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Diagnostic

REGIONAL SHORELINE MONITORING STUDY AND DRAWING UP OF A MANAGEMENT SCHEME FOR THE WEST AFRICAN COASTAL AREA

REGIONAL DIAGNOSTIC

UEMOA

IUCN

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The regional study for shoreline monitoring and drawing up a development scheme for the West African coastal area was launched by UEMOA as part of the regional programme to combat coastal erosion (PRLEC – UEMOA), the subject of Regulation 02/2007/CM/UEMOA, adopted on 6 April 2007. This decision also follows on from the recommendations from the Conference of Ministers in charge of the Environment dated 11 April 1997, in Cotonou**.** The meeting of Ministers in charge of the environment, held on 25 January 2007, in Cotonou (Benin), approved this Regional coastal erosion programme in its conclusions.

This study is implemented by the International Union for the Conservation of Nature (UICN) as part of the remit of IUCN's Marine and Coastal Programme (MACO) for Central and Western Africa, the coordination of which is based in Nouakchott and which is developed as a thematic component of IUCN's Programme for Central and Western Africa (PACO), coordinated from Ouagadougou.

UEMOA is the contracting owner of the study, in this instance through PRLEC – UEMOA coordination of the UEMOA Commission. The work has been carried out under the supervision of:

⇒ **The PRLEC[1]-UEMOA Regional Steering Committee** set up to improve the orientation of the different projects and oversee their diligent and efficient execution. This is presided over by the State, which holds the presidency of the Council of Ministers of UEMOA.

⇒ **The PRLEC- UEMOA Regional Scientific Committee,** established with a view to assisting the UEMOA Commission in validating the technical and scientific contents of projects initiated within the framework of the implementation of PRLEC. This committee also expresses a technical and scientific opinion on all the reports drawn up within the framework of the implementation of this programme.

Supervision: Malick Diallo, UEMOA, Director of the Environment and of Water.
Papa Goumba Lo, President of the Regional Scientific Committee of UEMOA's Regional Programme to combat Coastal Erosion.

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Technical and publications coordination: Jean-Jacques Goussard – EOS.D2C / EAM-GEOME

[1] Programme to combat Coastal Erosion, UEMOA (West African Economic and Monetary Union).

What the coastal players have to say ……

Penda M'Béga, daughter-in-law of the village chief, Saly-Poste:
"We were strongly affected by the destruction of our palaver tree, the baobab, during the last rainy season."

Baboucar Diom, Village Chief, Saly-Poste (translated from Wolof):
"I was born here and I grew up here. The damage we had this year was unprecedented. The sea has been advancing gradually for a long time, but it had never destroyed homes before. This year (during the last rainy season) four houses were destroyed, including one of mine.
When I was a child, we had to walk a long way – like from here to the Fram hotel (ml: 200 to 300 metres) to reach the sea."

Mamadou Pouye, village chief, Saly-Nakhniakhal (translated form Wolof):
"Before the sea moved a lot, we had a house we had to give up in 1985 to move to higher ground. It is still there but there is no room round about it to leave our canoes.
At Saly-Niakhniakhal, our village-district, there wasn't much damage because it's further from the sea than Saly-Poste, for example. I have been the village chief for over thirty years. In the past, the sea never came as high up as that. Our grandfathers couldn't have imagined that this would happen.
I remember in 1939, when my father came here to build this village, you had to walk 800 m to reach the beach. Today that has all gone; you have to build as high up as possible."

Mamadou Diarra, Rural Community of Malikunda:
"We have had major problems with the sea level rising. In one coastal village: the sandbag dykes built in 2002 by the villagers were destroyed by the waves.
At Baling too we have problems. This site is a rehabilitated village. It used to be called 'Tropical' and was a leprosy centre. The damage has been to property: the market was destroyed. The main cause is the lack of drains. During the drought years, people built anywhere, in particular in areas that were flood-prone but this was not visible because of the drought. People built homes there without digging drains, without thinking about making the area viable. When the rains returned, these areas were flooded or destroyed."

Christophe Diouf, village chief, Palmarin Facao:
"Right next to here, there used to be dunes 3 m high that the sea has eroded and eliminated. When I was young (I'm around fifty years old today) we practiced sport, went for walks and played on the dunes. Today, the beach is right on the edge of the village.
Erosion is the biggest environmental problem we have here. I fear for the future, of course, because we have coastal erosion on one side and river erosion on the other (the first is responsible for the second)."

Jean-Paul Guillon, Djidjack tourist camp, Palmarin:
"This year, here, the sea has risen a lot more than in previous years: approximately ten metres more."

Cécile Sar, nurse, who lives in Palmarin:
"The sea rising is terrible. When I was little there were lots of trees between the village and the sea. Now the sea is right at the edge»

These quotations were taken from the report on how coastal erosion is perceived in Senegal, produced by Marie-Laure de Noray Dardenne within the framework of the SDLAO study.

ABBREVIATIONS

ANCORIM	Atlantic Network for Coastal Risk Management
CDC-ST	Coastal drift current – sediment transport
CILSS	Comité Inter Etats pour la Lutte contre la Sécheresse au Sahel – Inter-state committee for combating drought in the Sahel
DEM	Digital elevation model
ECOWAS	Economic Community of West African States
GCLME	Guinea Current Large Marine Ecosystem
GHG	Greenhouse gas
MEA	Multilateral Environmental Agreements
OMVG	Gambia River Basin Development Organization
OMVS	Senegal River Basin Development Organization
PRCLEC	Regional Coastal Erosion Control Programme (UEMOA)
RAMPAO	Network of West African marine protected areas
SRTM	Shuttle Radar Terrain Model
SSA	Sub-Saharan Africa
SWAC	Sahel and West Africa Club
UEMOA	West African Economic and Monetary Union
UNEP	United Nations Environment Programme
IUCN	International Union for the Conservation of Nature
WA	West Africa
WALTPS	West Africa Long-Term Perspective Study

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1. INTRODUCTION

The myth of a predominantly continental Africa "with its back turned to the sea[2]" would appear to have worn rather thin. The migrations consecutive to the droughts in the 1970s and 80s, the development of major urban centres, practically all on the coast, in colonial times, were later relayed by post-independence developments, which have given the West African coastline all the appearances of a veritable "**pioneering front**"; This ties up with a colonial history the first stages of which were also the creation of the trading posts and factories which were motivated by the prospect of "mining" the natural and geological resources of the interior. This history is not completely a thing of the past, as witnessed by the essentially "utilitarian" nature and the customary usage values which are the basis for the development and use of the West African coastal areas. The current imperatives of protecting people and assets from a concept of security and social progress today impose the necessity of revisiting the relation between African societies and their coastal land areas.

Pragmatically, the integration of the economic dimension of the growing threats weighing on the coastal societies today also calls for new reference points and new parties for the development of land and marine areas which must become transboundary. It is a question of envisaging **in a coherent and functional manner** the specific dynamics of a regional coastal interface, which would certainly provide resources and multiple ecological services, but whose land area, which is after all limited, must be optimised and managed to be able to maintain its role as support and development engine for the coastal countries.

This summary was produced on the basis of various contributions made within the framework of the drawing up of the Management Scheme for the West African coastal areas. The approach was to explorer the different compartments that would provide today a grasp of the reality of the coastal systems in this region and the way they function.

The diagnostic study is based on an initial characterisation of the West African coastal area from the point of view of lithology, morphology and of the natural agents (winds, ocean waves, tides, currents, etc.) responsible for the process of change and transformation affecting the shoreline. The elements relative to climate are given in annex 1. The biodiversity of coastal systems is also touched on briefly, as most of the items gathered on this topic are given in the national diagnostic studies which make up the series of documents no. 5 of the study.

The human stakes are broached in a prospective sketch to 2030 and 2050, which, although dealing with broad outlines, respects rigorous methodology and highlights the general trends, which will most certainly lead to a rapid, major concentration of land use and human stakes on this particularly fragile coastal area.

The risk situations related to coastal erosion concern, to various degrees, practically the entire coastline from Mauritania to Benin, but some of these situations are today particularly worrying, bringing into play three major components**, necessarily "close to the sea"** and therefore in the front line of the human use of the coast: Harbours, the rapid and often careless development of residential habitat on the coast of peri urban areas (accompanied by much and speculation) and the human settlements related to fishing livelihoods.

Against this background, climate change over the next few decades will be expressed as profound changes in the natural behaviour of coastal land areas. The question is therefore to integrate these changes, which will probably not always be gradual and linear, into renewed approaches to planning based on the precautionary principle and on a forward-looking vision of the potential changes. To adapt to these new configurations, the real challenge facing the coastal States today is the pooling of resources and the sharing of experience regarding the problems and solutions.

These approaches to adapting in the coastal areas should take into account the reciprocal influences between coastal territories, the transboundary interdependence of sea fronts, the functional role of natural infrastructure in preserving irreplaceable ecological services that are necessary for development in a situation where the population is still growing.

This original regional study has brought together several dozen technicians and scientists from the South (from the countries concerned, from Mauritania to Benin) and from the North at the service of a common goal which is part of UEMOA's environmental policy. The findings should contribute to the strategic retreat necessary to

[2] Pelissier. P. 1990.- Post-scriptum to Rivages. L'Afrique tourne-t-elle le dos à la mer ? **Cahiers d'Etudes Africaines** . 117, XXX-1, 7-15p.

avoid making "back to the wall" decisions, which today have largely shown their limited usefulness for the preservation and sustainable management of the coastal heritage.

The detailed diagnostic study of the situation of the coastal areas of West Africa has been drawn up on a number of scales: Regional and national but also local through the case studies.

This diagnostic study resulted in different typologies with commentary, expressed through the cartography. These different levels of diagnostics are presented in the following documents:

Annotated typologies in the cartography:	Document 3
National diagnostic studies:	Documents 5 A to K
Case studies:	Documents 6 A to

On a regional scale, three major thematics were broached:

- ⇒ Geomorphology and sensitivity to erosion of the West African coasts.
- ⇒ Analysis of human stakes on these coastal areas, including a prospective study to 2020 and 2050.
- ⇒ Effects of climate change.

2. WEST AFRICAN COASTAL AREA: THE CAUSES OF THE FRAGILITY [3]

On the coasts undergoing accumulation, which are by far the most represented in West Africa, the mobility of the shoreline largely depends on the local balance of supply and removal in the sediment budget. Removal operates under the action of natural agents (coastal drift, ocean waves, wind, etc.), which are also partly responsible for sediment supply. Removal may also be the result of human activity, either directly (extraction of building materials from beaches, for instance), or indirectly (the creation of surfaces that reflect wave energy or installations that disrupt the operation and the exchanges between the different sediment compartments of the beaches or that disturb the coastal drift parallel to the shore).

Which types of sediment supply?

In the Northern zone of Mauritania at the delta of Senegal river **sediment supply is essentially aeolien**. This supply is difficult to evaluate, and is redistributed along the coast towards the South by the Canaries current, associated with a regular North-South coastal drift more or less parallel to the shore (**see annex 2**).

A pronounced rainfall gradient

Rainfall varies from less than 100 mm in the Saharan areas of Mauritania to more than 3,000 mm on the coasts of Guinea, Sierra Leone and Liberia. The climate of West Africa is primarily modulated by the seasonal movements of the intertropical convergence zone, which separates the continental mass of hot, dry air with North-Easterly winds (Harmattan) and the mass of moist sea air originating from the Gulf of Guinea (monsoon).

See annex 1.

Starting from the South of the Cape Verde peninsula (Dakar), sediment supply is essentially fluviatile. **River sediment supply** corresponds to the network of major coastal rivers on most of which dams have been built which are responsible for intercepting a significant part of the continental sediment load**.** The extension of the catchment areas in correspondence with the orographic and geological characteristics leads to the differentiating of:

⇒ The major river basins, in particular transboundary, extensively present in the Sudan zones, with moderate rainfall.

⇒ The small river basins, in a topography dissected by peneplain on Precambrian formations covered by a thick mantle of alterite, located in the zone with the highest rainfall (particularly in Liberia, West of Côte d'Ivoire where annual rainfall sometimes exceeds 3,000mm).

In the mangrove and/or lagoon areas, these sediment fluxes are largely trapped in the river mouths, either by sand-mud formations and the roots of the mangroves, or in the coastal lagoons. These accumulations of sediment are remobilised and put back into circulation in the marine environment seasonally by flood peaks, or on a day-to-day basis by tidal currents where these are significant (particularly in Guinea Bissau and Guinea).

Data exists at various points on the coast regarding the sediment loads transported by the coastal drift current (**see annexes 2 and 3**); on the whole this data is old and sometimes contradictory.

The whole coastal system is first of all conditioned by the sediment legacies dating from the last transgressions and remobilised by the morphogenic agents (currents, winds, ocean waves). Continental fluxes, whether aeolien or fluviatile, only partially contribute to maintaining the legacy stocks. This is a hypothesis which has not yet been confirmed.

