic to the government of Cameroon. Moreover, the degradation of the biophysical milieu has shouldered with waterborne diseases such as diarrhea, cholera, dysentery etc. Without updating/reformulating and adequately implementing strategic urban policies, this destruction will continue to deplete the limited coastal resources. Douala, the economic capital and chief seaport of Cameroon, is the industrial pivot of the country. This coastal city handles over 80 percent of the country's commercial and industrial activities (Eyong, 2003). Douala is the most urbanized coastal city in Cameroon with

an estimated population of 2,000,000 inhabitants[1]. The fast growing nature of the city, coupled with poor management strategies, has meant that there is increasing pressure on its coastal resources. There is, therefore, a need for future long lasting solutions to reverse or mitigate the prevailing condition.

2 Brief literature review

2.1 Population growth and industrialization

Trends in population growth can shape the array or plan of an urban area. According to Alexandratos & Bruinsma, (2012), the global urban population will grow to 4.9 billion by 2030 while the world's rural population is expected to decrease by some 28 million between 2005 and 2030. The study also reveals that the urban population of Africa and Asia is expected to double between 2000 and 2030. Most disquieting of all is the fact that the urban population is concentrated primarily in coastal areas (Cao, 2010). These huge statistical changes in urban population growth coupled with their subsequent socioeconomic impacts upon education, health care, transportation, sanitation, and physical security, amongst many others, will likely result to uncontrolled urban growth, a glaring portent of sprawl. The rapid population growth of coastal areas does not tend to produce many socioeconomic benefits, but will exert more pressure on the environment and will subsequently increase the burden of policy makers. The availability of information and analysis on how population growth can perpetuate coastal planning are essential to understand these challenges. Therefore, policy options that can pave the way for a comprehensible balance between urbanization, environmental sustainability and economic growth are needed (Makropoulos et al., 2008).

The establishment of industry in a given area is normally an indicator of population concentration. Coastal areas are blessed with enormous resources and so serve as lucrative areas for industrial installations. Once the industries are set, there is an inevitable inflow of workers, which, in turn, necessitates residential development. With time, the roads start radiating from the industries to link areas of demand as well as areas of supply. It is evident that the development of industry during the industrial revolution had no strategic, pre-written plan, but was an uncontrolled outgrowth of industrialization from one place to another, and as such had many negative environmental and social impacts. In China, urbanization is caused mainly by industrialization, the growth of population, the practice of the policy of regulation and optimization of Industrial Structures (Chan, 2010). Ngoran (2014) points out that the industrialization of coastal cities blended with rapid urbanization in China had had a nefarious impact on agricultural land. Though industrial development in coastal cities has contributed to the economic prowess of many countries, it has also produced controversial results, and therefore, it is imperative that timely and adequate socioeconomic and environmental studies are needed.

2.2 The Implication of Urbanization

Uncontrolled or unplanned urbanization mounts a lot of pressure on the coastal ecosystems and thereby exerting a deleterious effect on them (Hinrichsen 2013). Continuous occupancy of more coastal land (reclamation) for habitation result to deforestation (Kausher, et al., 1996; Das, 2015), shrinking of coastal farmland size (Long et al., 2009), alteration, and fragmentation of species habitats (Cicin-Sain & Belfiore, 2005; Didham et al., 2007) and might alter the biogeochemical cycle of such an ecosystem if not timely addressed. Recourse of integrated coastal management (ICM) might, therefore, offer a plethora of possibilities on how nefarious anthropogenic activities on the span of the coastal ecosystem could be addressed in order to achieve sustainability. ICM is more appropriate here as it involves a holistic management approach that adequately handles human activities that fall within different sectors.

The more spontaneous habitat on the coast tends to substitute wetlands, breeding grounds for aquatic organisms and even farmlands (Salm et al., 2000; Ngoran, 2014). It is predicted that the United State will consume 7 million acres of farmland, 7 million acres of environmentally sensitive land, and 5 million acres of other kind of land by 2025 as a result of unprecedented urban expansion (Pijanowski & Robinson, 2011). The loss of agricultural land to urbanization means not only the loss of fresh local food sources, but also the loss of habitat and species diversity, since farms include plant and animal habitat in woodlots and hedges.

Urbanization is cited as major a factor in air pollution (Gong et al., 2011), since the car-dependent lifestyle leads to increased fossil fuel consumption and emission of greenhouse gases (Finkelstein, 2004; Cervero & Murakami, 2010). Urbanization contributes to poorer air quality by encouraging more automobile use, thereby adding more air pollutants, such as carbon monoxide, carbon dioxide, ground-level ozone, sulfur dioxide, nitrogen oxides, volatile organic carbons, and microscopic particles (Frumkin, 2002). These pollutants can inhibit plant growth, create smog and acid rain, contribute to global warming, and cause serious human health problems. Apparently, it seems that low-density urban growth or sprawl can provide better environmental condition and fresh air, but Bhatta (2010) found out that urban air pollution progresses despite sprawl. Increased

[1] Institut National de la Statistique Cameroun 2010 population

temperature in urban areas also has indirect effects on air pollution. As the temperature rises, so does the demand for energy to power fans, air coolers, water coolers, and air conditioners; all requiring power plants to increase their output. The majority of power plants burns fossil fuels, so increased demand of power in summer results in higher emissions of the pollutants they generate, including carbon dioxide, particulate matter, sulfur oxides, nitrogen oxides, and air toxics. These in turn increase the social costs (Figure 1).

