NATURAL AND ANTHROPOGENIC CHARACTERISTICS OF THE CAMEROON COASTAL ZONE

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Abstract

This presentation gives an illustrative view of the coastal and marine environment characteristics of Cameroon (Latitudes $2°20^{1}$ – $4° 40^{1}$) located within the Gulf of Guinea, in terms of natural factors and anthropogenic influences. The approach in the methodology used for the work consisted of field and desk data collection; collection of information from existing reports and other documents; desk study and development of various products from existing information. Bimonthly samplings of 4 days each were carried out within the 3 main strata (Kribi- open ocean ecosystem; Douala- an estuarine ecosystem and Limbe- a mixed system.) of the coastal and marine zone of Cameroon. Within each of these ecosystems, observations and photographs were made. These and other illustrations gave the natural characteristics and anthropogenic influences to confirm what was seen in terms of the physical Characteristics; continental shelf; wind conditions ;climate ; precipitation ; rivers and how sea level rise is influenced by temperature, salinity variations, current patterns. Other economic activities along the coast are illustrated. All these will meet up with the need to develop various products from the coastal and marine zones of Cameroon; as expressed by most scientists, students, researchers, economic and other operators including private sectors operating here.

1. **Introduction**

Cameroon's coastal and marine environment is located within the Gulf of Guinea (GOG) Large Marine ecosystem (Figure 1).

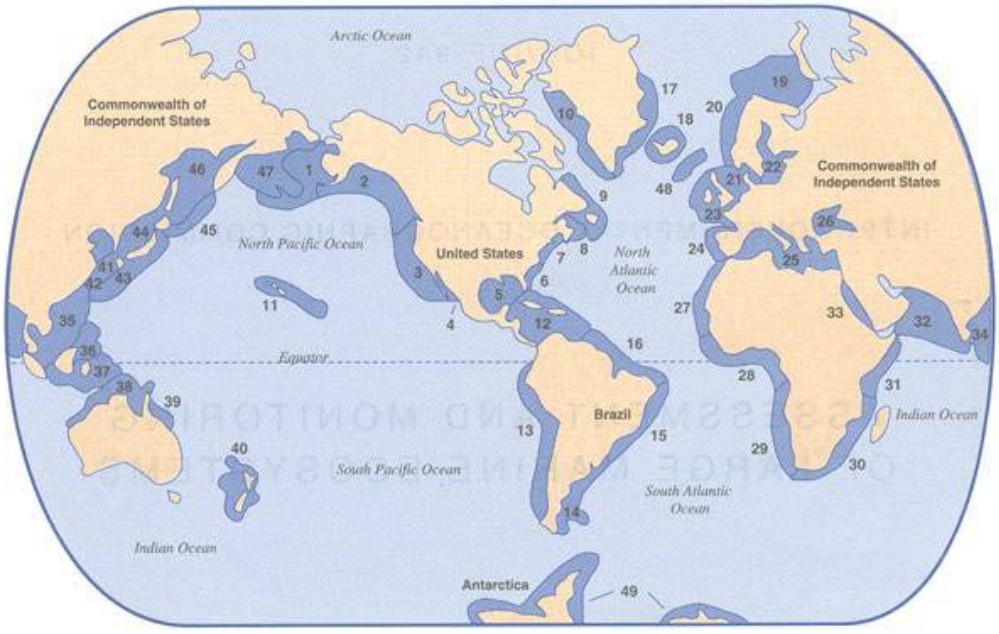

Figure 1. Gulf of Guinea large marine ecosystem (28) within the world map of large marine ecosystems

The GOG shelf lies strictly in the Equatorial north Latitudes 0°N and longitudes 8°W to 12°E with a total coastline of 1360 nautical miles (Awosika and Ibe, 1998). Within this coastal and marine ecosystem, operate several socio – economic activities such as fisheries, offshore and onshore oil exploitation, industrial, port and agricultural activities; sand and mineral resources exploitation. These anthropogenic characteristics exists in line with dynamics in natural futures of the zone such as natural disasters, hydrodynamics, winds, ocean waves etc to determine the state and characteristics of the coastal and marine environment. These have resulted in very productive ecosystems when considered from a global perspective, with much prospects for socio-economic development.

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2. Objectives

This presentation gives an illustrative view of the coastal and marine environment characteristics of Cameroon (Latitudes $2°20^{1}$ – $4°\ 40^{1}$) located within the Gulf of Guinea, in terms of natural factors and anthropogenic influences.

The need to develop various products from the coastal and marine zones of Cameroon has been expressed by most scientists, students, researchers, economic and other operators including private sectors operating here. There is the need for well documented characteristics of the coastal and marine zone.

3. Methodology

Site: Cameroon's coastal and marine aquatic ecosystems
Duration : Two months

Equipment & field materials:

- Existing fish identification/taxonomic field guides on coastal zone characteristics
- Camera

- Field note books and writing materials

Field personnel : 3 Field Scientists and 3 Technicians

Experimental design:

The approach in the methodology used for the work consisted of:

- Field and desk data collection,
- Collection of information from existing reports and other documents,
- Desk study and development of various products from existing information

Bimonthly samplings of 4 days each were carried out within the 3 main strata (Kribi- open ocean ecosystem; Douala- an estuarine ecosystem and Limbe- a mixed system.) of the coastal and marine zone of Cameroon..

Within each of these ecosystems, observations were made on the natural and antropogenic characteristics (fishing, industries (agricultural and chemical) and other man made influences. Photographs and observations wee also made on the natural characteristics and anthropogenic influences to confirm what was seen.

This product development was geared towards meeting up with the needs for further studies of coastal and marine resources/areas with particular emphasis as a field guide and on physical processes that most influence the coastal and marine resources, contributing to its sustainable management.. The possible beneficiaries of this study include, among others, port services, coastal engineering, fisheries services, coastal management, scientific research and students.

Methodology of study

A review on literature available in both Government and Non-Government organisations, Libraries along Cameroon's coastal and Marine Environment, the capital cities of Yaounde (administrative and Douala (economic) was made to gain background knowledge on the natural and anthropogenic influences.

Field studies were carried out at target points along Cameroon's coastal and marine environment from Campo beach at the borders with Equatorial Guinea (Latitudes 2°201 N) to the Extreme western point (Latitudes 4° 40^1 N) at Bakassi Island at the borders with Nigeria for a duration of 1 month continuously.

Field data and information acquisition came from direct observations, photographs, structured and semi – structured interviews and literature. The natural factors covered consisted of the

physical characteristics, continental shelf, wind conditions climate, precipitation, hydrology, sea level rise, temperature, salinity variations and current patterns. The anthropogenic influences were determined through visits to existing structures and locations of economic based activities.

4. Cameroon's coastal and Marine Environment

Figure 2: Hydrological net work of the Republic of Cameroon

The Republic of Cameroon (Figure 2) is one of the Central African countries located at the centre of the Gulf of Guinea, within the Bay of Biafra. It has an area of 475, 412km^2 with a population of approximately 15 millions inhabitants (year 2000 estimate).

The coastal environment of Cameroon (Figure 3) is opened to the Atlantic Ocean with a coastline of about 402km (Sayer et al, 1992). This coastline extends from 2° 20' N at the Equatorial Guinea borders to 4° 40' N at the Nigeria borders. it is located between Longitudes 8°15^1 E and 9° 30E.