An entity composed mainly of soft and dynamic coastal areas

Of the estimated 9,780 km of coastline (at a scale of 1:75,000) from Mauritania to Benin, rocky coasts represent under 3% of the coast line. These coasts are made of rock that is often altered and fractured, subject to landslides and erosion. The remainder of the coast line is composed of:

[3] See annexes at the end of the document.

Unstable and/or very dynamics coasts

⇒ Mangroves, continuously evolving (48%)
⇒ Sand banks, estuaries, river mouths, spits and islets by nature also very unstable and dynamic (12%).
⇒ Sandy formations of lidos (thin sandy rim between a lagoon and the sea shore, also unstable and highly changing - 7%)

Less dynamic coasts, but still subject to natural episodes of erosion and accretion outside of human intervention.

⇒ More or less straight sandy coasts, relatively stable but subject to cyclical phases of erosion and accretion, also very sensitive to nay disruptions of the coastal drift (16%).

⇒ Stepped coasts or headlands and coves, where the coves are compartments more or less separated by rock outcrops or less soft. Their stability strongly depends on the orientation in relation to the ocean waves and currents (14%). The sediment stocks here are often very limited.

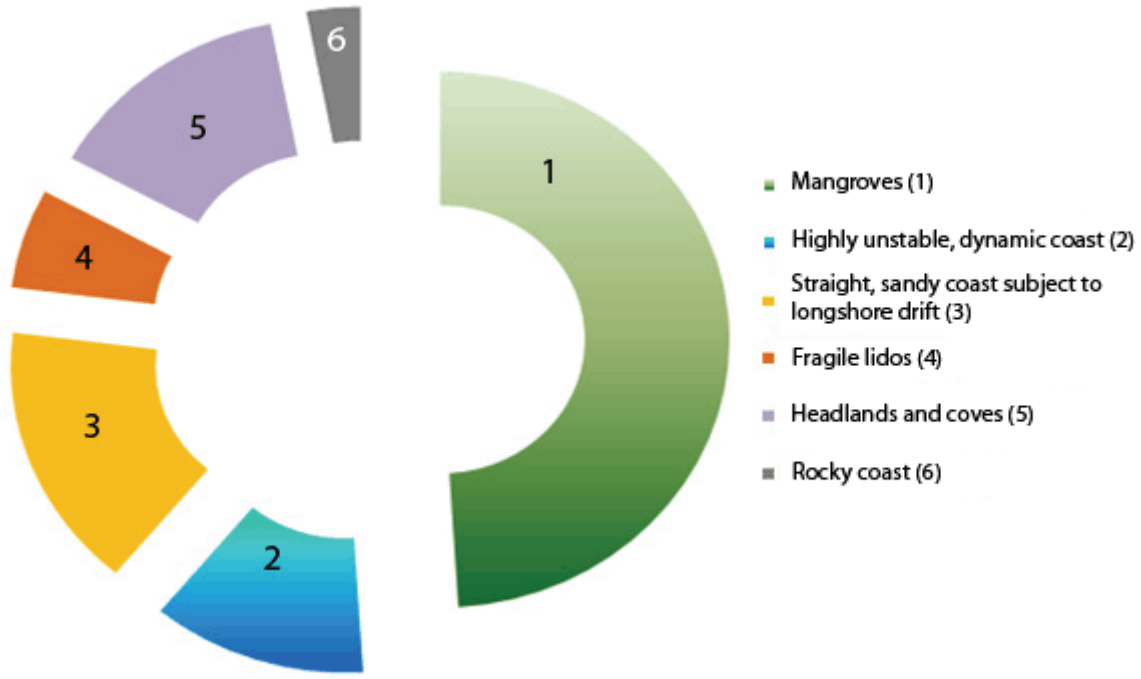

Figure 1. Percentages of length of shoreline according to the different coastal facies.
Note the high proportion of mangrove coasts, also related to the fractal
Dimension that characterises the shoreline in these milieus (see also document 3).

A relatively "defenceless" coastal area

There are, however, a few rock outcrops that structure this coast in headlands that are less soft but often fractured and fragile, and few in number:

⇒ Basalts and other rocky formations on the Cape Verde Peninsula (Senegal)
⇒ Rock outcrops at Cap Verga and the Conakry peninsula (Guinea)
⇒ Breakwater at Freetown (Sierra Leone)
⇒ Relict of sandstone or hardpan spared by erosion (sandstone on the Senegalese Petite Coast, the Bijagos and around the periphery of Accra)
⇒ Granites and metamorphic rocks presents on all of Liberia, Western Coast d'Ivoire and the central part of the coast of Ghana.

The continental shelf

The landform is, on the whole, not very rugged. The continental shelf is narrow in the main, around thirty kilometres on average, except from Guinea Bissau to the Sherbro islands in Sierra Leone, where it widens considerably to 200 km. This continental shelf is marked by some major deep features: the Khayar canyons in Senegal to the North of the Cape Verde Peninsula, and the deep canyon ("*Trou sans fond*" (Bottomless pit)) that cuts through the shelf perpendicular to Abidjan in Côte d'Ivoire. For certain authors, these bathymetric features contribute to trapping the sediment transported by the coastal drift current parallel to the coast.

Figure 2. Continental shelf from Mauritania to Benin (blue shading from 0 to -300 metres)

A regional sediment legacy that is redistributed and shared within the large hydrosedimentary compartments

The propagation of ocean waves affects the whole of the two major sea fronts along this coastline, West and South, **with an orientation that is generally oblique**, **which contributes to the generation of a significant coastal drift current parallel to the coast.**

The circulation and redistribution of sediment is governed on the major part of the coast by this coastal drift current, which is subject to annual variations, but the resultants of which are globally North-South all along the western sea front (from Mauritania to Guinea Bissau) and West-Easterly along the Gulf of Guinea. In certain cases, these variations are considerable: the drift is reversed seasonally on the Grande Côte of Senegal, and the resultant observed through the physiography of river mouths and estuaries indicates an East-West orientation for a large part of the coast of Liberia and Sierra Leone.

In the portion of coast between Guinea Bissau, Guinea, and the North of Sierra Leone, sediment circulation and redistribution is primarily governed by tidal removal currents, **combined with river spates in these regions with high seasonal rainfall**. It should be noted that the tidal ranges are very wide in this zone, exceeding 5 m

in places, while the average for the whole coastal area studied is in the order of 1 m. In these zones where rainfall determines important annual spates, river dams can reduce these spates and restrict the expulsion of the mud plug, an important source of sediment supply usually put into circulation in the coastal waters during these episodes.

Coastal facies and profiles

The cartographic analysis performed on a scale of 1:250,000 and presented at 1:500,000 appended to this diagnostic report and the management scheme represents a typology of coastal facies that centres around two complementary readings:

⇒ A classification of the shoreline by segments defined in accordance with the systemic typology presented in document 3.

⇒ On a coastal rim approximately 20 km deep, zoning carried out in accordance with the sediment characteristics and methods of potential transfer of sediment to the coastal area. The criteria of this zoning are presented in document 3.

These elements of analysis are accompanied by a reflection on the sensitivity of the different classes to the sea level rising, human land use and the principal geodynamic characteristics (see document 3).

There are five distinct major coastal profiles from North to South:

⇒ **The straight coastal regions from Mauritania to the Cape Verde peninsula,** composed for the most part of sandy formations subject to the direct action of the coastal drift. In the immediate proximity of and behind the ridge/sandbar, there are vast expanses of low-lying salt marshes situated below sea level in places.

⇒ **A coastal region with headlands and softened coves from Cape Verde peninsula to Basse Casamance** with the exception of the major estuaries. This coast is structured by rocky outcrops of sandstone and badly deteriorated, fragile ferruginous cuirass.

⇒ **The mangrove coastlines from Siné Saloum in Senegal to the Sherbro islands in Sierra Leone**.

⇒ **A coastal region highly structured into rocky headlands and sandy coves from Liberia to the West of Coast d'Ivoire.** This same profile is to be found also in the central part of Ghana.

⇒ **From the West of Côte d'Ivoire to Benin** stretch two large sediment basins of soft coastline (Coast d'Ivoire and Dahomey basins) also characterised by important lagoon and channel systems parallel to the coast and situated behind a sandbank that is very narrow in places (lidos). These two large sediment basins are separated by the Three Points Cape in Ghana and a few adjacent formations that are more or less rocky (sandstone) or in headlands, right to the mouth of the Volta.

The major part of the coast in West Africa has a high sensitivity to coastal erosion related to (i) the nature of the materials (mobile sandy sediment or highly altered and fractured rocks; (ii) the circulating sediment fluxes which remain limited either due to continental or river mouth trapping, or due to the coastal sediment partitioning that can be observed on coasts that are more predominantly structured in headlands and coves.

The developments and infrastructures that disturb a coastal drift that is quite typically parallel to the shore create observable direct impacts: siltation updrift and erosion downdrift of the portions of the coastal region that have undergone human artificialisation.

In the headland and cove coastal regions (stepped), the diversity of situations in relation to the dominant ocean waves and the coastal drift current means that the sensitivity to erosion should be analysed on a case by case basis depending on the local configuration.

In every case, coastal development should be part of a multiple scale plan enabling the local erosion management to be placed in the wider context of the large hydrosedimentary compartments concerned.

3. COASTAL BIODIVERSITY: THE COMMON LEGACY OF THE COASTAL STATES

The biodiversity of the coastal ecosystems of West Africa is directly related to the variety of types of coast and to the steep bioclimatic gradient characteristic of the region, covering the Saharan, Sahelian, Sudanese and Guinea-Congolese zones[4]. In the North in Mauritania, the Golfe d'Arguin constitutes a pivotal biogeographic area where the southern distribution boundary of certain northern species, such as cordgrass, is to be found. These species grow alongside mangroves, among the most northerly on the continent. The biodiversity of the coasts of West Africa is first of all characterised by extensive wetlands, corresponding to the morphology of flat, low-lying topography of the major part of the coast and to the interpenetration of fluvio-marine influences.

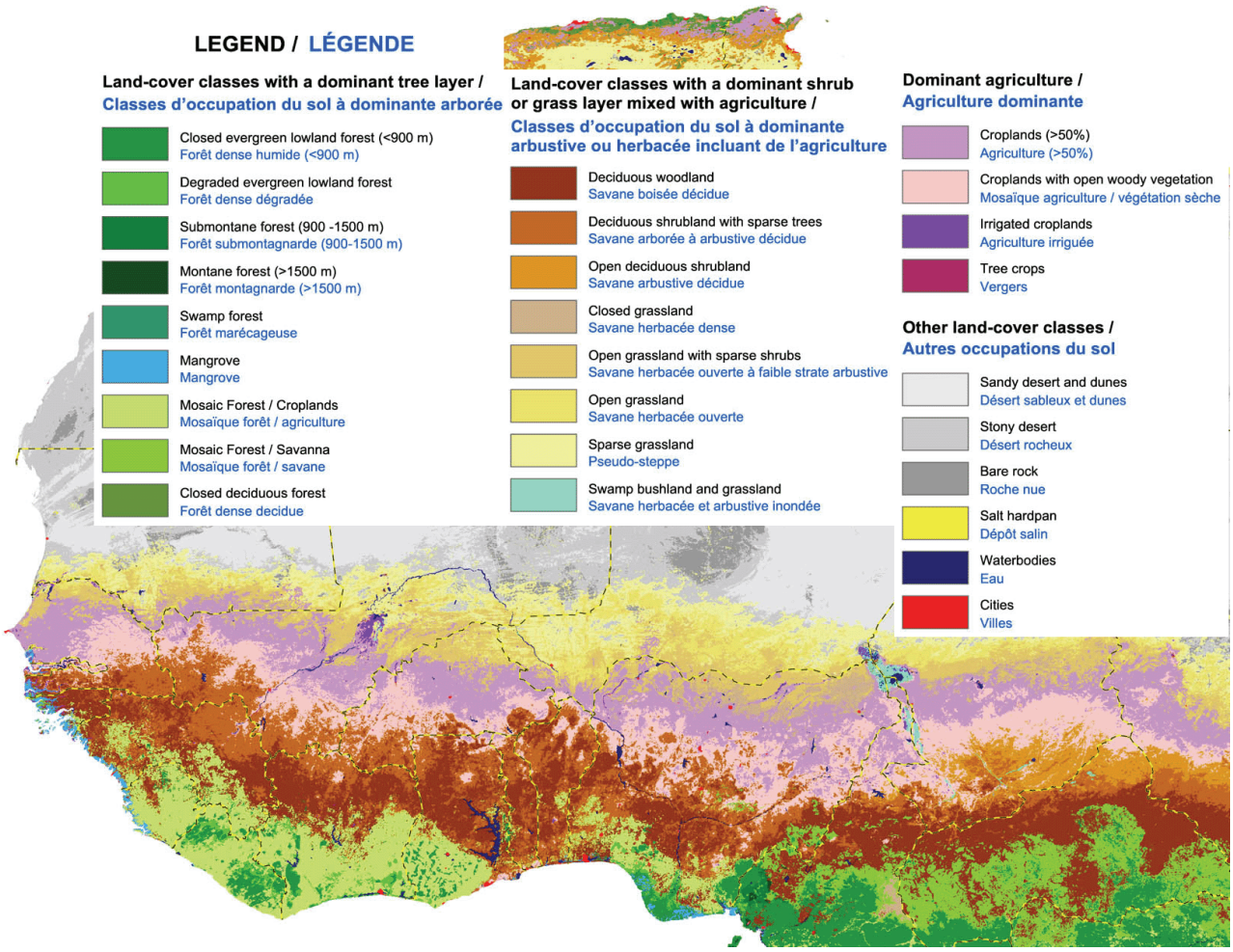

Figure 3. Land use in West Africa (2000).
Source: Global land Cover 2000 project. Joint Research Centre. European Commission.