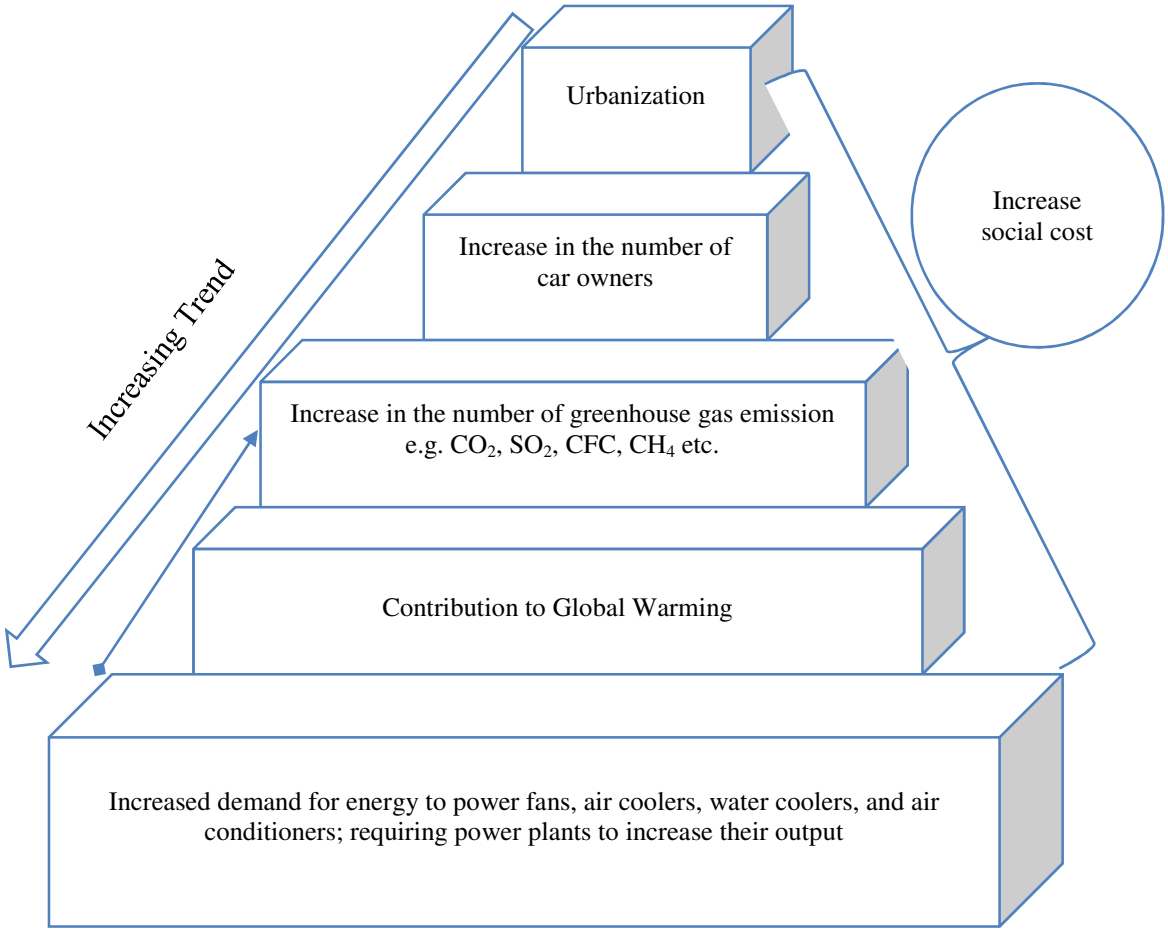


Figure 1: Impact of Urbanization on Social Cost.

Urbanization has a damaging effect on both the quality and quantity of water. Urbanization is accompanied by more impermeable man-made surfaces, such as concrete and tarmac, and is impermeable; therefore, rivers in urban drainage basins tend to have short lag[1] times due to higher amounts of surface runoff and drainage systems taking water into rivers quickly (Gumbo, 2011). So urban areas located in flood prone areas are at increased risk of floods, as well as inundation and erosion (Douglas et al., 2008). As new developments continue on the periphery of the existing urban landscape, the public, the government, planners, and insurance companies are more and more concerned with flooding disasters and increased damage due to floods (Jonkman et al., 2008). In urban areas, water runs off into storm sewers and ultimately into rivers and lakes. Extra water during heavy rain can dramatically increase the rate of flow through wetlands and rivers, stripping vegetation and destroying habitats along river banks. It can also cause damaging floods downstream and lead to an increase in water pollution from runoff contaminated with lawn and garden chemicals, motor oil, and road salt. Widely dispersed development requires more pavements that can cause more urban runoff that pollutes waterways (Sun et al., 2013). These pollutants can be absorbed by humans when they eat contaminated fish from affected water-bodies and when they drink from contaminated surface water or groundwater sources. In addition, heavy rainstorms occurring in cities and towns with inadequate systems for managing storm water can cause untreated human sewage to enter waterways (combined sewer overflow).

[1] Lag time is the time from the center of mass of excess rainfall to the hydrograph peak. Lag time is also referred to as basin lag (http://www.dnr.state.mn.us/water/hydroterms.html. Accessed: 06/01/2014).