The coastline here is defined as the area extends from low tide mark to 60 km hinterland and to 200 nautical mile limits offshore. The continental shelf is about 10.600km^2 with an Exclusive Economic zone (EEZ) of about 15,400km^2. All aquatic ecosystems of this coastal plain of the Atlantic are covered within these limits, notably: ocean, coastal forests, deltas, sand dunes, mangroves, coastal rivers, estuaries, bays, lakes, beaches muddy coasts. The total drainage river basin is about 2.7 x 10^5 km^2 with the Sanaga contributing the highest sediment load (2.8 x 10^2 km^3 / year) .

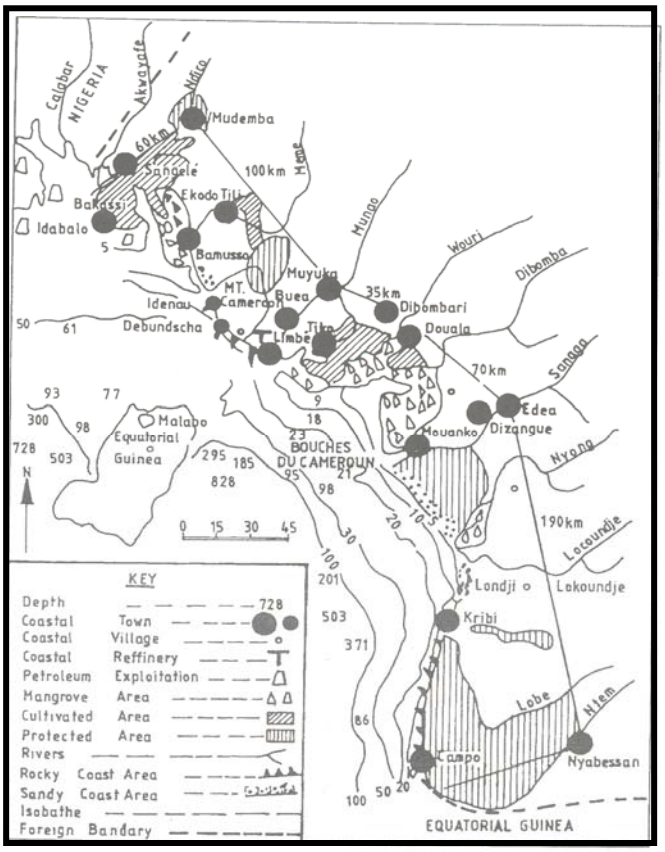


Figure 3: The limitation of Cameroon coastal and marine environments

The limits of the coastal environment starts from the high tide mark up to 60km inland. The continental limit is illustrated by a hypothetical line drawn from the north to the south which passes through : Mundemba, Muyuka, Dibombari, Edea and Nyambessan. This line passes through the national provinces of South – West, Littoral and South.

5. Physical Characteristics

5.1 Climate and oceanographic conditions.

5.1.1 Climate

The coastal climate in Cameroon, just as in the rest of the Gulf of Guinea, is influenced by the meteorological equator, which is the meeting point between the anticyclone of Azores (North Atlantic) and that of Saint Helen (South Atlantic). This climate results from the combined effect of convergence of the tropical oceanic low pressure zone and the inter-tropical front within the continent. Along the coast, rainfall intensity increases from south to north.

Recorded values show average annual rainfall of 3,000 mm in Kribi, 4,000 mm in Douala and more than 11,000 mm in Debundscha.

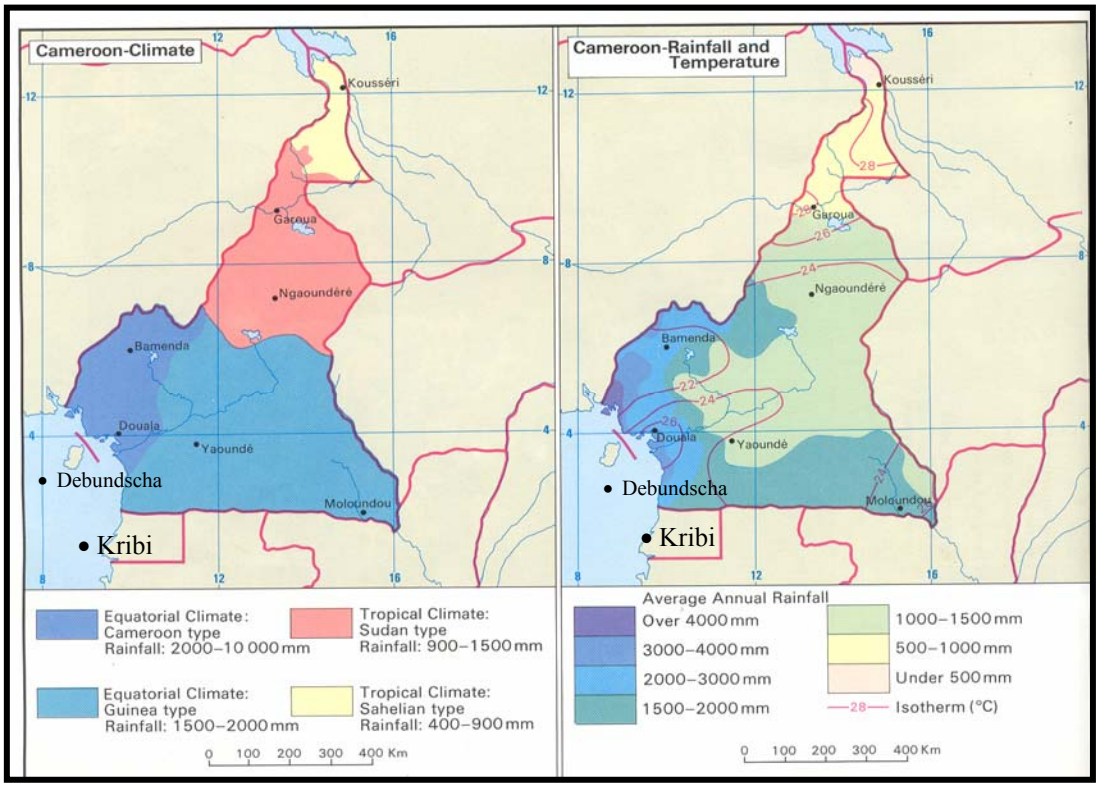


Figure 7: Cameroon climate: rainfall and temperature (Modified from Macmillian school atlas for Cameroon 1985)

There are two distinct seasons: a long rainy season of more than 8 months and a dry season which generally stretches from November to February. Air temperature is high throughout the year (above 25°C).

The coastal climate is also characterized by monsoon winds of the Guinea type, predominantly south-westerly. These winds cause humidity values to be almost always at saturation point. Wind speeds attain exceptional values of 18 m/s (April 1993). In general, average wind speeds recorded over period of 10years (1983 –1993) vary between 0.5 and 2 m/s.

5.1.2 Oceanographic conditions.

5.1.2.1 Water temperature and salinity

Cameroon coastal surface waters are warm throughout the year; unlike the coastal waters of other West African countries (Côte d'Ivoire, Ghana, Togo Benin etc) which are characterized by seasonal upwelling. Water temperatures remain always above 24°C. This warm water layer has a thickness of 20 to 30m (Crosnier, 1964) depending on the location and the

season. It overlies a less warm water layer whose temperature varies between 18 and 20°C. There is a thermocline between the two water layers which plays an important role in the dynamics of living organisms. Cameroon's coastal waters are generally characterized by low salinity due to high rainfall and a dense river network which supply freshwater. Lafond (1967) recorded peak salinity values of 20o/oo at 15 km from Douala port in the dry season and less than 12% in the rainy season.