Major natural areas

There are four major, extensive, more or less protected natural areas along this coastline: the Banc d'Arguin National Park in Mauritania, the Delta of the River Senegal, the Bijagos archipelago and the Sherbro-Robertsport complex between Sierra Leone and Liberia. Between these large natural areas, some of which have already been subject to conservation measures for some time (Arguin, Bijagos), is an interspersed network of natural areas that are still relatively preserved, some of which are subject to local protection measures (RAMSAR sites, Marine Protected Areas under shared governance in Senegal, etc.).

[4] White. F. 1983.- **The vegetation of Africa**. UNESCO.

Dense Guinea-Congolese forest

The last relicts of the Guinean coastal forests (Guinea Bissau, Guinea) are today largely deteriorated, or have simply disappeared. However, a few dense forest areas remain in places, in particular in Liberia, with little data available on the actual status and distribution of these formations. Secondary forests from the recolonising of plantation areas that were previously artificialised are better represented from Liberia to Ghana. Note that the dense, evergreen Guinea-Congolese forests extend from Cap Palmas to Cape Coast in Ghana, at some distance from the coast. These formations extend to Nigeria after an interruption (Dahomey gap), due to the bioclimatic reasons from Keta in Ghana to Benin inclusive. There is practically no forest remaining on the actual edge of the coastal area.

These hinterland forest facies vary depending on the edaphic conditions (rock outcrops and cuirasses, wetland depressions, leached sand on coastal terraces), orographic conditions (reliefs), bioclimatic conditions (duration of the dry season) and the intensity of human intervention (fires, conversions and secondary re-growth after plantation or slash-and-burn).

This coastal evergreen Guinea-Congo rainforest is recognised as exceptionally rich with a diversified flora including a notable proportion of endemic species. Like the dense coastal forests of Guinea, these forest entities are also highly threatened.

Mangroves

The mangroves of West Africa are completely different in their composition from those in East Africa. The 7 main species they comprise (*Rhizophora mangle*, *R. harrisonnii*, *R. racemosa*, *Avicennia germinans*, and *Laguncularia racemosa, Acrostichum aureum, Conocarpus erectus*) are also distributed on the eastern coasts of tropical America. These mangroves grow in the intertidal zone. The cover approximately 14,000 km² in the zone under study, and are subject to the influence of various factors: oceanographic, sedimentary, geomorphologic, but also and increasingly, anthropic.

Nor very diversified from a floristic point of view, these mangrove communities nonetheless play a vital role for the coastal ecosystems as a whole, in particular by the high net production that characterises them, which is exported to marine milieus and enables a rich and diverse piscifauna to be maintained. Their physiographic characteristics (shallow gradients, the cryptic nature of milieus that are crowded with the roots of the mangrove trees) also make them essential reproduction zones for a high proportion of fish species that make up the region's fishing stocks. The small areas of estuarine mangroves in the Gulf of Guinea, particularly in countries like Togo and Benin, are extremely threatened and specific protection measures are required.

The pressure on the mangroves and these coastal ecosystems is increasing today. A distinction will be made between:

- ⇒ **Biomass removal:** Wood for energy (supplying the nearby urban concentrations for smoking fish or producing salt in Guinea), for services, fisheries and the gathering of attached organisms, molluscs and crustaceans, removal of bark and of various species in traditional pharmacopeia.

- ⇒ **Conversions and clearance**: artificialisation for rice production, salt production, or shrimp farming, which is expected to expand in the future, in particular in Guinea. The surface area occupied by mangroves in the region is thought to have decreased by a quarter between 1980 and 2006[5])

Changes in mangrove surface areas are also governed, however, by continental drought cycles or on the contrary, abundant rainfall, which largely condition the retreat or advance of mangrove stands. These systems are particularly dynamic and sensitive to changes in mud banks, the physiognomy and topography of which are under the influence of coastal hydro-sediment forcing.

Preserving these original systems also conditions that of the veritable ethno-ecosystems that characterise these areas and their population which is largely dependent on a daily basis on resources valorised locally through complex production systems adapted to these particular milieus. The contribution of these ecosystems to the subsistence strategies of certain coastal societies (in Siné Saloum, Casamance, the Gambia, Guinea

[5] Corcoran. E. & al.. 2009.- **Les mangroves de l'Afrique de l'Ouest et centrale**. PNUE - Programme des Mers Régionales.

Bissau, Guinea and Sierra Leone) is fundamental, as much at the level of food, food security and pharmacopeia as from a cultural point of view.

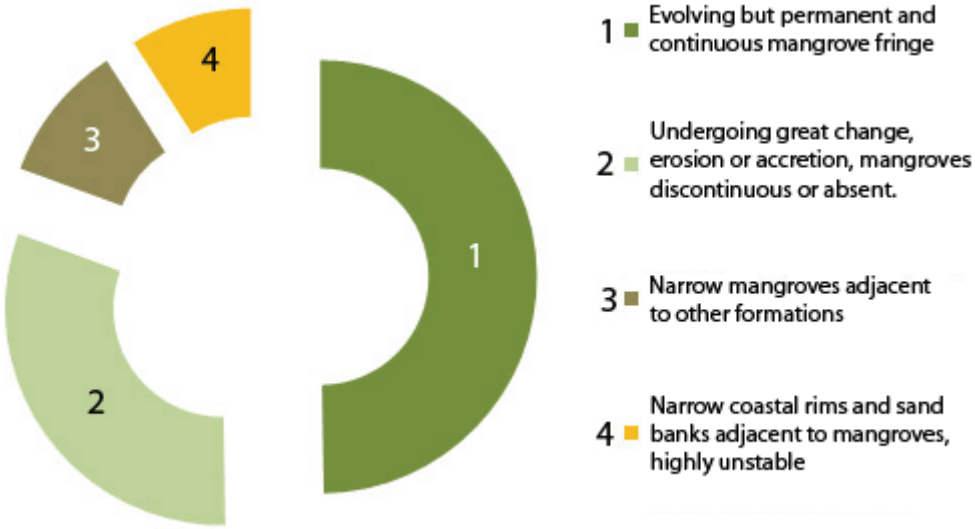

Figure 4. Proportion of coastline according to physiography of mangrove stands (entire study area).

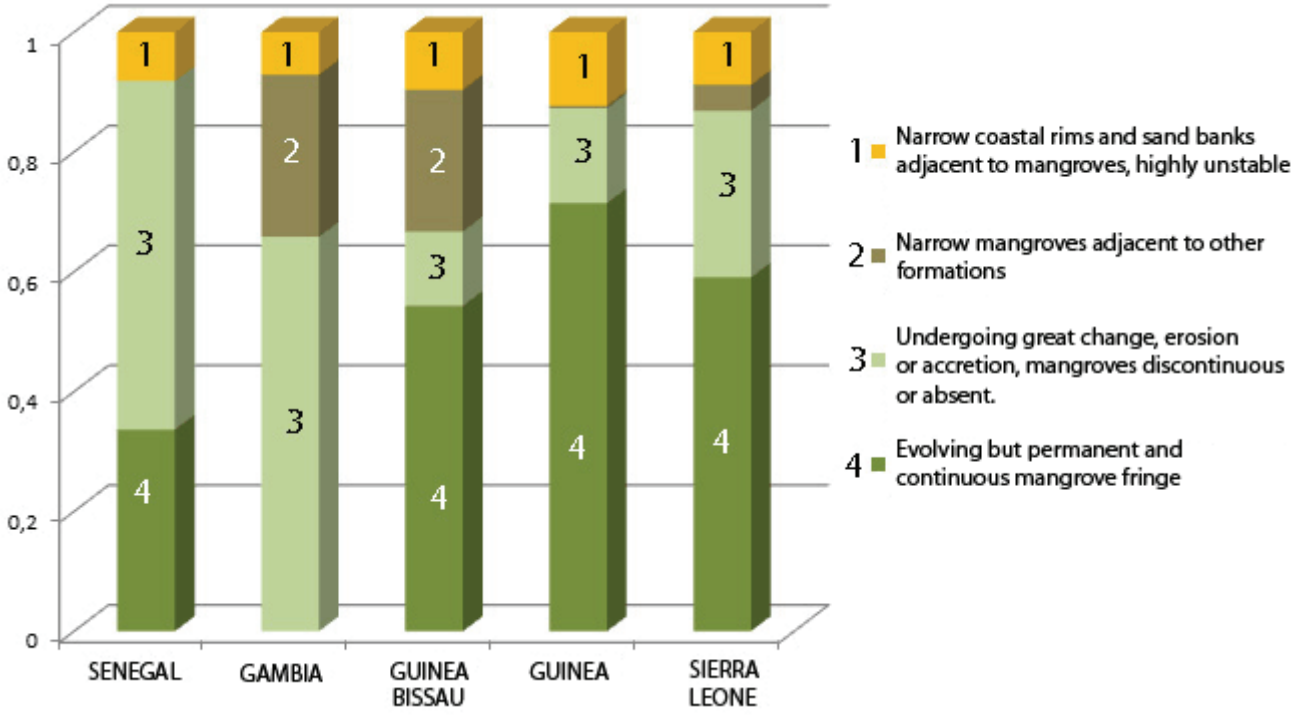

Figure 5. Proportion of coastline according to physiography of mangrove stands (by country).

Five West African governments (Mauritania, the Gambia, Guinea, Guinea Bissau and Serra Leone) have ratified a charter that commits them to cooperate for the protection of the mangrove in the sub-region. This mangrove protection charter also comprises detailed plans of action specific to each country.

Estuaries …

Beyond the mangroves, the string of small estuaries stretching from Sierra Leone to Côte d'Ivoire also constitutes an extremely rich network of ecosystems, home to marine, fluvial and brackish water fauna, the diversity of which is relatively unexplored and unknown. This diversity attaches to the multiple gradients

(salinity, topography of the banks and coastal lagoons, conditions, sediment dynamics and local current systems) which characterise these milieus.

Fauna, piscifauna and emblematic species

Various emblematic species in the region are under threat. Among them, the manatee, but also the sawfish (*Pristis pristis*) which is today threatened with extinction.

The vital economic role played by fishing stocks, including the shared stocks of migratory fish (mullet, croaker, bluefish) should be particularly highlighted. These fish populations are largely dependent on the maintaining of adequate, preserved habitats (spawning grounds) for reproduction.

The wetlands in West Africa also play host to a large proportion of Palaearctic migratory avifauna, already subject to the effects of climate change, in coastal milieus that play a crucial role in the maintaining of these populations during their overwintering periods. These milieus correspond globally to the richest and most endangered natural systems (mangroves, estuaries and peripheral milieus, coastal marshlands).

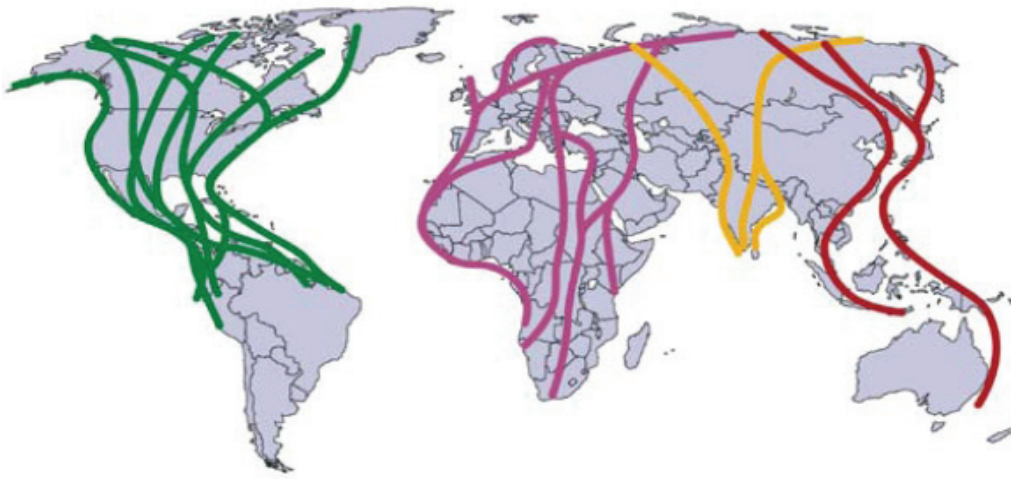

Figure 6. Principal migration routes of Palaearctic nesting birds (aquatic avifauna). Taken from UNEP-CMS. 2009.- **A bird's eye view on flyways**. 70p.