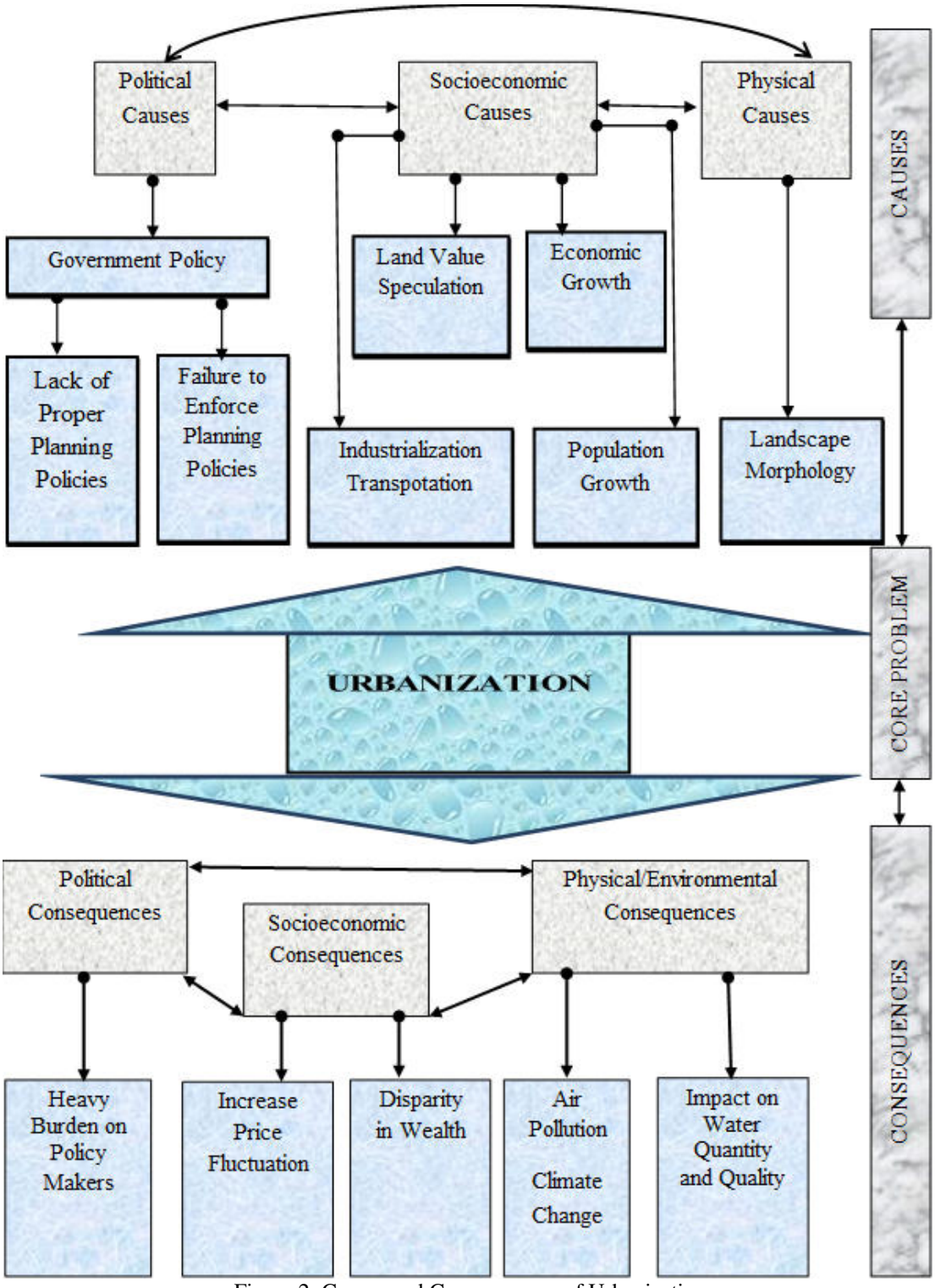


Figure 2: Causes and Consequences of Urbanization

3 Causes of urbanization in Douala, Cameroon

This section tackles the causes of urbanization within the Douala coast and it does so by observing three different eras: the pre-colonial, the colonial, and the post-colonial.

3.1 The pre-colonial era

The pre-colonial era within the Cameroonian coast is the period before 1884, that is, before the colonization of Cameroon. Before the year 1884, the terminology, "urbanization" did not exist. However, this period is still vital as it depicts man's perception of the environment. Before 1884, the population of Douala was less than a

hundred thousand and with limited technology, the Douala inhabitants were subjected to live in harmony with the natural environment. The deterministic theory[1] (Environmental Theory) is strongly affirmed during this era.

3.2 The colonial era

The colonial era spans from 1884 to 1960. The colonial period could further be divided into two; the period in which Cameroon was under the German colonial rule (1884-1916), and the period under the British and French influence (1916-1961 and 1916-1960, respectively). This span of time is very significant because it sets the stage and orientation of Cameroon's coastal development. The colonial masters played an eminent role in setting up schools, construction of roads, railways, establishing plantations, and industries, and most importantly the construction of the seaport and an airport. All the existing opportunities created by the colonial masters acted as pull factors that contributed in shaping up the coast of Douala.

3.3 The post-colonial era

This depicts the era from 1960 onwards and paints a clear picture on the evolution of urbanization in Douala and Cameroon at large. This section tallies on national factors that have spearheaded urbanization as well as the role orchestrated by international factors. The theory of possiblism[2] well affirmed decades after independence.

3.3.1 Structural Adjustment Program and Economic Instability

Cameroon was hit by economic crises from the year 1987. The inability of the State to put in place an immediate economic problem solving mechanism aggravated the situation. The ultimate recourse to this economic hazard was the adhesion to the Structural Adjustment Program (SAP) proposed by the Bretton Woods Institutions[3] (Ngoran, 2014). Under the SAP, the State withdrew from agricultural subvention intervening organs, such as the National Board for Marketing of Basic Commodities (ONCPB) and Unions of Agricultural Cooperatives (UCO) (van der Laan et al., 1990). This led to the closing up of State subvention intervening organs in the agricultural sector. This crisis amplified rural-exodus as living conditions became precarious in nearby rural areas due to the high costs incurred in producing export-led produce (cocoa, coffee, rubber, tea, etc.) and a relatively low profit margin in return (Ngoran, 2014). Once in this urban space, the migrants were compelled to undertake agricultural practice due to limited employment opportunities existing in the formal and informal sectors. Continuity of agriculture could only be favorable at the periphery of the urban space and as time went by, there was a quest for shelter, which resulted in an unprecedented and unplanned nature of houses in major receiving areas like Douala city.