5.1.2.2 Hydrodynamics

Tides on the Cameroon cost are of the semi – diurnal type. In general, the amplitude varies between 0.3 and 3m depending on the location. Their effects are felt in the estuarine complexes. The propagation of the waves and ebb-tides is enormous, but is poorly known. Olivery (1986), Morin et al. (1989) estimate them at 10 million cubic metres at River Dibamba and 50 at River Wouri in nature are tidal currents and are sometimes violent: 1 to 1.5 m/s for the flux and up to 2.6 m/s for the reflux. The river flow disturbs this already unstable system by submerging the estuarine complexes. According to observations made by Chaubert et al. (1977), sea swells are from the South to South west sector and of distant origin. Their peculiarity results from the double obstacle constituted by Bioko Island and the widening of the continental shelf at the level of Rio-del Rey.

5.1.2.3 Continental Shelf

Cameroon's continental shelf (Figure 3) has a gradual descend from the coastline to 30, 50 and 100m depths (Morin et al, 1989 ; Zogning et al 1984 ; Boye et al 1974). The northern end of the shelf extends for approximately 25 nautical miles with the Southern being straight extending for an average of 15 nautical miles. In terms of relief, there are two districts zones, separated at the Lokondje river estuary . In the north, the gradient is low, with a drop to 130m depth. This zone is rocky with an interference of sandy layers. At the northern end of the Sanaga estuary are rocky layers, with a series of mounds around the islands of Macias Nguema (Bioko-Equatorial Guinea). This area of the coast is favourable for trawling (Industrial fisheries) (Crosnier, 1964)

5.2 Coastal Characteristics

5.2.1 Campo to Mouth of River Nyong

The coast is high and shows an alternation of rocky outcrops and sandy mud. The main rivers are: Ntem (Picture 1), Lobe, Kienke, Lokoundje and Nyong. Their discharges are low and they transport little allusion towards the sea. Mangroves are slightly represented; when present, they are in the form of patches on rocky substrate, this is comparable to situation described by Villiers (1973) along the Gabonese coast. On the continent, the vegetation is made up of low altitude Atlantic forest, proceeding on the seaward side by patches of a few

Picture 1: Campo beach with immigration services of equatorial Guinea viewed on the opposite side of the river Ntem.

species of grass which grow on the beaches.

5.2.2. River Nyong to Limbe

The coast is low and is characterised by the presence of estuary and river mangroves, separated from the atlantic forest by a marshy complex of brackish waters. The rivers here are:

Dibamba (Picture 2), Wouri, Mungo and Sanaga. These waterways have high discharges (Table 1) and transport huge quantities of sediments towards the sea. The Mungo enters the sea through a delta which with the other rivers, form the Cameroon estuary. The creation of the Douala-Edea fauna reserve has been justified by the great faunal diversity of this area.

Picture 2: River Dibamba Viewed from the bridge (some mangroves and fishermen's campo visible)

5.2.3 Limbe to Idenau

The coast is volcanic and is overhung by Mount Cameroon with a peak at 4,095m at the level of Fako . This larval flow took place from the 25th march 1999 damages done to road infrastructure, Limbe Idenau with palm plantations and other village agricultural crops, Mountain forests, other diverse animal resources with destabilisation of existing ecosystems. the vegetation is made up of low altitude mountain forest rich in endemic species.It is characterised by lava flows and the industrial plantations of the Cameroon Development Corporation (CDC). These plantations presently cover more than 90,000 hectares. The Mabeta-Moliwe reserve is found here.

Table 1. Cameroon's coastal river systems and hydrological zones. (Angwe and Gabche, 1997)

Zone	Major rivers	Length (km)	Catchments (drainage area)	Sediment yield kg/year	Flow range (Annual mean) m 3/s	Total dissolve Solid TDS (mg/l)
1. West	Cross river	160	800	----	171-7.570	38.75
	Ndian	----		----	246	---
	Meme	----			300	---
	Mungo	150	2,420	- $1.0x10^9$	27-236	78.1
	Wouri	250	82,000		49 – 1,425	43.58
	Dibamba	150	2,400		49-1,425 480	43.58 28.4
2.Sanaga	- Sanaga	890	135,000	2,8 x109	500 – 5,700 (2000)	96.26
3. South	Nyong	800	14,000	----	25.7-367	19.1
	Lokoundje	185	---	----	(194)	
	Kienke	100	---	----	----	----
	Lobe	80	1,900	----	----	----
	Ntem	460	31,000	----	50-764 (288)	----

Picture 4: Blockage made to roads infrastructure at Bakingili on the way to Idenau during Lava flow of 1999

Picture 5: The Cameroon Development Corporation (CDC) palm plantation (left) Bota –Limbe

5.2.4 Idenau to the Nigerian border

The coast is once more low and marshy. This part of the coast is watered by the mouths of Rivers Akwayafe, Ndian, Lokete and Meme which together form the Rio-del-Rey estuary. The vegetation consists of mangroves and swampy species. In the hinterland, the atlantic forest includes the Korup rainforest National Park.

5.3. Geological aspects

5.3.1. Sedimentary basins.

The Cameroon coast includes three sedimentary basins of differing dimensions. These are the Campo-Kribi basin, the Douala basin and the Rio-del-Rey basin. The Campo-Kribi basin covers an area of 45km2 (1 to 3 km wide and 25 km long). It is situated north of River Ntem and its fossils give it great paleogeographic importance. The elevation varies between 30 and 100 m. the slope variations measured at sea are a reflection of the situation obtained on land. This can be explained by the existence of many recent faults parallel to the coast and rising several metres above the base. These faults are associated with the formation of the Congo basin, the Lobe waterfall , the Ntem and Bongola rapids.

Picture 6: Lobe River fall directly into the Atlantic ocean

The Douala - Rio-del-Rey basin stretches from latitudes 20 to 50 north. It is made up of two sub basins: the Douala basin in the east (7,000km2) and the Rio-del-Rey basin in the west (2,500km2). From south to north, one passes successively through symmetrical gomorphological settings on both sides of Mount Cameroon:

- The Sanaga delta
- The “bouches du Cameroun” or Cameroon Estuary (Picture 7)
- The volcanic horst proper
- The Rio-del-Rey and Cross River estuary
- The Niger delta

The Douala – Rio-del – Rey basin takes the shape of an isosceles triangle with its peak at Yabassi and its sides measuring 150km. The height of the triangle corresponds to the maximum width of the basin (50 to 60 km). The relief has preserved traces of destructive tectonic activities which carve out the base into steps. The 200 m isobath off Douala is at the same distance from the coast (40 km) as it is off Kribi-Campo. On the other hand, within the Rio-del-Rey basin, this isobath lies up to 80 km from the beach. The continental shelf in this area is twice as broad as it is in the south east of Mount Cameroon.