Sea turtles and coastal erosion

Among the migratory species protected within the framework of the CMS (Convention on Migratory Species), six species of sea turtles have been spotted in the region[6]:

⇒ **Green turtle** (*Chelonia mydas*): presence and nesting of certain turtles in Mauritania (Banc d'Arguin, Baie du Lévrier) as far as Dakar. Presence observed and nesting in Siné Saloum. Strong presence in the Bijagos archipelago, which hosts 2,000 females each year, constituting the largest breeding colony in West Africa. Nesting is observed in Sierra Leone and Liberia, as well as in Ghana and Benin.

⇒ **Loggerhead sea turtle** (*Carreta carreta*): Strandings observed in Mauritania, possible presence in Senegal, catches and laying (?) evoked in Guinea Bissau and Guinea. No information about its presence in the Gulf of Guinea.

⇒ **Olive ridely turtle** (*Lepidochelys olivacea*): Has been observed in Nouadhibou, possible laying in Senegal, but this has not been confirmed. Small nesting population in the Bijagos, as well as in Liberia and in Côte d'Ivoire.

⇒ **Kemp's ridley turtle** (*Lepidochelys Kempii*): presence to be confirmed in Senegal, no observations in the other West African countries.

⇒ **Hawksbill sea turtle** (*Eretmochelys imbricata*): A few individuals have been captured in Mauritania, it is widely spotted in Senegal as far as the Saloum delta and Casamance. A small population is observed in the nesting period in Guinea-Bissau and Guinea. Reports of catches by fishermen in Côte d'Ivoire and some specimens have been caught in Togo and Benin

Boucar N'Dioye, warden of the Langue de Barbarie National Park:

"With the abandoning of land that was too saline, the inhabitants of the Barbarie spit, who always used to work in two areas - farming and fishing – have fallen back on fishing only. And as there is no longer enough fish, they are forced to travel great distances: to Mauritania, Guinea or Sierra Leone.
They are away for a long time and sometimes create conflicts where they go. In addition, they leave their families here for weeks on end. Some have tried out the route to Europe...
(…)The park has another problem: with the closing of the river mouth, the fishermen from the villages downdrift can't land where they used to. So we had to create other landing points. The fishermen come on foot, through the Park, to the landing points, and disturb the turtles, accidentally destroying their eggs, or trapping turtles in their nets. This year we had to set up daily surveillance. It's not poaching, it's related to the fact that now the nets are positioned in the areas the turtles are in."

⇒ **Leatherback sea turtle** (*Dermochelys coriacea*): Numerous sightings in Mauritania and nesting observed in the Baie du Lévrier. Possible laying in Senegal and in Guinea Bissau and Guinea. Laying confirmed on a site on Sherbro island in Sierra Leone, and in Liberia, Côte d'Ivoire, Ghana and Benin.

These different species are particularly sensitive on their laying sites to changes in beach profiles and in particular to eroded cliffs that may form during intense marine meteorological episodes or under the influence of erosive processes. The presence of free water behind the beach may also disorientate the young turtles after hatching. Maintaining these populations is also closely dependent on coastal seagrass beds, which also play an important role in trapping sediment.

Conservation and natural infrastructure

The natural coastal milieus in West Africa contribute directly to producing ecological services that are useful or even indispensable to the coastal societies, perhaps even more so in the context of climate change on the agenda today. These ecological services procure identifiable benefits on every scale, including global: carbon sequestration by the mangroves, seagrass beds and coastal marshlands, the importance of which is recognised.

[6] The elements provided were taken from the summary produced by Jacques Fretey for the United Nations Environment Programme in 2001.

⇒ **Self-maintenance services**: constitution of habitats and of the milieu. Maintaining of energy flows and nutritional cycles through primary production, inter and intra ecosystem services and functions, reproduction, nourishment, etc.

⇒ **Provisioning services:** fisheries (artisanal, staple, and commercial), agriculture, firewood, ligneous and non ligneous gathered food products, aquaculture, crafts, building (materials and service wood), pharmacopeia, genetic resources, etc.

⇒ **Regulation services:** climatic (carbon sequestration), coastal protection against marine erosion and extreme marine weather events, treatment and recycling terrigenous and effluent input from human activities, waste water purification, protection against floods from continental waters, stabilisation of mobile dunes, etc.

⇒ **Cultural services:** Landscape appeal and environmental quality (formation of beaches, islands and coastal landscapes), leisure activities (urban beaches for example), research and education, cultural and religious heritage (customs, traditional ways of life, artistic expression), etc.

Karim Sall, chairman of the young fishermen's association and chairman of the management committee of the MPA of Joal-Fadiouth:

"The mangrove plays an important role against erosion. It prevents the island of Fadiouth from disappearing. This islet is almost entirely surrounded by mangrove and the roots and leaves of the mangrove trees prevent the island from disappearing. In way, it serves as a dyke. If there was no mangrove, the mixed cemetery (Christian and Moslem) would have been seriously affected."

Not all of these ecosystem services are subject to systematic economic valorisation to date, except for a few sectors such as fishing. This also means that these services are globally still functional. Nonetheless, the concerns related to coastal erosion show that functional deficits in coastal systems can have a considerable economic impact.

4. WEST AFRICAN COASTAL AREA: HUMAN LAND USE FOOTPRINT

The different forms of human land use in the coastal areas are analysed in the typology presented with the cartography information in document 3 (cartography of stakes).

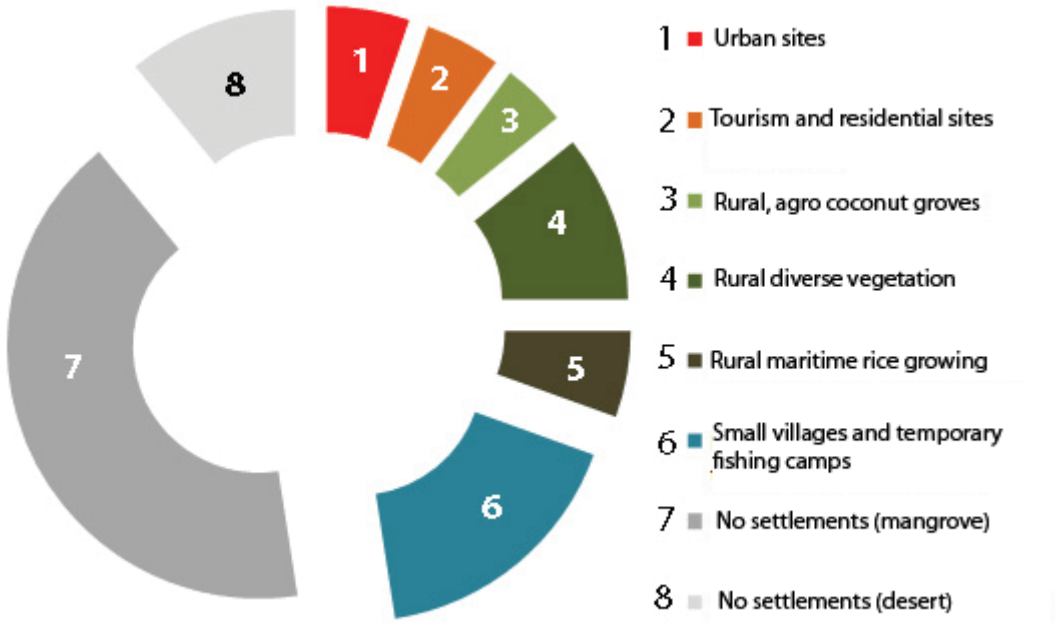

Figure 6. Distribution (in percentages) of types of human land use
in the first kilometre of the coastal fringe

While certain segments of the West African sea front have long been settled by traditional maritime peoples (the Balanta in Guinea Bissau, the Lebou in Senegal and the Imraguen in Mauritania), it was colonial history that profoundly transformed this sea front, first of all through the trading posts, then through ports that are precursors of the metropolises familiar to us today.

The current human footprint on these coastal areas is dominated by the concentration of population and economic stakes related to the (i) urbanisation and its forerunners (communication routes, relief from isolation, electrification, recent changes in artisanal fishing strategies, etc.); (ii) rapid development of tourism and residential areas, often on the periphery of urban areas. Access to water in dry areas also constitutes also a key factor in organisation and distribution and in the growth of human settlements.

4.1. DEMOGRAPHIC-ECONOMIC STAKES AND URBAN FABRIC

For the purposes of this study, the coastal zone has been somewhat arbitrarily defined as a 25 km strip from the shoreline, which explains the rather alarming rates of land use sometimes observed. In certain countries, such as Benin, for example, the coastal zone is considered on a width of 70 km.

Shoreline dynamics are a completely natural phenomenon which is in no way new, except perhaps in its possible intensification and acceleration, and so the organising of a social response to this phenomenon can only be justified by (i) threats caused by these dynamics to the security of people and assets installed in the coastal zone; (ii) the fact that these human installations and activities sometimes reinforce these dynamics in a way that is not conducive to reducing the aforementioned threats.

These key socio-economic issues clearly primarily concern the urban zones for obvious reasons: the concentration of population, infrastructure and investments. In addition, the development of these urban zones cannot be dissociated from demographic considerations related to the **geographic distribution of population**

settlements. Land settlement is therefore one of the key variables to be taken into account, but it is clearly not the only one. A second variable concerns economic activity and its related consequences in terms of infrastructure, services and space consumption. It should be clearly noted that reflections on these two subjects should be placed in the global context of the West African region and more generally that of Sub-Saharan Africa (SSA), because the future of the coastal area and fringe is related to that of the whole region that coastal are belongs to.

Demographic transition: in the middle of the ford ….

Sub-Saharan Africa is the **last region in the world to undergo demographic transition**. This process implies a population multiplication of a factor of almost ten between 1950 (approximately 180 million) and 2050 (more than 1.7 billion according to United Nations forecasts). The total population growth rates rose from 2.3% in 1950 to 2.6% in 2000. Forecasts predict a rate of 2.2% in 2025 followed by a decrease to 1.7% in 2050. This tenfold increase in the population of SSA will be differential and heterogeneous, with some desert areas or areas already densely populated to the point of saturation being evidently less concerned.

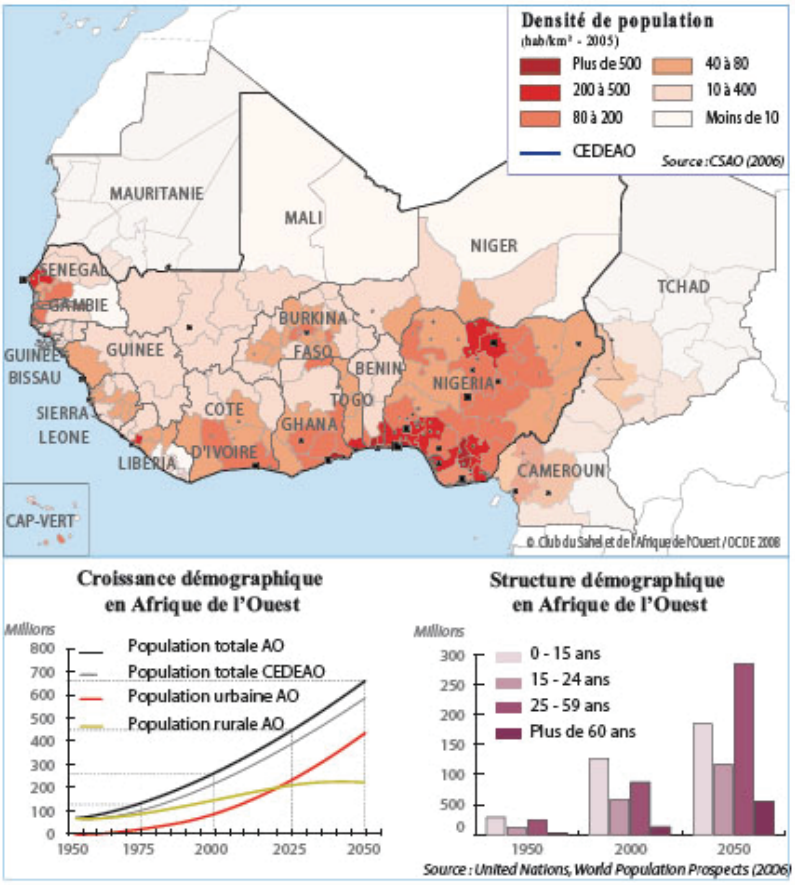

Figure 7 – Demographic indicators in West Africa (source: SWAC

Redistribution of population between coastal and landlocked countries

Over the past half-century, the proportion of the total population of West Africa living in the twelve coastal countries (including Nigeria) **increased from 27% to 31%,** while the natural growth rate (births minus deaths) of these coastal countries is typically lower than in the landlocked, less advanced countries. The past growth of this ratio is therefore a result of **net migration from the interior towards the coastal countries.** Despite the troubles which have affected several coastal countries such as Côte d'Ivoire, Liberia and Sierra Leone, this migration has continued over the past two decades. The ratio of total population in the coastal region to total population of the 19 countries in the WALTPS study represented 27% in 1950 compared to 31% in 2006.