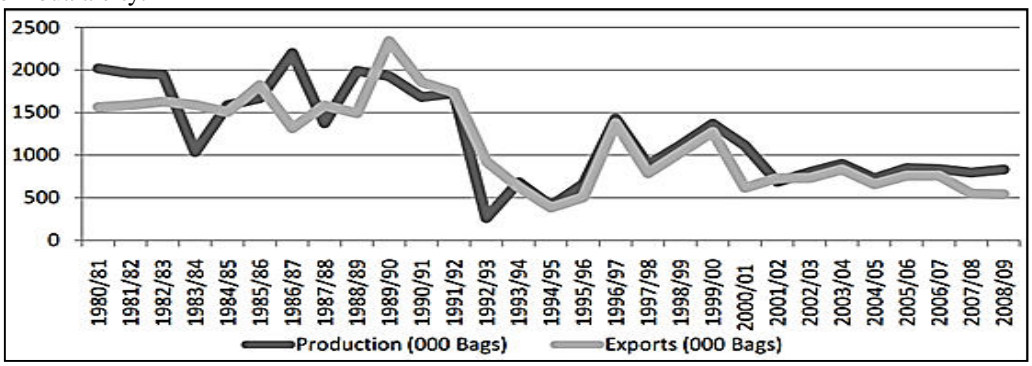


Figure 3: Coffee Production and Exports (000 Bags) 1970-2009
Source: National Board for marketing of Basic Commodities (ONCPB)

Another reason that explains urban expansion in Douala is the retrenchment of works from the public service. The civil service reforms of the early 1990's exacerbated the economic hardship in Cameroon. Many civil servants were laid-off[4] and some had their salaries sliced by 2/3 (Baye, 1998). Under such economic depressions,

[1] Environmental Determinism is also known as climatic or geographical determinism. It holds the view that the physical environment, rather than social conditions, determines culture (*Sluyter* and *Andrew,* 2003).

[2] This idea was proposed by a French geographer Paul vidal de la Blache. According to him, nature or the environment does not dominate on man as postulated by Alexandre Von Humbolt of the determinist school of thought but he postulated that nature offers possibilities and opportunities to man, from nature then; man uses his culture and level of technology to exploit nature. Possibilism affirms that man can dominate the environment by influencing the natural barriers to suit his taste. Human technologies and cultures have allowed man to rule and control whenever they are barriers to his activities. Man therefore has always modified the environment conveniently to suit his method operation.

[3] The World Bank and its sister organization, the International Monetary Fund, were created at Bretton Woods New Hampshire in 1944. Together they are referred to as the Bretton Woods Institutions or BWIs.

[4] Official documentation on the consequences of the economic crises on labour and employment projected the layoff of 30.000 workers in all sectors of the public service and state enterprises. By voluntary or forced departures, the numbers of public service workers declined from 188.200 in 1990 to 155.210 in May 1995. During the same period, the total amount of wages passed from 300 billion francs to 190 billion francs CFA annually.

many civil servants could neither afford the money to buy a nice plot of land, nor could build a good house due rise in the cost of building materials (Moyo, 2009).

The devaluation of the FCFA[1] (Franc Communauté Financière Africaine) in 1994 further worsened life in this urban setting leading to generalized poverty (Adepoju, 1994). Shortly after its implementation (devaluation) imported goods became twice as expensive prior to the period before, further handicapping or weakening the purchasing power of residents. This prompted many dwellers to put up a quick residential structure as the last resort. Retrenchment of civil servants and the devaluation of the FCFA, have all favoured horizontal extension of the city rather than vertical rise. This form of urban extension should be discouraged as the negative effects on the environment are ginormous.

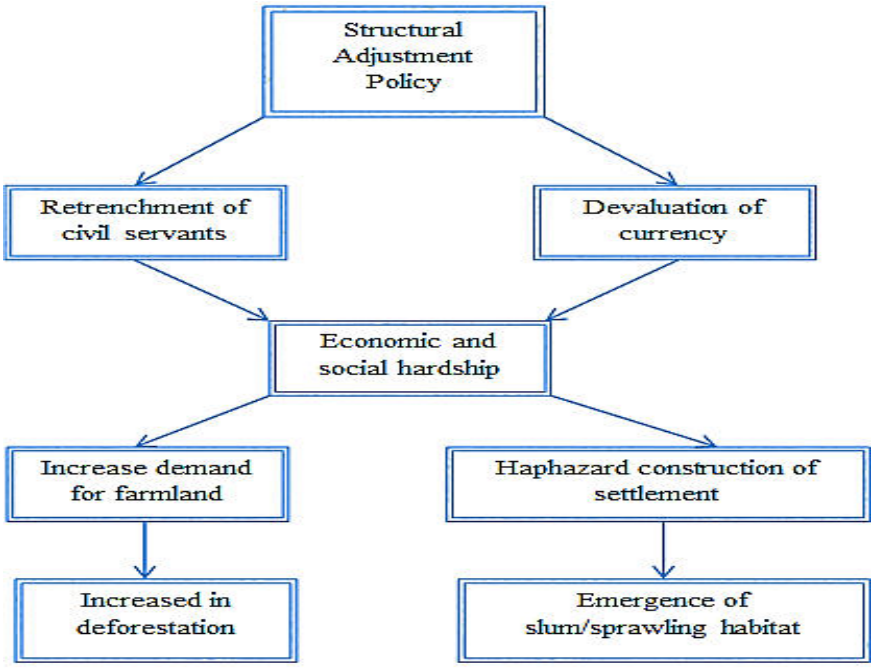


Figure 4: Structural Adjustment Policy as a Contributing Factor to Urban Extension

3.3.2 Government Policy

Government policy in Cameroon has acted as a pull factor to population concentration by favouring urban development over rural development. The government of Cameroon over decades has been channeling a larger share of the budgets toward improvement in two major cities, Douala and Yaoundé. This has, however, oriented migratory tendencies toward these major cities. The following reasons elucidate why Douala has been an attractive spot and why the city, especially its littoral zone is a show-case of rapid urbanization.

Population Growth

Douala being a primate city[2] performs purely urban functions, such as administrative, economic, religious, and cultural centres from the early contacts with Western Europe. Douala has continued to grow at a fast pace to accommodate large human population increases resulting from 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 program 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 a 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.