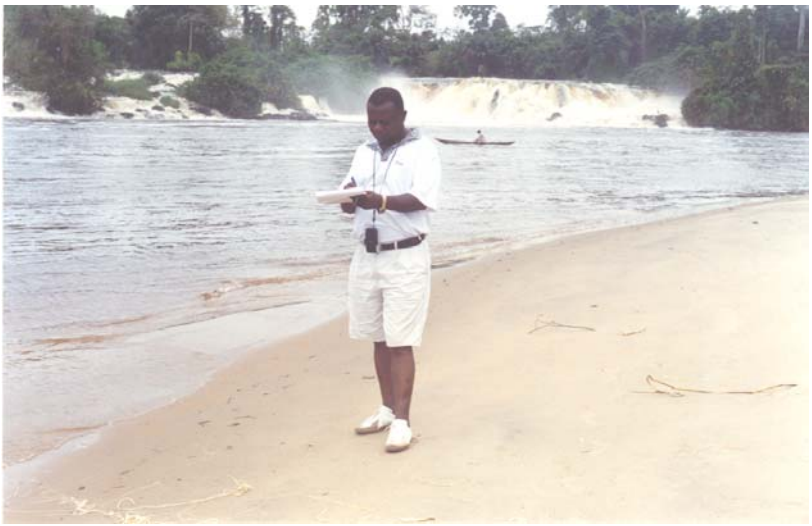
Picture 7: Cameroon Estuary

6. Coastal erosion

The action of waves, heavy rainfall and human activities have resulted in intense coastal erosion in Cameroon. This is common in the towns of Kribi, Limbe and Douala as shown in pictures 8, 9 and 10.

Picture 8: Beach in Kribi with the coconut trees facing the threats of coastal erosion

Picture 9: Sandy Beach of Grand Batanga with a view of the rocky falls of the Lobe directly into the sea.



Picture 10: Dr. Folack (at sandy beach) at the Lobe beach viewed form Grand Batanga

Picture 11: Kribi, rocky beach below the Lycée de Kribi (at sandy beach)

Is a zone with alternating sandy and rocky beaches (Picture 9). The withdrawal of the coast from the sea is quite significant at Mpala Kribi and Lycee de Kribi (Picture 10): with great impacts of coastal erosion on road infrastructure and building (hotels, living houses etc) . There is great need for their protection. Protective measures against erosion are common through the use of sand bags in Campo, concrete walls in Bota Limbe (Pictures 11,12 and 13)

Picture 12: Typical example of the withdrawal of the coast from the sea at Kribi - Lycee Sandy beach with pelagic fishing net and coconut trees facing risks of erosion.

Picture 13: Campo beach with sand bags / tyres used bags / tyres used as protective structures against erosion

Picture 14: Bota – Limbe beach with volcanic rocks infront of catholic eathedral with beach protection built opposite.

Picture 15: Bota – Limbe volcanic rocky beach opposite protective wall against erosion

The intensive sand mining within the mangroves(Pictures 15, 16 and 17) and rivers (e.g. Mungo) getting into the sea has contributed significantly to erosion and reduced the stabilization impact of the mangroves to the coastal zone.

Picture 16: Heaps of sand mined from the Cameroon estuary mangroves at Youpwe

Picture 17: Second sand mine of fine to large grained sand mined from the mangroves at Youpwe

Picture 18: Sand mine specialized in extracting yellowish and brownish fine grained sand in the mangroves

7. Dynamics of sedimentation

Sediment deposition leads to the creation of sandy offshore bars whose origin is either marine (effect of the Benguela and Gulf of Guinea currents) or volcanic (Mount Cameroon). The progression of offshore bars and sandy spits parallel to the coast (Souelaba Point (Figure 4)), and of various points between idenau and Bamusso is caused by:

- The predominance of the Benguela current over that of the Gulf of Guinea which flows from west to east.
- The low amplitude to tides (2 m on the average)
- The low charges of coarse detritus material in rivers which through a woody hinterland .

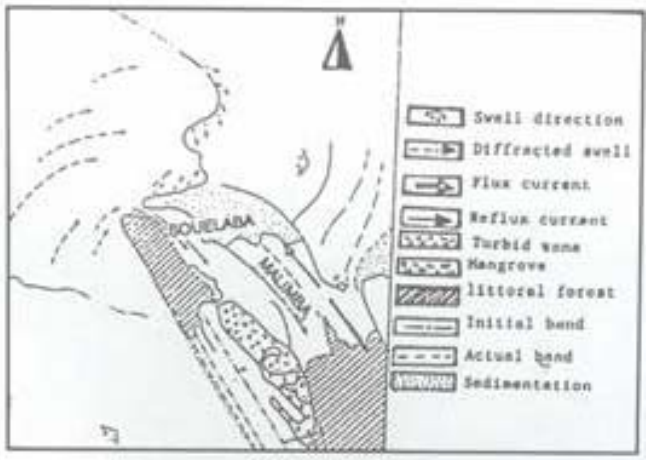


Figure 5: Evolution of the souelaba bar point

The edification of these coastal structures tends to regularise the coastal profile.

Erosion is significant along the volcanic coast of Cameroon. A displacement of the coastline towards the continent has been observed in the South West Province. The estuaries and mangroves are characterised by high turbidity, which extends right up to 30km into the sea from Bakassi. This phenomenon is also noticed in the estuaries of “Bouches du Cameroun”. The entire eastern part of the Rio –del-Rey basin is blocked by accumulations of mud and fine sand advancing southwards towards the River Meme. The evolution of the coast will also depend on the quantity and rate of deposition of alluvial material. Table 1 gives the discharge of the main rivers within the Cameroon coastal zone. If the discharge is high while the flow is slow, waves will easily disperse alluvium on the shores, thereby creating beaches. Between River Akwayafe and Limbe, the offshore currents can reverse direction, this phenomenon can either lead to enlargement of the beaches, or otherwise cause erosion like in the case of Bamusso. A presentation of erosion and sedimentation phenimenon along the coast is given in Figure 6. The portion of the coast between Kribi and Campo consists of crystalline rocks which appear sometimes as isolated outcrops in the sea (Picture 19). This rocky portion is characterised by the absence of significant deposits of sand and mud.

Picture 19: CDC Bota beach, Limbe with a view of Bota islands seen as an outcrop offshore

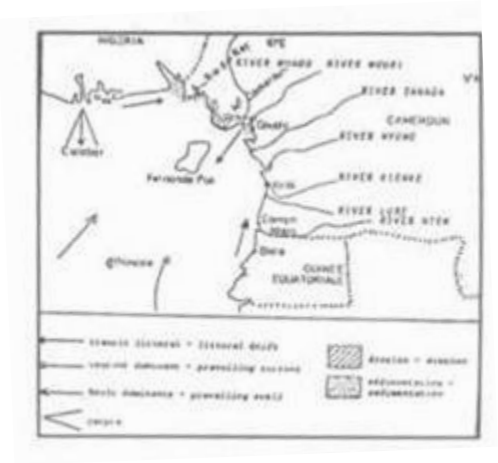


Figure 6: Erosion and sedimentation along the Cameroon Coastline

8. EFFECTS OF SEA LEVEL RISE AND RIVER DISCHARGE

Sea level rise will lead to different types of response from different coastal ecosystems. Some of the most important impacts that may be observed on the mangroves of the Cameroon Estuary are discussed below:

8.1 Erosion

Increased inundation and erosion are the two main mechanisms by which land can be lost as a result of sea level rise. In the Cameroon Estuary mangroves, the effects of inundation will be more important since the zone is largely dominated by muddy coasts. For this main reason, the Brunn Rule would not give an appropriate estimate of the effects of erosion.