The **population of West Africa is characterised by its high mobility**. To assess the real significance of these net inter-state migration flows and compare population mobility in sub-Saharan Africa with the other regions in the world, the size of the entities considered should be taken into account. Net migration between the countries in a region is all the more significant the smaller the country, which is the case in Africa. When this factor is taken into account, it emerges that mobility between countries in West Africa has been and remains much lower than in other regions of the world[7].

Local mobility: 30 to 40% of the population of West Africa no longer live in the place they were born in. International migration is only one aspect of population redistribution in the area within the region. The WALTPS study showed that after a lapse of time of a generation, an estimated 30 to 40% of the population of West Africa no longer resides in the district or commune they were born in. It can be noted from the map below that rural highly populated areas (with a density greater than 50 persons per km²) develop preferentially on the periphery of the cities (this map shows cities with populations of more than 50,000 in 1990). The maps of market pressure from the WALTPS study also show the importance of urban networks and infrastructure in the integration of rural areas and the primary sector.

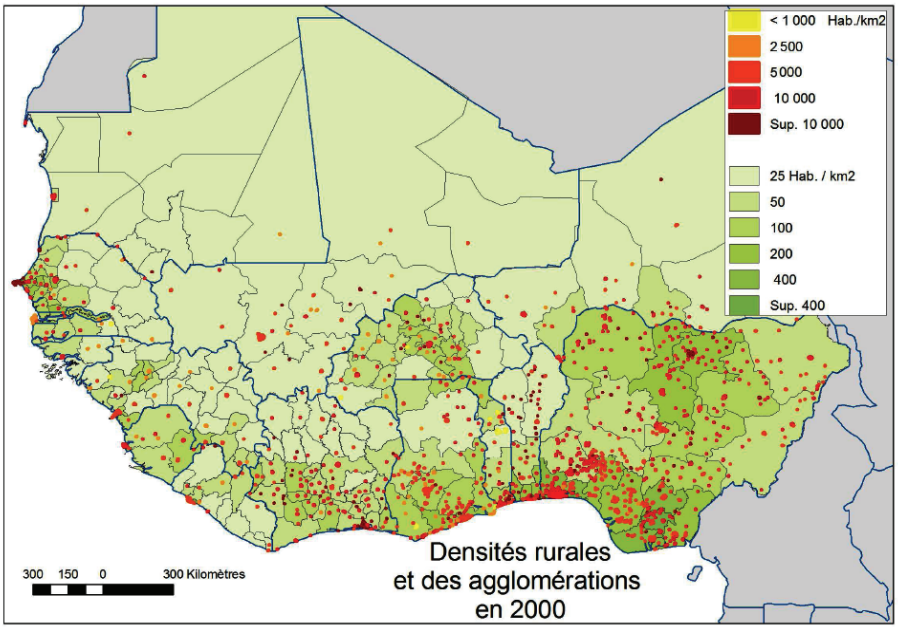

Figure 8. Rural densities and conurbations in 2000 (according to the AFRICAPOLIS programme).

What kind of urban growth?

Historically, the major capital cities on the coast of West Africa have been driven by the tertiary sector since the large trading posts of the colonial era. They developed as transit areas for exchanges between the continental interior and the rest of the World.

Today, **urbanisation is one of the most visible aspects of population redistribution**. Between 1950 and 2006, the urban population of sub-Saharan Africa grew by a multiplication factor of 14, compared to 6 in North Africa and 4 in the rest of the world[8]. Over and above the urban bias argument, according to which this urbanisation process is the result of debatable policies, and is both dangerous and unsustainable, the results of the WALTPS study should also be taken into consideration, for example, when they show that the division of labour between consumers and producers of food, led by urbanisation, is an important driving force for the transformation of the primary sector and the rural economy[9].

[8] The reasons for this urban growth that is faster than everywhere else and their multiples implications are clearly explained in the ILTA (1984) and WALTPS (1995) studies, and in the Ecoloc programme, to which the reader may refer.
[9] Multiplication of the density of local activity by a factor in the order of 100 to 1000 and radical changes in the types of activities and behaviour patterns of all the players involved.

The data analysed (see annex 3) shows that the coastal zone defined (at a width of 25km) **concentrates slightly more than half of the total urban population of the coastal countries in around one twentieth of the total surface area of these countries.** This proportion seems to be decreasing slightly, from 57% in the 1960s to 53% in 2010. This evolution is the result of two opposing phenomena:

⇒ Opening up to external exchanges, with its consequences on the coastal tropism.
⇒ The advancement of urban systems in the national territories (multiplication of "préfectures", sub-prefectures and/or other secondary towns).

To these structural factors can be added, since the 1990s, the crisis of States and structural adjustment which affected more particularly the political capitals of the coastal countries.

Outside the capitals, population growth rates in coastal towns are of the same order as those of continental towns and slightly higher than in the towns in the non-coastal countries of West Africa. These urban growth rates **are nonetheless steadily declining**, from 7.8% in 1960-1970 to 4.4% in 1990-2000[10].

The relative weight of the coastal zone in the total urban population of the countries and the trend in these ratios vary, of course, depending on the country, the surface area and morphology, and the degree to which the national urban networks are embryonic (as in Mauritania) or mature (Ghana and Côte d'Ivoire). **In most of the coastal countries with small surface areas, urban growth rates have reached or exceeded 10% per year at certain times.**

Urban footprint and space consumption

According to a recent World Bank study, **the surface area of towns increased on average by 3.2% between 1990 and 2000,** while the population of the towns in the sample increased at a rate of 1.5%. The size of towns is not a major factor for differences in growth rates: from 1 to 2% for the population and 2.5 to 3.6% for the surface areas.

For the African cities included in this study, the growth differential between urbanised surface area and urban population **is greater than in the rest of the world, in the order of 3% or more**. **The urbanised surface area per urban capita is in the order of 150 m² in Africa,** compared to an average for the developing countries of 125 m² (cities in Asia are, in general, built more densely than in the rest of the developing world).

Surface construite et urbanisée par habitant urbain (m²/hab.)

Surface construite (1)	1990	2000	Tx de crois. 1990 2000
ASS	105	150	3,6%
PVD	105	125	1,8%
Moyenne mondiale	155	185	1,8%
Surface totale urbanisée (2)		*210*	

Nota 1 Source : The Dynamics of Global Urban Expansion World Bank 2005

Nota 2 : d'après données AFRICAPOLIS

It emerges form the study that the urbanised area per capita **depends mainly on income level**. One additional point of per capita GDP is reflected in an additional point in per capita space consumption by urban population[11]. **Although we have no precise data on this subject, it may be pointed out that in a context**

[10] This downward trend in urban growth rates has been analysed in the WALTPS study, and is both structural (related to the decline in relative importance of the reservoir of rural population) and linked to the economic situation (modern economic crisis, structural adjustment, slowing down of migratory flows, etc.). The apparent one point decline in urban growth rates over the past decade 2000-2010 could be partially explained by a statistical and methodological bias (urban extensions subsequent to the last censuses and available pictures not taken into account).

[11] This relation globally reflects the incidence of several factors of land use that change with income: increase in the size of accommodation but especially of the space associated with accommodation (fall in net density); increased use of

marked by low investment capacity and lack of land ownership control, urban growth in Africa is often horizontal and not very dense, with the exception of precarious housing settlements where the densities are high.

As an order of magnitude for West Africa, the average standard is 150 m² urbanised space per urban inhabitant (excluding parks, water features, land where building is not authorised, or which is not yet developed or inhabited).

However, the footprint of the agglomerations is greater than built-up land area alone. According to the AFRICAPOLIS study, the total surface area occupied by agglomerations in 2000 was in the order of 200 m² to 300 m² per capita, and an average 210 m² per capita for the coastal agglomerations identified in this study, if Abidjan, which is said to have an abnormally low rate of space consumption, is not included.

The AFRICAPOLIS report states: "The average density of agglomerations did not increase from 1950 to 2000 as far as we can estimate in the current state of our work based on a sample of 97 towns for which we have the surface area in 1960. This sample accounts for 1/9th of the total agglomerations with populations of more than 10,000 in West Africa but 44% of the urbanised land. This primarily concerns the largest agglomerations… Between 1950 and 2000, the urbanised area of our sample increased from 766 to 6,381 km2, the average annual extension of urbanised land was therefore 5.1% compared to 4.3 for the population."

For the coastal towns, the average standard was 210 m² per inhabitant in 2000, with an average growth rate of 1% per annum.

Surface agglomérée et consommation d'espace par habitant des villes côtières en 2000 (source Africapolis)

Pays	Nombre de centres côtiers	Pop totale (millions)	Surface totale(km²)	Surface par hab (m²/h.)
Bénin	11	1,31	258	198
Côte d'Ivoire	20	3,65	331	91
Cap Vert	9	0,21	39	184
Ghana	42	3,47	890	257
Guinée	4	1,30	298	229
Gambie	6	0,53	238	451
Guinée Bissau	7	0,35	83	238
Liberia	8	0,89	269	304
Mauritanie	2	0,63	113	179
Sénégal	19	2,82	304	108
Sierra Leone	7	0,82	113	137
Togo	11	1,15	206	180
12 pays côtiers	146	17,12	3142	184
12 pays côtiers hors Abidjan	145	13,97	2890	207

(particularly) personal vehicles and correlative increase in space for driving and parking; increase in public facilities, office areas, etc.

Emprise urbaine de toutes les villes de Côte d'Ivoire et du Ghana selon l'étude AFRICAPOLIS en 2000

		Surface totale occupée (km²)	Population 2000 (1000 hab)	Surface occupée par habitant (m²/hab)
Côte d'Ivoire	196 centres	994	7624	130
	Abidjan	253	3148	80
	Autres centres	741	4475	166
Ghana	218 centres	2128	7852	271
	Accra	574	2516	228
	Autres centres	1554	5336	291

Medium and long-term demographic forecasts

The official projected population figures established by the United Nations do not take into account future migrations between countries. Due to the differences in natural growth rates mentioned previously, without these migratory flows, in 2050 the West African coastal region would only hold 29% of the population of the WALTPS study region. This hypothesis is difficult to accept, because it is difficult to ignore the differences in agro climatic potential and market access between landlocked Sahelian countries and coastal countries[12].

The stoppage or even reversal of net migratory flows between landlocked countries and coastal countries could make West Africa one of the most unstable regions in the world and one of the most prone to internal and intra-regional conflicts. Managing settlement means anticipating and facilitating future population movements, or at least the movements which are structural and not linked to the economic situation.

The population projections by region should therefore incorporate a hypothesis of net migrations for West African landlocked countries towards coastal countries, of the same kind and of a comparable amplitude to those suggested in the WALTPS study. With this hypothesis, coastal countries would concentrate 32% of the population of West Africa in 2020 and 33% in 2050. This hypothesis concerning migrations has clear repercussions on the growth of the rural populations of landlocked countries and on the growth of the urban and rural populations in coastal countries.

	Population totale en millions d'habitants. Source : UN Pop. Division corrigées pour les migrations entre pays enclavés et pays côtiers						
Région	**Composition**	**1990**	**2000**	**2006**	**2020**	**2025**	**2050**
WA Littoral	12 pays	60	79	94	131	148	231
WA pays enclavés	7 pays	142	186	208	281	313	476
WALTPS	19 pays	201	265	302	412	461	707
ECOWAS	15 pays	179	236	267	366	409	629
Sub-Saharan Africa	49 pays	510	661	766	1032	1151	1748
Littoral en % de la région WALTPS		*30%*	*30%*	*31%*	*32%*	*32%*	*33%*

[12] Even if all the ore deposits, oil products and other natural resources situated in land-locked countries were valorised, the major part of indirect activities induced by the exploitation of these natural resources **would be found in the coastal countries**. Despite mineral wealth (including uranium and no doubt oil), Niger will never have the population of 58 million predicted by the United Nations for 2050!!

Taux de croissance de la population totale par région selon les données UN corrigées pour migrations					
Région	**Période**	**90-2006**	**2006-2020**	**2020-2025**	**2025-2050**
WA Littoral	12 pays	2,9%	2,4%	2,4%	1,8%
WA pays enclavés	7 pays	2,4%	2,2%	2,2%	1,7%
WALTPS	19 pays	2,6%	2,2%	2,3%	1,7%
ECOWAS	15 pays	2,5%	2,3%	2,3%	1,7%
Sub-Saharan Afric	49 pays	2,6%	2,2%	2,2%	1,7%

What are the medium and long-term urbanisation scenarios?

Positing a medium and long-term vision of urbanisation trends that are inevitably based on supposition and somewhat artificial hypotheses is clearly fraught with difficulties. However, these long-term views are derived from:

- ⇒ The conceptual framework of the WALTPS study, which has been largely substantiated by the changes observed in the course of the last fifteen years after the study appeared.
- ⇒ The town by town projections established by the AFRICAPOLIS study for the 2010-2020 period, for only those agglomerations identified in this study, using relatively conservative hypotheses, not taking into account the redistribution of the population within the region of West Africa, nor the multiplication of small, "new' urban centres with populations of 5,000 to 20,000, which were not yet visible on the aerial photographs but the emergence of which can be expected, at the crossroads of the transport networks, on the periphery of large cities and in the dense rural areas.