Beside natural population growth, the government policy of providing family allowances to state employees has also impacted population growth positively, but the rapid growth in Douala's population has not been commensurate with the available resources at hand. The latter is a glaring example of the Malthusian theory[3] of population growth. Contradictorily, according to Ester Boserup[4], it would have been expected that

[1] The FCFA is the name of two currencies used in Africa which are guaranteed by the French treasury. The two FCFA currencies are the West African CFA franc and the Central African CFA Franc.
[2] A primate city is the leading city in its country or region, disproportionately larger than any others in the urban hierarchy
[3] In the 18th century Malthus wrote that the rate of population growth was faster than the rate that food supplies could grow and with time, there would not be enough resources for everyone.
[4] Boserup opposes the Malthus' theory by postulating that necessity is the mother of invention. That is, if there is crisis, someone will invent the solution

more invention be made to give Douala the face it deserves, but a necessity in the domain of environmental protection has rather been the mother of destruction. The population of Doula has swelled from 800,000 inhabitants in 1987 to more than 2000,000 inhabitants today (Table 2).

The rapid growth of the Douala population also created a demand for housing that the state and municipalities are not able to meet. Thus, the private sector has become the dominant player in the field. Many of the existing housing facilities are self-made with precarious and unhealthy conditions and are generally occupied by vulnerable populations. These dwellings are built either in valleys or in the low marshy or waterlogged areas. It is generally realized that most of the constructions on risk prone areas are largely linked to lengthy bureaucracy and the lax nature of city management authorities.

Table 1: Repartition of Population by Sub-Divisions-Douala

Division	Subdivisions	Population		Growth Rate	Projection	
		1987	1998		2005	2015
Wouri	Douala 1	154369	236330	3,94	309899	456420
	Douala 2	152304	246800	4,49	335543	520385
	Douala 3	323867	436869	3.32	583024	808222
	Douala 4	65431	189000	10,12	371211	973686
	Douala 5	130000	296647	7,79	501472	1061624
	Manoka	8500	20000	1,92	34475	28998

Source: Bucrep-Cameroon

Accessibility[1]

Accessibility, in terms of transport communication, plays a vital role in the structural layout of a city. Douala, the economic capital of Cameroon, is the most accessible city. The city opens to the Atlantic Ocean and it is served by the largest sea port of the country and the entire central Africa. The city is also blessed with the largest international airport of the country and a dense network of roads. The connectivity of the city does not only benefit nationals, but also the land logged population of countries, such as the Republic of Chad, Central African Republic, Gabon, and Congo.

Briefly, the SAP, government policy (centralization of socioeconomic activity, retrenchment of civil servants) poverty, and land tenure problems are the causative factors of the disproportionate form of settlements layout in Douala.

3.4 The Implication of Urbanization on the Coast of Douala

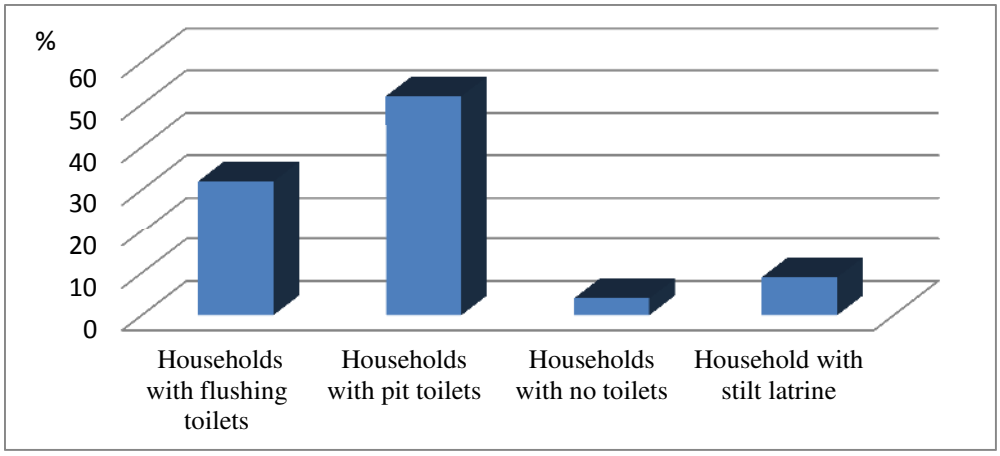
The rapidly expanding coastal population of Douala has exerted an ever-increasing pressure on coastal habitats and resources. Coastal activities, such as industry, agriculture, sand mining, coastal urbanization, deforestation, etc., change natural conditions and processes, degrading coastal resources and habitats. The effects have serious socioeconomic consequences.

3.4.1 Socioeconomic Implications

Health Implications

Like most economic capital cities in Sub-Saharan Africa, the sanitary situation in Douala is a cause for concern. A good proportion of the population does not have access to good toiletry systems and as a result, fecal deposits are discharged into the environment without proper treatment (Evans & Kantrowitz, 2002). The poor disposal of wastes into the environment has meant that the population is exposed to many diseases (Pimenta de Castro Fonseca, 2014). At most, 2% of the population is connected to a sewer system (Eneke et al., 2011); many existing sewers are probably non-operational, and there are non-functioning wastewater treatment facilities (Graph 4).

[1] Accessibility is the degree to which a product, device, service, or environment is available to as many people as possible



Graph 4: Sanitation Coverage in Seven Low-income Districts (2002)
Source: Guévart et al., 2006

Guévart et al. (2006) mentioned that fecal sludge management is completely unrestrained and chaotic, with dumping of sludge into open drains and that, in informal settlements, most households have very poor quality stilt latrines (latrines sur pilotis) over a shallow ditch; and when these ditches are dislodged, it is usually in an informal way. Takm et al. (2010) present detailed quantitative data on sanitation coverage in seven low-income districts (Bonoloka, Oyack, Brazzaville, Madagascar, Soboum, Newtown Airport and Tergal): on an average, 32% of households have flush toilets, 52% have pit latrines, 9% have stilt latrines, and 4% practice open defecation close to the house or in water courses. Newtown Airport and Madagascar are particularly poor settlements, in marshy sites and with around half of houses built from ply board. Cholera is endemic (Takem et al., 2010).