Erosion due to sea level rise, though not a primary cause of land-loss within the study area, will have other important effects:

- Predicted sea level rise will lead to increased efficiency of wave erosion, with sediment removal from the upper part of the tidal spectrum and deposition in the lower part. This will destroy the few sandy beaches in the mangrove (e.g. Cap Cameroon, Kange fishing).
- Increased erosion would also result in removal of mangrove substrate above mean sea level and deposition offshore (Ellison, 1992) leading to a gradual retreat towards inland of the mangrove. As trees recede, more rapid erosion would occur resulting in the formation of small cliffs in the seaward front. In the case of the mangroves under study, inland migration would eventually lead to recession of the mangrove.

- Erosion along the seaward margin of the mangrove would also expose less productive anaerobic soils, leading to a better oxidized and more productive soil system.

Sedimentation

The mangroves environment receives large volumes of allochthonous sediments from inland rivers. If there is significant increase in rainfall patterns in the river catchment, vertical accretion of sediment will keep pace with predicted sea level rise. Tidal activity within the Cameroon Estuary will also affect sedimentation rates. Increased tital currents with expected sea level rise will therefore promote higher sedimentation rates in the mangrove zone.

8.2 Inundation

To asses land loss due to inundation the simple inundation model of IPCC was used. Taking into account the sea level change and the micro-topography of the mangrove, the mean water level mark corresponding to the selected sea level rise scenarios is shifted inland. The predicted land loss shown in figure 5.1 was evaluated for 2025, 2050 and 2100 time horizons using corresponding sea level rise values. Land loss is expected to vary between 4950 ha (4.5% of total area) for a sea level rise of 20cm, and 33,000 ha (30%) for a maximum sea level rise of 90cm.

8.3 Flood frequency.

The mangrove zone will be affected by increased flood frequency in the event of any rise in mean sea level. In general, any low – lying coastal area that faces permanent inundation will first experience an increase risk of flooding with sea level rise. With increasing sea level, more areas of the mangrove will be lost to inundation.

8.4. Salt Water Intrusion

The assessment of salt water intrusion in rivers and estuaries usually is a difficult task due to scarcity of data. Regression analysis performed on maximum salinity recorded at Japoma, in the River Dibamba, at about 35km to the estuary, projects up to 30% increase.

Present maximum value of salinity in the mangrove ranges between 17 and 19% in the dry season. With a projected sea level rise of 86cm in 2100, the intrusion of sea water in the mangrove could bring salinity to the high sea value (25%), corresponding to a 30% increase.

A decrease in rainfall would not affect this maximum possible salinity. In the case of increased rainfall the change will probaly be lower because of increased river discharge.

The Oude Essink model (1996) was used to assess the spatial extent of salt water intrusion in the River Wouri. When the model was run under present conditions, it gave a salt water wedge of 42km. This compared favorable with the observed value of 40km. In year 2100, the projected salt water wedge length will range from 39km (-2.6%), to 67.5km (+26%) as a result of an increase or a decrease in rainfall. (Table 5.1 and fig.5.2).

Table 6 : Projected length of salt water wedge in the Wouri River (km).

Time Horizon					
2025		**2050**		**2100**	
Rainfall change (%)	Length of Salt water wedge	Rainfall change (%)	Length of Salt water wedge	Rainfall change (%)	Length of Salt water wedge
+4.2	48.8 (+6.3%)	+8	44.8 (+3%)	+15	39.2 (-6%)
-3.2	56.9	-6	60.1 (18.3%)	-11	67.5 (+25.7%)

8.5. Bio-geochemical Implication and Pollution.

Most toxic metals (Hg, Pb, Cd, Zn, Cu, …) accumulate in mangrove sediments in the form of insoluble sulfides and are not bio-available (Harbinson, 1986). Oxidation of waters and sediments as a result of increased erosion due to sea level rise would dissociate these sulphides, releasing trace metals, and pose a threat to mangrove and other coastal food chains. This represents a considerable health risk through consumption of fish, shellfish and other resources harvested in the estuary . Observed concentrations remain low, compared to accepted levels (table 5.2)

Table 5.2. Levels of some heavy metals in some organisms in the Cameroon coastal zone

	Concentration of metal in mg/kg						
Metal Organism	Hg	Cd	Zn	Cu	Fe	Mn	References
Oyster	0.061	0.057					Mbome et al 1986
Shrimps	0.05	0.10					
Fish	104	1.1					
	0.12	0.03		2.8	0.50	0.50	
C. senegallus			1.03	2.20	8.72	0.16	Angwe, 1987

P. typus			2.25	0.39			
P. senegallensis			0.23	0.47			
P. elongatus			0.28	0.42			
E. fimbriata			0.26	0.32			
S. piscatorium			0.45				

Increase rainfall in will bring more nutrients and particulate material but also result in more agricultural pollutants (pesticides, herbicides, fertilizers) being carried into area from the large surrounding plantations (table 5.3).

Table 5.3 Mean levels of some organochlorine pesticides in some organisms in the Cameroon Estuary mangrove. (Source Mbome and Mbi 1991) ND = Not detected

Concentration of Pesticides (mg/kg)				
Substance Organism	Lindane	Aldrin	DDT	PCB
Fish	1.6	2.4	-	-
Prawns	98	ND	244	342
Oysters	1.44	1.71	113	209

9. NATURAL RESOURCES

9.1 Living resources.

9.1.1 Fisheries .

The exploitable species of the equatic fauna consist essentially of fishes, shrimps and molluscs. Their distribution has been described by Crosnier (1964) (Table 2). Several communities are exploited within Cameroon's coastal waters. *Nemato Palaemon hastatus* represent 16%, Pelagic 63%, Demersal 19% and Penaedes 2% of the exploitation. Their values are illustrated in figure 5. The diversity of exploited species explains the abundance of fishery resources. Fish of the Sciaenidae and clupeidae families are overexploited.

The same is true for some shrimps in the northern part of the coast. In the south, where the bottom of the sea is rocky, there are stocks of demersal fish and lobsters which are either not exploited or under –exploited. Besides these exploited species, Cameroon's coastal waters also contain zooplankon, consisting essentially of copepods which serve as food for fish.

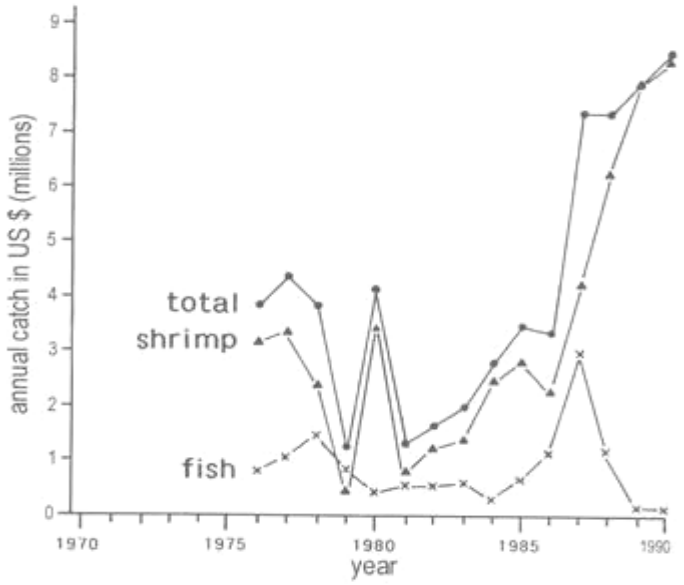


Figure 7: Monetary values (US$) for Cameroon's marine fisheries production (Source: Gabche et al, 2000)

9.1.2 Micro and macrophytes.

These are essentially phytoplankton, macro-algae and sea grasses. The phytoplankton is made up mainly of diatoms, dinoflagellates, cyanophycea. Very little study has been carried out in this area. The few works available include those of Folack (1988, 1989) relating to a study of phytoplankton distribution and phytoplankton pigments in the Kribi region, Valet (1973) on marine macro-algae, Valet (1975) on chlorophycea and Gutwinski (1906) on fresh water algae.