It should be noted that these are only averages which should not obscure the heterogeneous nature of land use and the fact that certain more or less landlocked regions will not undergo such developments.

Future urban population growth rates are expected to fall by approximately 4% per year between 2000 and 2010 (when the probable underestimation of the AFRICAPOLIS study at 3.6% by 2020 then 2.5% on average from 2020 to 2050 is corrected)

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12 pays côtiers	(millions d'hab.)	1950	1980	2000	2010	2020	2050
Populaton totale		19	44	79	102	131	231
Population urbaine		2	14	33	46	66	140
Population rurale		18	30	46	55	65,0	92,0
Ratio U/R		0,10	0,47	0,72	0,83	1,0	1,5
Taux de croissance de U/R			4,3%	2,4%	1,5%	1,9%	1,4%
Taux de croissance de P			2,7%	2,8%	2,6%	2,6%	1,9%
Taux de croissance de U			5,8%	4,4%	3,4%	3,6%	2,5%
Taux de croissance de R			1,5%	1,9%	1,9%	1,7%	1,1%

- ⇒ **The rural population will continue to grow at over 1% per annum until after 2050,** which reminds us that, except for special cases (such as Mauritania or the Cape Verde islands) there is no rural exodus in Africa**:** with the total rural population doubling between 2000 and 2050, rural settlement will continue, with restructuring.

- ⇒ **The ratio of Urban to Rural population,** the growth of which is roughly proportional to the growth in number of urban consumers of foodstuff per farmer**, should grow by almost 2% per year from now till 2020, then at 1.4% beyond.** Farmers' market productivity and cash incomes are also expected to grow at these rates.

This particularly dynamic future urbanisation scenario is compatible with the future economic growth scenario at rates of around 6% per year in the long period presented further on, which is completely plausible.

Unless the coastal countries in West Africa and more generally in sub-Saharan Africa are the seat of generalised, repeated political and economic crises, **by 2020 the governments and local authorities of these countries could well have to manage an increase of over 40% in urban population, which would**

then more than double between 2020 and 2050. It should also be remembered that certain urban centres (in Liberia, for instance) regressed partly under the effect of certain crises.

Urban growth in the coastal zone: two possible scenarios

The tables below document two scenarios for urban growth in the coastal zone, both based on the same snapshots of settlement and urbanisation in the 12 coastal countries in 2020 and 2050, as shown previously.

⇒ **Dominant scenario: this scenario accepts the fact that coastal tropism would continue to constitute the most important structuring factor in the future, which is consistent with the economic growth hypothesis presented below, which would be reflected in particular by growth in the "modern" economy and in exchanges between West African countries and the rest of the world higher than proportional to the Gross Regional Product.**

⇒ **"Controlling disparities" scenario: this scenario is based on the hypothesis of deliberate policies to develop the land in the coastal countries, aimed at accelerating the development of what the WALTPS study called "Zone 2", distant from the coasts, corresponding, for example, for Côte d'Ivoire and Ghana, to the latitude of Yamoussoukro and Koumassi. Account taken of the response times of the local dynamics to such deliberate development policies, the "controlling disparities" scenario does not differ greatly from the dominant scenario except in relation to the long term, that is, for this study, to 2050.**

12 pays côtiers						Scenario tendanciel		Maîtrise des déséquilibres
Zone littorale	**(millions d'hab.)**	**Année**	**1950**	**1980**	**2000**	**2020**	**2050**	**2050**
Population des villes littorales			1,1	7,7	17,8	*36,0*	*83,0*	*74,0*
dont les métropoles des 12 pays côtiers			*0,8*	*6,2*	*14,0*	*26,0*	*61,0*	*54,0*
Villes littorales en % de la pop urbaine totale			62%	56%	54%	54%	59%	53%
Taux de croissance de la pop urbaine littorale				5,9%	4,2%	3,9%	2,8%	2,4%
Population rurale littorale			5,3	8,4	12,5	18,0	27,0	29,0
Population totale littorale			6,3	16,1	30,3	54,0	110,0	103,0
Niveau d'urbanisation du littoral			17%	48%	59%	67%	75%	72%
Pop. littorale en % de la pop. des 12 pays côtiers			33%	37%	38%	41%	48%	44%
Densité de population du littoral (hab/km²)			55	140	264	500	1000	900

The total urban population of the coastal zone is therefore expected to double, from 18 to 36 million between 2000 and 2020, while the rural population is expected to grow by half**.** The average population density in this zone would therefore rise from 260 to 500 per square kilometre, **with considerable differences in this average depending on the country:** the two extremes are Benin with 1,800 persons per square kilometre and Guinea Bissau with 300 persons per square kilometre[13], if we exempt the two special cases of Mauritania and Cape Verde.

From 2020 to 2050, the coastal urban population would increase from 36 to 83 million under the dominant scenario and to 74 million under the "controlling disparities" scenario. The incidence on the average rates of urban coastal population growth would therefore be 0.4% (2.4% compared to 2.8% in the dominant scenario).

Even at the relatively distant date of 2050, a priori there is therefore little room to manoeuvre between the two scenarios.

[13] Remember that this data is directly dependent on the arbitrary width defined for the coastal fringe, which is 25km in this case.

	1950	1980	2000	2020	2050	2050
Bénin	60	610	1480	3600	8900	7600
Côte d'Ivoire	100	1460	3700	7300	16100	14000
Cap Vert	20	70	210	400	600	600
Ghana	310	1550	3580	7000	16700	14300
Guinée	40	690	1390	2600	6400	5600
Gambie	30	170	560	1200	2800	2700
Guinée Bissau	50	150	350	700	2100	2000
Liberia	20	410	960	2100	5300	4900
Mauritanie	0	210	650	1400	3000	2800
Sénégal	290	1510	2910	5400	11100	10200
Sierra Leone	80	420	870	1700	4500	4000
Togo	60	470	1180	2400	5600	4900
12 pays côtiers	1060	7730	17840	36000	83000	74000

Population des métropoles					Scenario tendanciel		Maîtrise des déséquilibres
Pays	Capitale	1950	1980	2000	2020	2050	2050
Bénin	Cotonou	20	400	910	1900	4700	4000
Côte d'Ivoire	Abidjan	90	1290	3150	5600	12200	10700
Cap Vert	Praia	10	40	90	200	200	200
Ghana	Accra	160	1040	2520	4800	11500	9800
Guinée	Conakry	40	670	1250	2300	5600	5000
Gambie	Banjul	10	100	410	900	2100	2100
Guinée Bissau	Bissau	50	120	300	600	1800	1700
Liberia	Monrovia	20	320	760	1600	4200	3800
Mauritanie	Nouakchott	0	180	560	1100	2400	2300
Sénégal	Dakar	250	1270	2260	3900	8000	7400
Sierra Leone	Freetown	70	380	740	1300	3600	3200
Togo	Lomé	40	420	1030	2000	4600	4000
12 pays côtiers		800	6200	14000	26000	61000	54000

Densité de population du littoral (hab/km				Scenario tendanciel		Maîtrise des déséquilibres
	1950	1980	2000	2020	2050	2050
Bénin	233	428	846	1800	4000	3600
Côte d'Ivoire	59	190	398	700	1400	1300
Cap Vert	52	72	108	100	200	200
Ghana	99	263	489	800	1800	1600
Guinée	43	164	290	500	1000	1000
Gambie	86	229	512	900	2000	1900
Guinée Bissau	21	32	56	100	300	300
Liberia	28	69	127	200	500	500
Mauritanie	0	29	70	100	200	200
Sénégal	75	172	290	500	900	900
Sierra Leone	61	109	182	300	700	600
Togo	193	499	1054	2000	4000	3700
12 pays côtiers	55	140	264	500	1000	900

Land consumption by towns in the coastal area in the medium and long term

For the future, it is acceptable, as indicated previously, that per capita urban land use will increase at half the speed of modern urban productivity (per urban capita GDP of the modern sector), and therefore at an average rate of 1% per year over the long period, in conformity with the past trend noted by the AFRICAPOLIS study. According to this conservative hypothesis, the urban footprint should reach an average 260 m² per urban

inhabitant in 2020 and 350m² per urban inhabitant in 2050, for effectively developed surface areas of 180 and 250 m²[14].

Surface construite et urbanisée par habitant urbain (m²/hab.)				Projections		
Surface construite (1)	1990	2000	Tx de crois. 1990-2000	Taux de crois. futur	2020	2050
ASS	105	150	3,6%	1%	180	250
PVD	105	125	1,8%			
Moyenne mondiale	155	185	1,8%			
Surface totale urbanisée (2)		*210*		*1%*	*260*	*350*

The results by country, given in the following table, are rather worrying. Even in the "controlling disparities" scenario, the area occupied by towns (built on or not) would cover practically the whole of the coastal zone in the case of Benin and Togo, and between 40 and 60% in the Gambia, Ghana and Côte d'Ivoire. These indications are obviously very rough. They may act as an incentive to review the concept and boundaries of the "coastal area": different criteria should no doubt be adopted depending on the country and the physical and human conditions. The "coastal areas" of Benin and Togo should no doubt be reviewed more largely, along with, perhaps, Ghana and Côte d'Ivoire. However, natural spaces not authorised for construction should also be included, which, on the other hand, reduce the "useful area" of coastal land for urbanisation. Added to this are the perspectives of shoreline retreat, which will clearly not help to increase the land available.

This very global, provisional analysis tends to prove that **the coastal area could, in the long term, become a practically uninterrupted conurbation** from Ibo country in Nigeria to Abidjan in Côte d'Ivoire, with metropolises with populations of several million every 100 km or so, and hundreds of satellites and farming towns serving the agricultural conversion areas, intensive farming areas and areas of industrial-type animal production, leaving little place for the development of tourism and the conservation of nature.

Here are identified also a few hot spots of coastal development, and the countries where it is most urgent to implement specific urban policies aimed at opening up to urbanisation places that are not equipped today or are not very suitable for urban development, due to lack of access and infrastructure or due to breaks such as those resulting from lagoons and coastal water features, **or preferably towards the coastal hinterland, thereby arranging the sensitive areas on the fringe immediately adjacent to the shoreline**.

This analysis could also act as an incentive to examine the possibility of setting up instruments on a sub-regional scale, with the principal institutions in the region and their partners (such as the CILSS-SWAC pair). These instruments would be to **closely monitor the settlement of the coastal zone and drive suitable land development policies, but these different points will be broached further on**.

[14] Note that this hypothesis remains very conservative, for the expected growth in per capita Gross Regional Product is perceptibly higher than the growth observed in the past.

Consommation d'espace des villes littorales							
(en KM² et en % de l'espace littoral)		Surface urbainsée (km²)			en % du littoral	Surface urbainsée (km²)	en % du littoral
Pays		Etat actuel	Scenario tendanciel			Maîtrise des déséquilibres	
	Surface de la zone littorale	2000	2020	2050	2050	2050	2050
Bénin	2664	311	947	3106	117%	2671	100%
Côte d'Ivoire	14260	777	1908	5621	39%	4905	34%
Cap Vert	4030	44	96	196	5%	196	5%
Ghana	12370	751	1825	5828	47%	5012	41%
Guinée	10760	292	680	2228	21%	1968	18%
Gambie	1725	117	305	982	57%	951	55%
Guinée Bissau	12590	73	195	732	6%	692	5%
Liberia	14090	201	549	1863	13%	1710	12%
Mauritanie	14550	137	354	1057	7%	995	7%
Sénégal	15330	611	1396	3870	25%	3573	23%
Sierra Leone	10990	184	431	1560	14%	1392	13%
Togo	1854	247	625	1951	105%	1723	93%
12 pays côtiers	115000	3746	9312	28994	25%	25788	22%
consommation d'espace urbain en m²/hab		*210*	*260*	*350*		*350*	

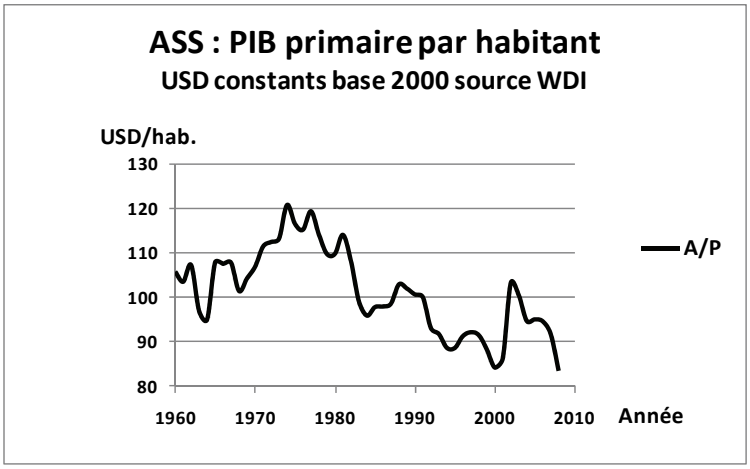
4.2. ECONOMIC OUTLOOK

The development, equipment and occupation of the coastal zones will also closely depend on how the economic situation evolves, which will determine investment capacity, in particular. This is a attempt to produce a long-term picture of the coastal economy and its implications us also given in annex 3. The data analysed shows the necessity of being able to provide environmental support to changes that may be considerable under the pressure of the markets.