Plate 1: Poor Allocation an Unhygienic Toiletry Stations: A) Less than 100cm Toilet in Mabanda, B) Sewage Oozing from a Toilet in Bonaberi, C) and D) are Constructed Directly on a Swamp at Venice-Bonaberi

The socioeconomic status of a person is associated with a number of factors that lead to the prevalence of diseases and human exposure to such diseases. The coastal population of Douala is prone to several diseases of which water borne-diseases are the most frequent (Fogwe & Ndifor, 2010). These diseases include malaria, diarrhoea, typhoid, dysentery, and cholera, and others (Banyouko Ndah, & Derrick Ngoran, 2012). It is evident from Plate 1 that the prevailing conditions are highly conducive to disease proliferation.

As observed in the field, those living in swampy areas were mostly low income earners and were the ones highly exposed to disease vectors. Swampy or marshy areas coupled with the warm climate of Douala are all unifying factors for the repartition of pathogens, such as Plasmodium (*Plasmodium vivax*, *Plasmodium oral* and *Plasmodium falcipalrium*), *Vibrio cholerea*, and thousands of bacteria. Malaria among other microbial diseases is very rampant in Douala, and accounts for more than 85% of the infectious disease incidence among coastal dwellers (Fogwe & Ndifor, 2010) (Figure 5).

Figure 5: Exposure to Disease Vectors, such as Mosquitoes

There is a direct link between spontaneous urbanization and the rate of disease exposure in Douala. Results from field work clearly demonstrate that low income earners inhabit near risk prone zones like swamps, whereas high income earners avoid such areas. This disparity in location is best explained by variation in land value; that is, lower in zones exposed to floods and very high in flood-free zones. For example, most areas in quarters, such as Bonaberi, Mabanda, Bonamoussadi, Bonajo, Village, Kotto, Bobongo, and Ndogbong are characterized by shanty structures elevated on swamps (Figure 6).

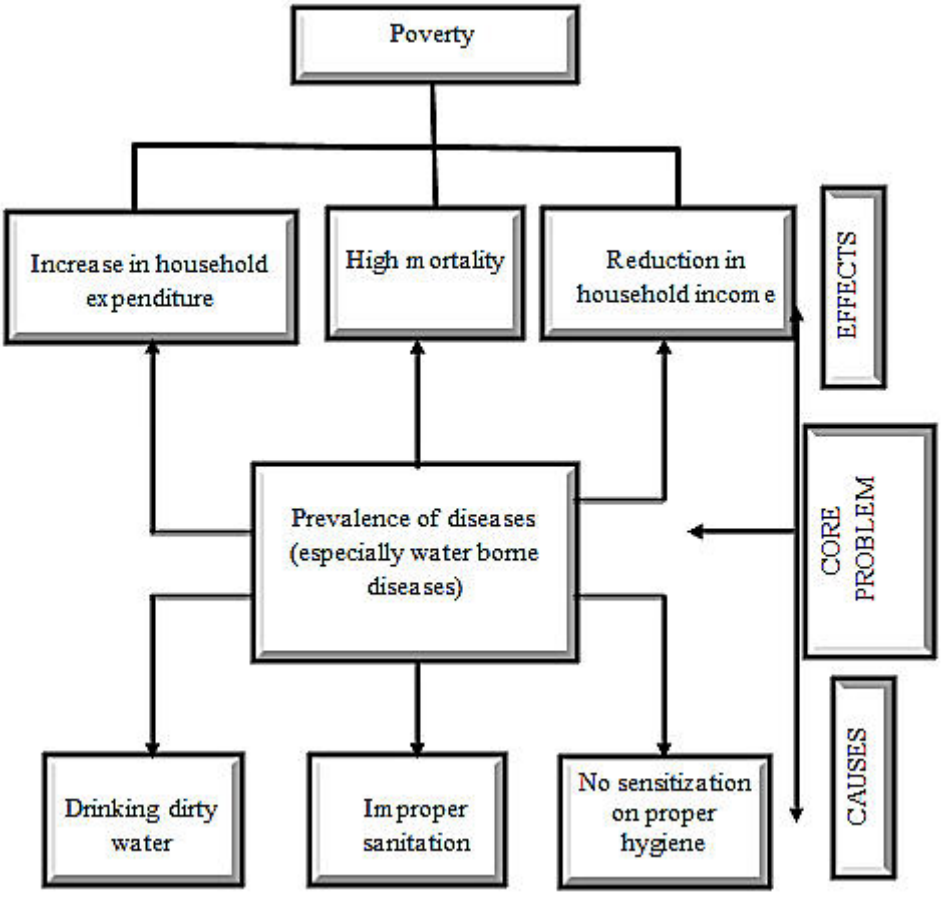


Figure 6: Problem Tree of Disease Prevalence

Implications on Education

The physical access to educational institutions is more difficult for poor households because the unplanned nature of the Douala coastal city. Poor households have more school access problems than non-poor households as a result of their less favourable practical circumstances. These access problems have an impact on the educational success of children from poor households (Plate 2).

Plate 2: Difficult Accessibility Due to Poor Planning

3.4.2 Environmental Implications

Intense anthropogenic activities have long been considered as significant drivers of coastal degradation. Douala is the city of concern by the national leaders in the management of its ecosystem because of important exchanges that it provides. This is mainly attributed to the presence of seaport in the town that increases the influx of people to the urban zone. The overpopulation of Douala involves important pressures on the availability of fresh water resources as well as marine resources.