9.1.3 Mangroves.

Mangroves of the Cameroon coast still have enormous potentials, despite the destruction of about one third of their total area. They cover 2,700km2 (Valet, 1973) and serve several purposes:

- Shelter interesting endemic species of flora and fauna.

- Mangrove trees constitute excellent shelter for shrimps, molluscs and fishes, and substrate for periphyton consumed by animals.
- Aquaculture and eco-touristi sites.
- Nursery zone for fish and other aquatic animals

For this reason, mangroves can be used as experimentation areas fro the control of the dynamics of fish stocks.

The red mangrove trees which are the most widespread species in Cameroon (90% of mangrove area) have very interesting properties which make them very useful (fire wood, construction of canoes, paddles and houses, production of latex for conservation of nets, etc…). This species of wood can also be used for sculpture.

9.1.4 Coastal forest.

The various facies of the coastal forest have a rich and diversified flora. Along the Cameroon coast, the vegetation of the hinterland is forest. Depending on the location, this forest presents different aspects and varying biological diversity. According to letouzey (1985), the term “atlantic forest” includes biafran forest and coastal forest. In the southern part, there is a wet, green Atlantic forest with three stages (trees, shrubs and grass). It has many creepers (lianas) of which an inventory has just been made by the TROPENBOS programme in Kribi. The most characteristic tree species of this zone are *Lophira alata and saccoglotis gabonensis. T*here are several vegetable species, in particular Cesapliniacea. One can also mention the presence in this forest, between Campo and Kribi, of Octoknema dinklagei, which is an endemic Octokmatecea described by Villiers (1974). The low altitude wet, green forest contains more than 600 different species. There are other high value species present here, like *Cynometra hanke* and Cola *edulis.* In the coastal zone, there are many protected areas rich in biodiversity, but some of these areas are presently subjected to massive destruction. This is the case of the Campo and Edea- Douala reserves.

From Limbe to Idenau, there is a low altitude mountain forest, followed by the afro-mountain forest of Mount Cameroon where the following species can be found: Nuxia congesta (Longaniacea), Podocarpus latifolius (= *P. milanjianus*)- (*Podocarpacea*), *Rapanea* melanophoer (Myrtacea), Prunus africana (Rosacea). This last species is very much

exploited for its bark which has pharmaceutical value. Along the lava flow paths which descend righ to the coast, there is a vegetation made up of *Nephrolepis pumicicola, Arthropteris cameroonenis (*fairly abudant), Phymatosorus scolapendria and pityrogramma calomelanos. Apart from these, one observes the presence of Emila coccinea, Bulbophyllum spp., Polystachya spp. and a few shrubs less than 1.5m tall, all belonging to rapid growth taxons: Alchornea *cordifolia, Bridelia micrantha, Cecropia peltata, Ceiba Pentandra, Ficus exasperata, Musanga cecropiodes,* The northern part of the coast is an atlantic forest of the biafran district (Letouzey, 1985). In the Mabeta-Moliwe zone, meticulous inventories have been made. These inventories show that the Mabeta-Moliwe forest contains at least 24 strictly endemic species. Also found in this forest are certain Salacia identified only in the Korup reserve, and certain *Psychotria* reported in the Douala – Edea reserve. Table 3 presents some of the typical taxons of the Mabeta-Moliwe reserve. Other inventories carried out in the forest reserve of Mokoko river given more than 2,000 samples of plants among which Duncan (1994) also found many endemic species.

9.2. Mineral resources .

9.2.1 Minerals.

A study of the mineral potential of beach sands carried out by BRGM (Geological and Mining Research Bureau) in the 1960s revealed the existence of mineral deposits in Cameroon's coastal zone (Fig. 3). Ilmenite occurs at the Souelaba Point (maximum of 331,000 t with an average content of 4.6% by weight), and at Kribi – Londji (137,000 t at 7%). Olivine deposits are known to occur on the West Coast near Idenau. Two blocks of nepheline syenite located at Eboundja between Kribi and Campo (*Mont des Elephants)* could be exploited as raw material for ceramic and glass industrial, and even for the manufacture of alminium cement . There are sand and gravel deposits of which the most important is located at Manoka Island with the reserves estimated at over 200,000 t. The mamelles iron ore deposit south of Kribi is evaluated at 300 million tons with a Fe content of 30-45%. Limestone deposits are known to occur west of Mbanga, near the Mungo river and at Kompina. Mineral water sources are being exploited near Muyuka (South West Province) and at Tangui (Njombe) in the Littoral Province. Polymetallic nodules are alo reported on Cameroon's deep sea floor, but they have not yet been detaily evaluated for eventual Exploitation.

9.2.2. HYDROCARBONS AND NATURAL GAS.

Cameroon has three (3) coastal sedimentary basins : the Rio – del – Rey, the Douala and the Kribi- Campo basins. Hydrocarbons (liquid and gaseous) have been discovered and are being exploited in these basins. Natural gas also exists as Gas-caps and associated gas. While dry gas -caps remain unexploded, associated gas. While dry gas and gas-caps remain unexploded, associated gas is produced with liquid hydrocarbons (crude oil). The heavier portion of the gas is maintained with the crude oil and is later separated refining for the production of liquefied petroleum gas (LPG) for domestic use. The lighter portion of the gas separated during crude oil treatment on the production platforms is either re-injected into the wells to maintain production pressures or burnt . Several Companies operate in the area of petroleum exploitation in Cameroon (Fig.4).

10. SOCIO –ECONOMIC DIMENSION

Introduction.

The coastal zone runs through three provinces, namely the South, Littoral and South West. Table 4 presents the demographic picture of the Cameroon coast for the year 1987. This represents almost 15% of the total population of Cameroon. With the growth rate varying between 2 and 6%, this population was almost doubled in 1995.

Population of the Cameroon coastal zone in 1987 (According to the General population Census of 1987).

The coastal region is considered as the economic lung of Cameroon because it hosts about 70% of the economic activities of the entire country. Consequently, with respect to national averages, this region has less jobs in the primary sector and more in the secondary and tertiary sectors : 36.9% of the active population is engaged in the primary sector as against 71.9% for the whole country : 21.4% and 41.7% Work in the secondary and tertiary sectors respectively, as against 7.3% and 20.2% for the whole country.

10.1 Development Infrastructure

Most of the essential infrastructure is found in the coastal region : roads, ports, airports, telecommunication, schools, hospitals etc. however, a good portion of the coastal zone is occupied by mangroves and creeks, and thus remains enclave.

10.2. Coastal ports.

For port infrastructure, the following can be cited :

- The port of Douala is situated on the mouth of the River Wouri, 25 km from the sea, and this poses a problem of siltation, thus demanding constant dredging. It is essentially a commercial port which receives only vessels with little draught, considering its location on an estuary. The port has a 10 km wharf. Upstream, there is a banana port at Bonaberi, in the vicinity of which is located the industrial zone. The collectors carry all residual waters from the area into the river Wouri.