Structural changes more difficult to apprehend

The departure point for an analysis like this resides in the data and national accounts logs which mainly measure cyclical economic fluctuations. The structural changes over a long period are more difficult to apprehend. The WDI[15] (for 2010) published by the World Bank show that average per capita GDP was expected to return in 1975 to the level it was at before the crisis… Nonetheless, the structure of population settlement has changed considerably in the meantime, while these indicators suggest that the informal per capita GDP would have declined by almost 50% in that period. Observation of the living conditions in rural localities or in popular residential areas makes this assertion debatable. Similarly, the apparent near stagnation of primary value added by agriculture - which would be reflected in the decrease f more than a third in per capita agricultural production – should be questioned, while the average food ration – which is still inadequate – improved in terms of both quantity and quality.

[15] World Development Indicators



Actual economic performance levels are probably under estimated

The actual performances of African economies therefore seem to have been underestimated by these indicators, which should be cross-referenced with population growth forecasts.

A second point concerns the possibility of an economic recovery, preceded by a take-off phase, a situation experienced by many regions in the world (Japan, URSS, China, India, etc.). 4% growth in per capita GDP in the economic take-off phase, then 6 to 8% in the catch-up phase are the actual values observed in these different cases. The scenario proposed here supposes that after a long period of institutional maturation, assimilation of post independence conflicts and opening towards the world, the time would be right for sub-Saharan Africa to begin the economic take-off phase. There is nothing extravagant about GDP growth of the order of 6% per annum until 2020 (or 4% for per capita GDP) then 5.7% from 2020 to 2050, summarised in the table in annex 2, and this is compatible with the picture of the redistribution of population and urbanisation mentioned above. This scenario would be reflected in a growth trend of the order of 4% per annum for primary productivity (that is to say, per capita value added in the primary sector), 2 to 3% per annum for average productivity and income in the informal sector (or, rather "popular" sector) and 0.5 to 1% per annum of productivity in the “modern” sector.

One of the particularities of this reading concerns change in the population redistribution between the primary and non primary strata of the population, or between the rural milieu and city, reflected in the ratio between primary and informal productivities. Currently this ratio is above 2. The stabilisation of population settlement should see it decline in the long term (to around 1.5 in 2050), as growth in the popular economy is the result of several factors:

- ⇒ A take-off in the agricultural economy enabled by expansion of the domestic market and intensification of city/hinterland exchanges. **The known limitations of natural capital (soil types, agro climatic constraints, saturation of land use) could, however, strongly hamper this perspective**[16]**.**
- ⇒ A slowing down of migratory flows towards the towns.
- ⇒ Growth in the size of towns and its effects on urban productivity.
- ⇒ An accumulation of capital and the valorisation of know-how developed in the course of the past decades in a multitude of micro-companies and informal production units.
- ⇒ Increasing interaction between popular economy and "modern" economy.
- ⇒ A gradual restoring of the capital for local public investments ("IFL") and improvement in local governance as a result of decentralisation.

Persistent duality of the urban economy

In this scenario, the growth of the non-primary "modern" economy draws on the change in urban population involved in the modern sector. The mutation of territories (settlement, equipment), accompanied by the

[16] Giraud. P.N. & D. Loyer. 2006. - **Capital naturel et développement durable en Afrique.** In A quoi ça sert d’aider le Sud ? Serge Michailof publisher.

corresponding public and private investment should enable the emergence of enterprises centred first of all on the African market (a population of almost 2 billion), but also in turn taking advantage of the reduction in comparative advantages in terms of labour costs in the countries with intermediate level income, which will also be confronted over this long term period with no less considerable environmental constraints. **This hypothesis of delocalisation of labour in low technology industries towards Africa should however be weighted, given the growing environmental pressure** (carbon, hydrocarbons) of globalised trading practices. In any case, such delocalisations would only concern the best equipped centres in terms of services and infrastructure.

The persistent duality of the urban economy, both popular (informal) and "modern" would obviously be reflected in the urban structures: "business districts" and residential areas with the standards of the developed countries and vast peripheral areas with the minimum level of equipment compatible with the local authorities' investment and management capacities and with the living conditions of the population. In this intermediate phase of the demographic transition, the disparities in productivity and income between the strata (modern, informal and primary) of the metropolises, average towns, small towns and the rural milieu could decline, but would remain high.

Tenfold increase in the Gross local product in the coastal fringe

Between 2008 and 2050, the density of economic activity as measured by the Gross Local Product per km² of coastal zone will be multiplied by a factor of 11 to 13. This is one of the parameters to be taken into account when drawing up certain components of the coastal development schemes: definition of vocations and rules for land use, zones devoted to heavy industry, practically non-existent today, urban environment (industrial estates, waste management, water supply, treatment of waste water, lagooning, etc.) and periurban environment (market garden belts, agri-towns, tourism areas, protected areas, etc.) development and service policies, land ownership policies. Countries in which the industrial pressure on the coastal area will be highest will be, like population, Benin (whose immediate proximity to Lagos makes the harbour area of Cotonou practically an annex of Nigeria), Togo, Côte d'Ivoire, Ghana and, more locally, Senegal with the Cape Verde peninsula and the Greater Dakar district.

The need to accumulate private and public residential urban capital and the recurring cost to the local authorities of maintaining public local investment capital evaluated in the case of Cotonou draw attention to two critical issues for the sustainable development of the urban or economic zones:

⇒ The balancing of development solutions that reconcile coastal development ambitions, goals in terms of equipment standards and quality of service on the one hand, and the preoccupations and priorities of governments and local authorities, and the capacity of local operators (enterprises and households) to change behaviour patterns and bear any excess costs.

⇒ The implementation of devices to mobilise local resources to face recurring expenditure and the methods for accessing funding through borrowing on a par with needs, taking account of the contributive capacities of households and operators. We have seen that the cost of maintaining public assets by the local authorities can and should therefore be wholly financed by a bearable levy on the value of private assets, therefore with no external financing. It is clear that the main success factor for the sustainable development of the coastal area would be to have all the local institutions effectively capable of maintaining their capital, which is not the case anywhere in West Africa today.

Take into account the perspectives of catching up economically

The possibilities of economic catch-up could today act as an incentive to the countries in the region to secure existing land reserves in the hinterland behind the coastal area that are strategic and equippable with a view to setting up activity zones. This retreat to the hinterland would also be encouraged by the increasing value of land, which would become prohibitive near the coast. This contrasted scenario also allows us to highlight the critical issues for the management of an ultra-dense coastal zone towards 2020 and 2050, and the necessity of preserving natural infrastructure and the corresponding ecological services, which will play a fundamental role in supporting such developments.

These figures confirm, if it were necessary, that the zone located immediately behind the actual coastline constitutes an area that is of strategic importance for the whole region, where competition for the use of land and sites will become increasingly keen.

The economic future of the eleven coastal countries and even of the hinterland will depend in large part on this coastal area, which, due to the population concentration, contains both a wealth of potential of all kinds will inevitable be subject to growing environmental pressures and constraints.

The expected economic growth should also improve the solvency of the territorial authorities, enabling, as is observed today in countries with intermediate revenue levels, the instigation of more or less ambitious urban renovation operations and the reclassification of districts allowing the anticipation and integration of the constraints and advantages related to the proximity of the sea.

It should be stressed, however, that these developments will occur in a very contrasted way depending on the region in question. Some countries, such as Guinea Bissau or Liberia, will simply continue to conquer land that is relatively unpopulated and where the urban fabric is and will remain relatively loose. The availability of water could constitute an essential restricting and structuring factor in how the land use in the coastal area evolves.

4.3. HARBOURS AND TRANSPORT INFRASTRUCTURE[17]

The countries in the region count 36 main identified ports (World Port Index), around fifteen of which have volumes of traffic in excess of 500,000 tonnes. It is obviously difficult to envisage the West African harbour network without including Nigeria, which is by far the largest. Most of the main harbour infrastructures (Nouakchott, Abidjan, Tema, Lomé and Cotonou) have caused profound disruptions of the downdrift coastal areas in relation to sediment transport.

Most of these ports handle international or even intercontinental traffic, as the regional traffic is not yet highly developed. These ports have a variety of different origins: built on the historical site of a colonial harbour (Cotonou), established in a peri-urban zone (Lomé), genesis of a satellite harbour town (Tema in the case of Ghana). In all cases, whether the ports were developed or extended in a particular context (at least in the Gulf of Guinea), marked by a narrow shelf, low sediment stocks and a strong longshore drift, these infrastructures have strongly disrupted coastal dynamics downdrift of and in the immediate proximity of the developments. These harbour systems also include several specialised facilities: ore wharfs, fishing ports with varying facilities and quays for landing catches, coastal shipping points in particular in mangrove areas or border areas typified by informal trading, such as between Benin and Nigeria.

Given the current issues at stake, the West African ports will have to increase both in terms of capacity and efficiency[18], and due to their configuration not all the ports are on an equal footing to face this challenge. International maritime transport is developing towards increasing use of containers and the increasing size of ships. At the same time, companies are undergoing concentration (acquisitions and mergers). This already implies being able to increase the capacity of the principal ports to allow the access of ships of more than 5,000 TEU (current capacity is often limited to 2,500 TEU).
While this trend may lead to the emergence of a few principal hub ports able to dock high tonnage units, these will be relayed (transhipment) by increased regional liaisons with ports of lesser capacity. The specialisation of one or two principal ports will certainly not be on the agenda. This is because shipping companies always conserve a strategy of relative diversification with respect to the risks of insecurity and emergency situations which should always be considered. The performance levels of the ports (in particular for transit towards isolated countries) will also remain dependent on the quality of road connections and on the level of administrative constraints to landing. The contingencies of political instability which still exists in places will continue to affect the appeal of West African ports.

A favourable growth context in the sub-region, combined with the trends mentioned above, indicates that most African ports will be lead to undertaking work to extend their capacity. The associated impact studies should be conducted with rigour and from

[17] See annex 4.
[18] Harding. A. & al. 2007.- **Ports et transports maritimes en Afrique de l'Ouest et du centre. Les défis à relever.** World Bank, EEC, UNDP. Programme de politiques de transport en Afrique Subsaharienne. Working document SDSTAP N° 84F. 56p.

the perspective of taking into account all of the coastal systems concerned. AGPAOC (Port Management Association of West and Central Africa) could become a key contact for dialogue relative to coastal erosion.

Furthermore, the penetration of the private sector in the management and even building of ports (for ore ports) as is the case for the projects in Guinea Bissau, Guinea, and possibly Saint Louis if the Senegal river navigability objectives set as part of the OMVS are met, should act as an incentive to the States to be vigilant in taking into account the environmental and coastal impacts of these new facilities.

Roads and land routes

The road network, which is of varying serviceability, and for which we do not always have a reliable picture on a regional scale (updated database[19]) is organised roughly into two types of routes:

- **Routes inland from the coast to the interior** historically connecting the West African port capitals with the interior of the countries**.** Some of these old routes are paired with a more or less functional railway line (Dakar-Tambacounda-Bamako; Conakry-Kankan; Abidjan – Bouaké –Ouagadougou) some of which are essentially for the transport of ore (Conakry, Nouadhibou). In the 1960s, these "penetration routes" were not connected to each other, except by the coastal route between Accra and Lagos, linking Ghana, Togo, Benin and Nigeria. Another coastal road served a part of Côte d'Ivoire from Abidjan to San Pedro. In Senegal, the internal road system was already relatively organised.

- **East-West interstate connections of regional importance:** Between 1960 and 1975 the East-West interstate connections were developed with the connection of the whole area from Côte d'Ivoire to Nigeria. The network in Senegal was also improved, as was the interconnection of the network of major cities in the non-coastal Sudanian-Sahelian countries.

The current situation shows 3 major regional routes:

⇒ **The coastal route from Port Harcourt to Nouadhibou,** with two functional interconnecting segments: Port Harcourt-Liberian border (Gulf of Guinea) and Kaolak-Nouadhibou in Mauritania. Between Liberia and Guinea Bissau, in many segments of the route serviceability is uncertain, and the route is not coastal, since it bypasses Liberia and Sierra Leone and does not connect with the coast. The same can be said of the Boké (Guinea) – Bissau liaison. NEPAD is planning to build a trans-coastal motorway link from Nouadhibou to Nigeria (6 lanes over a distance of 4,560 km at an estimated cost of US $10 billion).

⇒ **The Sudanian-Sahelian route** is more or less serviceable from Bamako to Kano in Nigeria. The link from Nouakchott or Dakar to Bamako is also more or less practicable, although conditions are sometimes difficult. A project for a Trans-Sahelian route is under study by NEPAD, the Dakar-Bamako segment is already scheduled.