Effects on Fresh Water

Uncoordinated urbanization compounded by poor waste management has contributed significantly to the deterioration of the water quality in Douala. Some industries operating in Douala discharge untreated effluents directly into canals, streams, and rivers that end up causing widespread deterioration in the water quality and the health of the coastal ecosystem. Domestic sewage and other wastes, as well as coastal and upstream non-point-sources of pollution from agricultural and hazardous waste sites constitute sources of contamination of both surface and groundwater sources (Plate 3).

Plate 3: Poorly Disposed Household Wastes Lingering on the Road

Water quality degradation is generally associated with health problems because of the presence of pathogens and other microorganisms as well as nitrates in excess and persistent organic micro-pollutants, etc. It is clear, that human interference on the coast of Douala induces huge disturbances with large impacts to the environment.

Agriculture constitutes one of the sources of income, especially in the periphery of Douala and its growth has led to the excess use of nutrients, pesticides, and other herbicides and organo-chlorine substances, including certain forms of POPS. Pig farming is an activity gaining importance in Douala (Plate 4). Pig waste is rich in nutrient, such as nitrogen and phosphorous. Pig waste also demands high biological oxygen demand (BOD) as well as is a source of human pathogens and parasites (Adeyemi & Adeyemo, 2007). Many of the piggeries are located in swamps and their wastes are intentionally washed directly into the adjacent streams. All surface water is discharged directly into marine water bodies and has the potential to adversely impact marine environments. In addition to the direct discharge of pig wastes into surface waters, the drainage of fields during precipitation contaminates surface waters as animal wastes are never treated. The socioeconomic impacts of untreated and poorly disposed wastes are enormous.

Plate 4: Animal Husbandry in Douala

Effects on Sea Water Resources

The gradual physical deterioration of coastal habitats, including critical wetlands in the coast of Douala, is causing the loss of spawning and breeding grounds for most species in coastal waters and resulting in the loss of a variety of once rich fauna and flora. Coastal geomorphological change, erosion, and sedimentation have been identified as having a significant and progressive adverse impact in Douala. Undoubtedly, unplanned human settlements are a major contributor to increasing coastal degradation in the Douala coastal environments.

Effects on Mangrove

The increase demand of mangrove as fuel wood and building material is gradually impacting the dynamics of marine habitats. Wanton cutting of mangrove and poor land-use practices result in increased coastal erosion in Douala (Plate 5). The loss of mangrove at the Douala estuary was estimated to be 24.29% in 2009 (Nfotabong-Atheull & Dahdouh-Guebas, 2013).

Plate 5: Wonton Cutting of Mangrove for Fuel Wood: A) Bonassama and B) Pont Noir

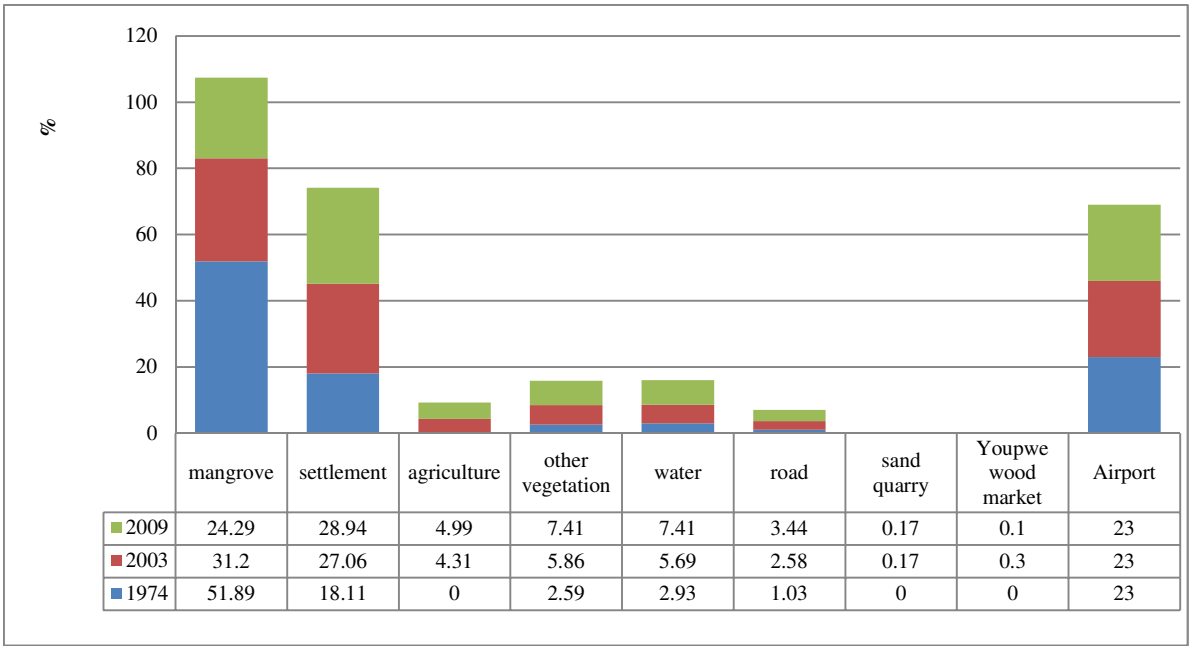
Moreover, the extension of the Douala sea port, the expansion of the Bonabéri industrial area, new drills at the river mouth and the extraction of sand (Plate 6), creating villages and fishing camps, adversely impact on the mangrove ecosystem (Feka & Manzano, 2008). These anthropogenic activities alter the structure and texture of the alluvial deposits, and therefore, severely limit the natural regeneration of mangroves.