- The port of Kribi is essentially a secondary port whose main activity is exportation of timber. The deep sea port project for Grand Batanga (Kribi) has not yet been abandoned. The Chad – Cameroon pipeline project will involve the construction several crude oil storage tanks and filling stations.
- The Limbe port, which has been reactivated by SOCATHAI for the purpose of maritime transport, has undergone major improvements. The petroleum terminal at Cape Limbo has been extended and can now receive large tankers.
- The Tiko port which for a long time was used by CDC, and than abandoned, is currently being repaired and refurbished for timber exploitation purposes by Fako Timber Company. It must be noted that this port is located in a creek and is about 10 km from the sea.

Picture 20: Ship at Douala port with goods from abroad

Picture 21 : Dr. Jean Folack behind a crane offloading the ship in Douala

10.3. Fisheries

In the coastal zone, the most important occupation of the rural population is undoubtedly small-scale fishery. Fishery contributes more than half of the animal protein consumed in Cameroon; annual consumption per inhabitant being between 13.6 and 19kg and representing about 42.3% animal protein. This covers 9.5% of the total needs.

Table 5 presents the main economic characteristics of coastal fishery in Cameroon. The cash value of fishery output in 1993 was 5,400 million FCFA for industrial fishery and 16,700 million FCFA for artisanal maritime fishery. For the same period, shrimp export came up to

3,000 million FCFA. In addition, coastal fishery embodies certain socio-cultural values which need to be preserved for a sustainable and integrated development of the coastal population. Various institutions have been specifically assigned to manage the fishery sector in Cameroon, notably.

- Ministry of Livestock, Fisheries and Animal Husbandry (MINEPIA), responsible for conceiving and implementing government policy with respect to fisheries. This ministry has supervisory authority over the Maritime Artisanal Fishery Development Mission (MIDEPECAM) and the Maritime Fishery Development Fund (CPDM). These two organisations provide advisory and logistic support to fishermen.
- Ministry of Scientific and Technical Research (MINREST) which, through the Specialized Research Station for Fisheries and Marine Science (SRAD-RHSM), Limbe, is mandated to carry out research in the fishery sector. This Station is under the Institute of Agricultural Research for Development (IRAD).
- Ministry of Industrial and Commercial Development (MINDIC), which intervenes in the creation of all establishments engaged in the commercialization and processing of fish products.
- Ministry of Transport (MINTRANS) which, through the Department of Merchant Shipping controls all navigation operations, ensures safety at sea and matriculates fishing vessels and canoes.
- Ministry of Mines, Water Resources and Energy (MINMEE) whose clearance must be sought and obtained before creating a fishpond.
- Ministry of Defence (MINDEF), responsible for the surveillance of territorial waters.

10.3.1. Industrial Fishery

Industrial fishery is practiced beyond the three nautical mile zone. It employs about 510 persons, of whom 237 work on land and 270 off-shore. If one adds the retailers to this lot, the number of persons engaged in the sector can be estimated at 1,500. The means of production include fishing gears (trawl, lines) and fishing vessels. Presently, the industrial fishing fleet included 35 fishing vessels, of which 6 were trawlers and 29 shrimp fishing

vessels. The average engine strength of the boast increased from 430 hp to 940 hp between 1973 and 1991.

A peak output level of industrial fishery was attained in 198/82 with 49 vessels which captured 23,000 tons of fish. Since 1982, fish catch has continued to drop from 13,900tons in 1983/84, 11,400 tons in 1985/86 to between 10,000 and 6,000 tons in the period from 1986 to 1996. This drop in catch can be attributed to two main causes: the closure of Nigerian waters to Cameroonian fishing vessels and over – fishing of demersal species, especially the Sciaenidae family. At the moment, shrimp catch has reached a maximum of 1,000 tons per year. Daily catch was 4.55 tons between 1975 and 1979, and 2,05 tons between 1986 and 1990. This drop is partially explained by the over fishing of stocks, combined with the fact that most of the industrial fishing vessels are shrimp fishing vessels which use nets with small mesh sizes (33 mm, compared to 50mm for trawlers). This leads to destruction of juveniles.

10.3.2. Artisanal and semi-industrial fishery.

This is practiced within the three nautical mile zone. It is quite diversified with respect to fishing methods, ecological environment and social component. In 1995, there were 24, 136 fishermen, of whom 17.19% were Cameroonians, 77.89% Nigerians, 2.15% Beninois, while the rest were Ghanaians, Equato-guineans, Togolese, etc. This sector has been amply described by Folack and Njifonjou (1995). Fishing gears used are quite varied and are subject to frequent repairs (Picture . Various fishing techniques can be identified, which are associated with the different fishing gears. Artisanal fishery is carried out using canoes which may, or may not be motorized (Table 6)

Picture 22: Artisanal fishing plank built canoes at Down beach Limbe

Picture 23: Repairs of artisanal fishing nets at Yoyo II fishing camp, in the Sanaga maritime statistical fishing zone

Seet (1979) estimated the potential of pelagic stocks at a minimum of 40,000 tons/year, this would imply that artisanal and semi-industrial fishery which targets on those stocks, has virtually reached maximum sustainable yield (MSY). In Cameroon, artisanal and semi-industrial fishery target on two families: Sciaenidae and Clupeidae. If this trend is maintained, these two families may become extinct. Apart from these target species, artisanal coastal fisheries is common along the coastal rivers of the Sanaga(Picture 21) where bivalve fishing(Picture 22) is common.

Picture 24: Artisanal fishing camp along the Sanaga river.

Picture 25: Heap of bivalve shells (on the way to Mouanko) from artisanal fishing in the Sanaga river, ready for exportation to a processing industry in Douala

10.3.3. Preservation and Processing.

Artisanal fish production of the coastal zone is not well known. Satia (1993) estimates it at 65,000 tons/year, to which must be added 7,000 tons/year for industrial fishery. Post –catch losses are estimated between 25 and 35% of total catch. This means that conservation techniques need to be improved.

Preservation techniques: The most frequently used technique is chilling and freezing (Eyabi, 1996). This is practiced mostly by industrial fishery. The product is kept fresh until it reaches the consumer: some artisanal fishermen use this technique; in this case, they use double-walled wooden boxes into which fish is packed at a fish/ice ration between 1:3 and 1:1. Salting and drying are scarcely used in the coastal area, due to climatic constraints. In effect, despite the high temperatures, dehydration is slow due to high humidity .

Processing techniques: Traditional smoking makes use of mangrove wood (Picture 22) is the most widely used processing technique among coastal artisanal fishermen. The quantity of fish and shrimps smoked yearly in Cameroon is estimated at 75,000 tons, representing about 60% of the total catch. The characteristics of traditional smoking of fish in Cameroon are (Eyabi, 1996):

- Structure used: *banda*
- Smoking temperature: 50-180° C
- Temperature in the vicinity of banda: 33 – 40°C
- Weight loss due to smoking: 40 – 75%
- Smoking time: 6-96 hours.
- *Banda* yield (smoked fish: wood used): 1:5 – 1:2.
- Degree of pollution by smoke: very high.
- Product colour: golden brown to dark brown.

Fish smoked thus, can be kept for 4-15days at a temperature of 23 – 40°C and a relative humidity of 50-100%. Some groups, sponsored by NGOs use improved smoking facilities such as chokor ovens. Smoking of shrimps is done using platforms protected by sheds. Smoking lasts about 24 hour.

Picture 26: Mangrove wood for smoke-drying of fish within Yoyo II fishing camp

Picture 27: Mangrove forest from where the wood is extracted with future threats of degradation

Perspectives : It is certainly possible to improve the preservation techniques highlighted above in order to reduce post-catch losses, the negative impacts on the environment and the health of consumers and fishermen (transformers); this would require the implementation of some innovative measures, in particular, the organisation of fishermen and traders in fishery products. The state should encourage private investments in the sector, by promoting small and medium size enterprises specialised in the construction of wooden boxes and the

production of ice. The state should also assist research institutions disseminating results available in this sector to the public.

10.3.4. Fisheries management.

The general policy for fishery development focuses on the promotion of national fish production (revamping artisanal fishery and developing aquaculture) in order to reduce fish importation. Emphasis will have to be laid on improving the situation of economic operators in the artisanal sector and reinforcing institutional support. Such support could include:

- Providing the distribution network for fish products
- Restructuring para-public institutions in the fishery sector in order to improve their effectiveness.
- Reinforcing training structures to increase the strength of supervisory staff. A draft of the National Fishery Master Plan has been prepared with the technical assistance of the FAO (Sheves et al 1992). Its two main objectives are:
- On the short-term, to implement management options on overexploited stocks, reduce post-catch losses and develop aquaculture.

To achieve these objectives, two main strategies are defined:

- Reinforcement of Central Fishery Administration in the areas of planification, development and management.
- Improvement of preservation and processing techniques

11. Agriculture.

Agriculture accounts for almost 50% of foreign currency earnings in Cameroon. Thus, it plays an important role in the economic activities of the coastal zone both in feeding the population and raising family revenues. Traditional and modern agriculture co-exist in the coastal area.

11.1. Traditional agriculture.

All what can be said here with precision is that there is a concentration of agricultural activities (mainly food crop farming) in the South West region, around the major towns and rural settlements. Food supplies come into the major urban centres from the west provinces.

11.2. Cash crop farming.

The Cameroon coastal area is not quite suitable for the cultivation of traditional cash crops such as cocoa and coffee. Cocoa production was less than 10,000 tons per year (6,029 in 1991/92 for a cultivated area of 15,246 ha, while coffee production was 2,273 tons for the same period. Total national production during that period stood at 110.000 tons for cocoa and 80.000 tons for coffee.

11.3. Industrial crop farming.

Agro-industrial activity of the coastal zone concerns essentially the following crops: oil palm, rubber; banana, tea (Fig.5). This activity is in the hands of big agro – industrial establishments which started off mainly with foreign capital, but which are currently undergoing cameroonisation . These companies include: HEVECAM. SPFS. SOCAPALM. SAFACAM. CDC and PAMOL (Folack, 1995: 1997a). CDC alone employs over 15,000 persons for a cultivated area of more than 90.000 ha. It is the second largest employer after the state.

Picture28: Main cash crops and agro-industrial companies along the coastal zone of Limbe.

12. Industrial activities

Manufacturing industries in Cameroon account for 17% of the GNP. The industrial activities of Cameroon's coastal zone cover 60% of national production and include local crafts, food processing, chemicals and minerals (fig.6) Table 7 gives the distribution of industries in the Cameroon coastal zone in 1985, when coastal industries contributed 48.8% of total national industries. Since then, there have not been any significant increases in industrial capacity as a result of the national economic crisis.

The immediate consequence of industrial concentration around a town is the increase of its population. This accentuates the problem of managing wastes from human activities, in addition to those produced by industries. Cameroon is a modest petroleum producer and possesses off-shore platforms in the Rio-del – Rey and Kribi regions. Petroleum activities involve several operations that generate pollution, notably exploration drilling production drilling, placing of pipelines. On the ground, there is installation of bases for maintenance and repairs, construction sites for platforms, construction of petroleum storage terminals, construction of refineries and gas treatment plants, etc. A recent initiative is being carried out through the Cameroon-Chad pipeline project which intends to export crude petroleum(Picture 23 and 24) refined from the Chad basin abroad.

Picture 29 : Construction work at the Kribi terminal of the Cameroon-Chad pipe line project.

Picture 30 : Broad view of the Construction work at the Kribi terminal of the Cameroon-Chad pipe line project.

13. Tourism.

The coastal zone is also characterised by intense tourism activities. Tourist sites include white sand beaches in the Kribi region, the Lobe waterfalls, the “rocher de loup”, the Mount Cameroon, Limbe Botanic Garden, Limbe Zoological Garden, Mile Six Beach (Limbe), Seme Beach the mangrove creeks and Lake Osa in the Dizangue area. Apart from Douala, Limbe and Kribi which attract tourists, coastal tourism remains a minor activity and is little organized. It is essentially a crude form of tourism which unfolds in form of holidays (Limbe, Kribi) or business trips (Douala, Limbe). Along the Cameroon coast, there are classified hotels and inns, with about 1.600 rooms and 2.615 beds (1996). This potential is concentrated in Douala, Kribi and Limbe, and is less than the current demand. Coastal tourism (Picture 21 and 22) in Cameroon today involves mainly foreigners, since Cameroonians lack the means and often seek accommodation with their family relations and friends Natural constraints which militate against coastal tourism in Cameroon are:

- Limited sunshine and relatively short dry season.
- Frequent accidents amongst swimmers, due to south westerly winds and currents.
- Poor organization characterized by chaotic estate development with no respect for the state domain.

All tourism-related projects must take these problems into account, to ensure a sustainable development of the coastal domain.

Picture 31: Tourism at the larval flow in Bakingili

Picture 32: Mile 6 Beach-Limbe, an important tourist site in Limbe ; sometimes contaminated with tar balls

14. Forestry and wildlife activities.

14.1.Forestry.

The forestry sector is one of the major pillars of Cameroon's economic development. The coastal zone is fully involved in this sector, since it is characterised by the mangrove Picture 25 and 26) and coastal forests described respectively in paragraphs 2.1.3 and 2.1.4. Specific data relating to the coastal zone are lacking but globally, forestry activities represent 20.3% of total export. The evaluation of the impact of forest exploitation is complicated. According to studies carried out by the FAO, the distribution of forest destruction factors is as follows :

- Uncontrolled burning of farmland (60%)
- Large-scale agro-industrial projects (30%)
- Irrational exploitation of timber (10%)

Within the Cameroon context, the permanent monitoring system of the vegetation cover, as well as norms for impact studies and intervention in the forest zone are provided for the Forestry Action Program.

Picture 33: Mangrove forest at its virgin stage around Youpwe in Douala

Picture 34: Mangrove forest at its advanced stage of degradation around Tiko in Fako Division, South West Province of Cameroon.

14.2. Wildlife.

The economic crisis in Cameroon, which is characterized by salary reductions and lay-off has forced many Cameroonians into the exploitation of natural resources. Amongst these resource, the fauna holds a very significant position, and its exploitation appears as a substitute activity to many small-scale economic operators. Hunting is estimated to generated and sustain about 10.000 permanent and temporary jobs. The coastal zone is a fragile ecosystem, and consequently, contains many protected areas where hunting is regulated or prohibited . These include the Campo reserve in the South, the Edea –Douala reserve in the Littoral, the Mabeta-Moliwe reserve and Korup Park in the South West. There is no efficient system of monitoring, and the poor exploitation of the fauna potential is due to:

- Forest fires:
- Encroachment into protected areas;
- Mismanagement of protected areas
- Poaching.