Plate 6: Sand Mining Boanassama Beach-Douala

Sedimentation or siltation is among the pertubating factors along the coastal stretch of Douala. Sedimentation is the accumulation of sediment (clay, gravel, silt, sand, etc.) in a river, lake, or other marine environment (Owens, et al., 2005). Mostly, artificial sedimentation has a damaging effect on the health of mangrove trees. Artificial sedimentation is mostly orchestrated by improper waste disposal from either domestic households or industrial wastes, reckless logging and mining operations, and poorly built and maintained roads (Ngoran, 2014). On an average, mangrove forests worldwide retain a natural level of sedimentation at a rate of 0.5 to 1 cm per year. Anything above this rate is considered to be an unnatural rate of sedimentation (Armstrong et al., 2010). Sedimentation becomes harmful to mangroves when portions of their roots become buried. When this occurs, there is less gaseous exchange between the roots and the water that surrounds them, thereby lessening the ability of the aquatic vegetation to respire and thus preventing an important physiological process. In addition, excess sediment inhibits adequate light from reaching the mangrove roots (Krauss, et al., 2008). Sedimentation above the accepted threshold on the coast greatly disturbs the life cycle of marine animals and more especially those that survive brackish medium.

Plate 7: The Impact of Sedimentation on the Mangrove Ecosystem, Mabanda-Douala

In 2009, mangroves on the Cameroonian coast represented 24.29%, which decreased to 22.10% in 2003. For the overall 35-year period from 1974 to 2009, the decrease in mangrove cover had been 53.16%. In 1974, settlements covered 18.11%, whereas in 2009, settlements extended to 28.94% with an increase of 60% over the 35-year period (Nfotabong-Atheull & Dahdouh-Guebas, 2013). The increase in areas occupied by water, road, agricultural land, sand quarry, wood market, and other vegetation types is shown in Graph 1.



	mangrove	settlement	agriculture	other vegetation	water	road	sand quarry	Youpwe wood market	Airport
2009	24.29	28.94	4.99	7.41	7.41	3.44	0.17	0.1	23
2003	31.2	27.06	4.31	5.86	5.69	2.58	0.17	0.3	23
1974	51.89	18.11	0	2.59	2.93	1.03	0	0	23

Graph 2: Land Use and Cover Changes from 1974, 2003 and 2009 of Douala (Cameroon) Peri-urban Setting

4 Conclusions

This study, "The Dynamism between Urbanization, Coastal Water Resources and Human Health: A Case Study of Douala, Cameroon", portrays some understanding of Cameroon's general background and the data gaps in relevant information and literature. The urban outlook of Douala has been typified and the engendering factors of urbanization and its resultant socioeconomic and biophysical impediments have been elucidated. The research emphasizes that inadequate policy implementation and weak law enforcement in Douala are hot issues to be addressed if negative effects of urbanization are to be curtailed. Although there is a master plan of Douala, it is archaic and its implementation has not been satisfactory; the result has been unauthorized and disorganized urban development and above all environmental degradation, lack of basic amenities within and around urban areas. Human health on its part will improve if the biophysical milieu is well taken of. This necessitates the involvement of all stakeholders and more especially the government

The outcome of the research also maintains that at the intersection of high birth rate and spontaneous urbanization, the sectoral approach of the government in handling environmental issues on one hand, and poverty alleviation strategies on the other hand, has been counter-productive. Therefore, there is need to change the traditional approach which cannot meet up the present exigencies.

In order to bridge the conflicting gap perpetuated by sectoral management in Cameroon, the following key points need to be taken into consideration when drawing up urban management plans in an effort to attenuate the environmental consequences of urbanization in a coastal city like Douala:

1. The decentralization of political power and relocalisation of industries from Douala to other regions in the country. This will go a long ways at curbing the trend of rural exodus.
2. There is need for flexible and low coast housing mechanisms that meet the housing need for an average Cameroonian.
3. The archaic master plan should be reviewed and updated such that it meets the objectives of sustainable urban housing[1]. To achieve sustainable housing, there is a need to provide community facilities, compact design, pedestrian friendly design, eco-efficient houses, etc.
4. There is need for a zonation[2] scheme of the urban landscape in order to minimize conflict of functions.
5. Government institutions and the media should ensure that the population understands that they are both victims as well as contributors of environmental problems.

[1] Sustainability is defined as a global process that also tries to help create an enduring future where environmental and social factors are considered simultaneously with economic factors (Newman, 2002, p. 1). He also defines what sustainability will mean for housing: 1. Ensuring there is a 'roof overhead' for the housing disadvantaged, 2. Ensuring housing is more eco-efficient, and 3. Ensuring housing is well located or is part of a project to improve locational amenity (Newman, 2002, p. 1).

[2] Zoning is a system of land use regulation which designates the permitted uses of land based on mapped zones, which separate one part of the community from another. Theoretically, its primary purpose is to segregate uses that are thought to be incompatible. In practice, zoning is used as a permitting system to prevent new development from harming existing residents or businesses. Zoning is commonly controlled by local governments such as counties or municipalities.

6. Architects, urban planners, and engineers need to cooperate in order to develop projects that not only fulfill its objectives in terms of urban reduction, but also consider other needs of local communities and the urban poor.
7. This has been dismal in the current planning practices since these are normally static master plans or development plans mostly addressing land use. These plans are also less equipped to review and evaluate any policy decisions dynamically so as to visualize the potential implications of a policy directive and also the regions of potential sprawl. Further, planners need to be informed of possible areas of sprawl to take corrective actions to mitigate the implications. In this regard, there is a need for a deeper understanding of urban sprawl phenomenon, capturing the dynamics and modelling it in order to visualize, review, and evaluate various policy options.
8. There is need for a change of mentality of the Douala inhabitants towards an awareness that the environment has its carrying capacity and when overstretched could lead to devastation in an undesirable manner. The time to re-plan and reshape the urban spatial structures of Douala is now if this city is to evade greater environmental problems.

Given that this work does address all issues related to urbanization along the coastline of Douala, it is solicited that further research be carried out in the domain for better understanding of the problems and their plausible solutions. This work at best does not give vivid answers to trends of urbanization and this is because of the difficulties in the acquisition of Landsat maps, data on the surface areas of Douala with respect to different periods, etc.

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