⇒ **The Sudanian route,** which links Kankan-Korhogo-Tamale-Kara-Parakou-Abuja. This route should be consolidated and reinforced in the light of the force of attraction these zones represent for agricultural and agro-food production.

A last route, still relatively undeveloped, could be described as coastal hinterland. This route would connect Nzérékoré, Yamussukro – Kumasi – Bohicon and could play an important role in the integration of the area inland of the coast. It would constitute a pertinent, driving measure in the reconfiguration of a future coastal area by relieving population pressure in the immediate coastal fringe, if accompanied by the associated structural equipment.

[19] Staff communication. AFRICAPOLIS.

4.4. SPATIAL EXPRESSIONS OF COASTAL LAND USE

Human land use of the West African coastal areas is expressed in different ways through the:

- ⇒ Development of built-up areas and urban areas
- ⇒ Transport infrastructure (roads, ports)
- ⇒ Footprint of production systems characteristic of proximity with the sea and lagoons (rice-growing, salt production, green/market garden belts and fishing) in rural coastal landscapes.

Growth and development of agglomerations: Spread and corridorisation

Spread: The first thing that stands out about the growth of agglomerations is the horizontal spread of built-up areas, with the evident consequence of considerable land use, rising cost of facilities (roads, power, sanitation, etc.), accentuated by the often low-lying, flat topography of the littoral areas occupied by coastal agglomerations. These are often situated on the edge of a lagoon, in situations that complicate the collection and evacuation of waste waters and rainwater… Spread is often also responsible for the "exiling" of population groups in a precarious economic situation to peripheral areas far from the centre. Note that the historical centres of the largest agglomerations are typically located in proximity to the sea front.

Corridorisation: agglomerations usually spread in corridors following the busiest communication routes. This corridor development can take on considerable dimensions in some cases, evolving into a long conurbation, as is the case between Keta (in Ghana) and the border with Togo, or between Lomé and Cotonou, in both cases along the coastal interstate road. In the case of Ghana, the model differs somewhat, with a mesh of "micro-centres", hub crossroads and small agglomerations in satellite positions around the major cities. These growth centres have a tendency to join up in the long term. In Senegal, there is an intermediate situation, where corridor concentration is sometimes weighted (except in the case of the Dakar peninsula) by a regular and relatively balanced road grid with tentacles stretching towards the different expanding secondary towns.

For the low income population groups residing in the sub-standard, peripheral districts, he distance from the centre, the site of most formal and informal economic activity, leads to high transport costs. The alternative sometimes consists in finding locations closer to the centre, which can cause sub-standard settlements to grow up in low-lying areas (often flood-prone), next to the seashore or a lagoon (for example, Port Bouet in Abidjan, settlements in the mangroves in Bissau and Conakry), on land that is often publicly-owned, and therefore with no previous right-holders.

Apart from the situation of the consolidated districts (historical, partly) of urban centres, the dynamics of extension to Periurban areas or areas in proximity to the sea is organised succinctly around for basic types:

- ⇒ Extensions related to industrial activities, with, in particular, the attraction of harbour areas.
- ⇒ Districts of ("spontaneous") sub-standard settlements near to centres and located in at risk areas.
- ⇒ Periurban extensions for residential purposes (seaside residences) or tourism, often along the coastal road routes on either side of the main agglomeration.
- ⇒ The fishermen's districts located very close to the shore and canoe landing areas, in more or less precarious settlements.

Most of the time, these urban and Periurban footprints develop without an overall plan and with no control of land ownership, which would have allowed prior consideration of the risks of settlements too close to the shore.

Ousmane Diallo, resident of Saly, municipal employee.

"I live in Niakhniakhal, in the third line. I've been in Saly since 1990. It has changed a lot, there's hardly any beach left. it's very serious!
it's hard because people have invested millions in building along the sea front. There are people from Senegal, but mostly foreigners."

These urban developments also imply the mobilisation of building materials leading to extractions and quarries. The extraction sites are logically located as close as possible to the sectors being extended and concern fragile coastal formations, such as dune rims, for the extraction of sand. In other cases, rocky materials are employed either in blocks, or crushed, as is the case in Togo for the beachrock freed by erosion, an effective natural protection for a coast that is under threat, today subject to exploitation. Generally, regulatory measures eventually ban the practice, but either these come late or they are difficult to apply as long as viable economic and environmental alternatives have not been identified and possibly accompanied by public action.

Tourism and seaside residences

The generalisation of a global residential and leisure model confers particular appeal on the coast, which is expressed through (i) urban sprawl on coastal areas, followed by (ii) the densification of building in periurban and/or interurban coastal areas. The most attractive segments of coast (not isolated, with the right exposure, possessing a heritage of attractive beaches preferably not too far from the urban centres) are experiencing rapid growth related to the expansion of a tourist clientele mainly international initially, but increasingly regional and national as a more or less wealthy middle class emerges.

The stability of the coastal areas "under tourism" in this way is threatened:

⇒ By the facilities built on the rim and on the backshore, depriving it of its sediment reserves and the exchanges that ensure its equilibrium.

⇒ By disrupting the coastal drift, either through the building of leisure facilities affecting the beach, or even the intertidal zone, or even more so by individual or “spontaneous” anti-erosion structures put in place by owners anxious to preserve an heritage of beach exposure already deteriorating. These improvements attempt to remedy after the fact the impacts of the careless location of buildings without taking beach dynamics into account. The inequalities here are flagrant, when the best placed owners protect the beach of their hotel or residence with the use of groynes to the detriment of rights holders situated downdrift of the groynes, who experience increased erosion on their land. Note also that these improvements, often in the same way as the buildings that made them necessary, are carried out on the maritime public domain.

Another consequence of the intensification of tourism resides in the specialisation of the functions of the coastal zone, with the emergence of conflicts for use of beach areas that are gradually contracting due to erosion, in particular with activities related to fishing (the beaching of canoes, fish processing, smoking, etc.).

The multiplication of spontaneous individual coastal defence and protection actions turns out to be completely counter productive, and aggravates the sediment deficits observed globally. This is also a factor that reinforces inequalities, for the attempts at localised solutions implemented by owners with sufficient means triggers an acceleration of downdrift erosion affecting the more modest properties of poorer population groups or even traditional villages, when these alternate with major hotel infrastructure, as on the Petite Côte in Senegal.

This "privatisation of the sediment heritage" is only one of the signs of the accelerated privatisation of the coast in sites that are "under tourism", which also leads to the public being denied access to the beaches in front of the seaside hotels and residences, or by the closure (walls and building) of sea views from public tracks and areas.

The future demand for seaside leisure resorts, in particular in the major metropolises, and the respect of landscape identity of all the coastal sites, should as an imperative be anticipated through a “back to basics” approach regarding the inalienable nature of the public domain.

Taking into account the acquired experience of the countries in the North regarding the impacts of poorly controlled densification of tourism in proximity to the shore should lead, in the emerging tourist or residential areas in West Africa, to drawing the contours of new modes of the urbanisation of leisure that are effective in terms of risk prevention and respect the landscape identity of the sites, which ensures their long term appeal.

Legal pluralism and control of land ownership

The acceleration of the often anarchic and spontaneous use of coastal land is all the more pronounced as land ownership control often remains hesitant in contexts that were still rural a short time ago, where legal pluralism prevails in terms of land ownership (customary law and modern law).

While the situations are obviously different, the institutional framework of land planning in the countries of the region has underground profound change since independence, the starting point of which has been the rise in informal transactions, while the state was officially the main player in terms of planning. Attempts of make the

land ownership process sustainable have witnessed the gradual withdrawal of the states and the transfer of these prerogatives to development companies and/or to territorial authorities. For the local populations, customary law is nonetheless still attached to the land that is subject to transactions. This legal pluralism constitutes the backdrop against which demand for coastal real estate has increased, driven by the quick capital gains realised and accompanied by doubtful or even completely illegal practices, sometimes combined with corruption ("spontaneous" allotments that short-circuit building permit procedures, frauds, sale of fictitious land or the sale of the same piece of land to several buyers). The insecurity typical of land ownership transfers in this context also acts a stimulant on the rate of transactions. The Gambia is perhaps the only one of the counties where the current distribution of land development and tourist activities seems to follow planning logic that is certainly relayed by the public authorities.

For the local populations, customary law has never really been discharged, and those who are attached, for example, to the property of the produce from plantations (coconut groves, for instance) are not alienated by the sale of the parcel of land.

The few land reserves it has been possible to establish make the population feel they have been robbed, comparable to the feelings aroused in the colonial era with regard to listed forests. This feeling is even stronger when the land planning operations lead to displacement and sometimes to the forced relocation of the population.

Fishing: An essential precursor of the human land use of coastal areas

With an EEZ in excess of two million km², and the existence of upwellings (essentially in Mauritania, Senegal and the Gambia) rendering the waters highly productive, fishing livelihoods are an essential component of the development strategies of the coastal states of West Africa, not only in building their GNP, but also in the struggle to attenuate poverty and malnutrition. Fishing is an important sector for employment (approximately 600,000 jobs in Senegal, more than 500,000 in Ghana).

The competition for access to these fishing resources is intensified in a global context of increasing demand, and access to pelagic resources (but also to a lesser extent, demersal resources) is coveted by foreign fleets - European fleets through fishing agreements, but also Asian (Korea, China) and Eastern European fleets. The way these foreign fleets respect the access conditions is sometimes relative, and the fiscalisation of the activity remains very unequal, depending on the states and their foreign partners.

While total catches have increased regularly since 1950, this growth should also be compared to the regular increase in fishing efforts and the efficiency of fishing units. The observed depletion of certain stocks of demersal species, the sensitivity and fluctuations recorded in certain specific fisheries, such as cephalopods, closely dependent on the conditions of the milieu (in particular of the upwelling), certainly attest to a deterioration in the composition, structure and organisation of marine biological communities.

Artisanal and canoe fishing: A diversified activity that takes multiple forms

Fishing practices and the relations coastal societies maintain with territory (land and sea) and resources appear extremely varied. They can be plotted on a gradient from the situation of the "farmer-fishermen", for whom fishing is often only a temporary activity within complex production systems, traditionally combining seasonal agriculture; to nomadic fishermen whose main activity is fishing.

Here we find the contrast between strategies based on (i) adaptation to a territory (in-depth knowledge of the milieu, extent of fixed and sedentary resources, valorisation of a complex mosaic of resources that are complementary in time and space) and (ii) on adaptability and mobility.

M. Diarra, Rural Community of Malikunda:
"Erosion creates major problems for landing. The fishermen are forced to go up to land at Pont-Sarène. They all go there because that's where there's enough space. They migrate, like seasonal workers."

Moussa Pouye, editor in chief of Radio Jokkoo FM, Rufisque:
"For the listeners, there's not enough fish. There are several reasons for this: 1 – you have to be able to go out to sea; 2 – as there are no coasts anymore, the fish swim out to the high seas; 3 – there's not enough beach left to land the canoes, to repair the nets, to process the fish."

Cheikh M.A. Dieye, mayor of Saint-Louis:
"The economic consequences of coastal erosion are heavy. There is practically no agriculture left. For the fishermen, there have been numerous losses of human life, and the distances to be covered to go and fish have increased considerably. Many fishermen set off for Spain, illegally. They know the sea very well, but the risks are immense and we all know what happens."

It is above all from the angle of diversity that coastal fishing activities should therefore be apprehended, diversity of techniques, strategies, means, goals and motivations. The history of canoe fishing in West Africa has been analysed by many players since the colonial era, and the present day period is certainly the one which has experienced the most profound transformations, principally due to two factors:

⇒ The droughts in the 1970s and 80s, which saw a reduction in the proportion of agriculture in some mixed and diversified production systems, and led to the population migrations from inland areas to the coast.

⇒ The motorisation of boats, with increasing access to capital, leading to an increased sphere of action, not only towards pelagic resources, but also towards the delocation, sometimes to a far remove, of fishing grounds.

Territories and canoe fishing

The observation of the historical location of fishing villages all along the West African coastal area hides the more complex and dynamic reality of the appropriation of coastal territories, in which can be distinguished:

⇒ **Fishing grounds**: Maritime production areas, but also estuarine or mangrove. Fishing grounds are defined as portions of space appropriated and exploited.

⇒ **Fishing centres:** Fishing centres evoke the occupation and management of the land part of the coastal area in relation with fishing activities. The land footprint of fishing activities takes different forms: fishing villages, fishing centres or migrant fishermen's camps.

Babacar Sy, Sapco, Saly
"At the level of the village – which has a population of around 20,000 – we have lost a lot of places for landing canoes; the fishermen are forced to land further on or to moor their canoes in the water (this is not good for the wood, which can sometimes rot)"
At Saly, few fishermen land, because you can't process the fish on the beach here, the smell and the smoke would disturb the tourists too much."

⇒ **Coastal territories:** More or less organised around fishing activities, the way coastal territories have evolved is partly determined by competing uses for space and resources, in which fishing can play a key role.

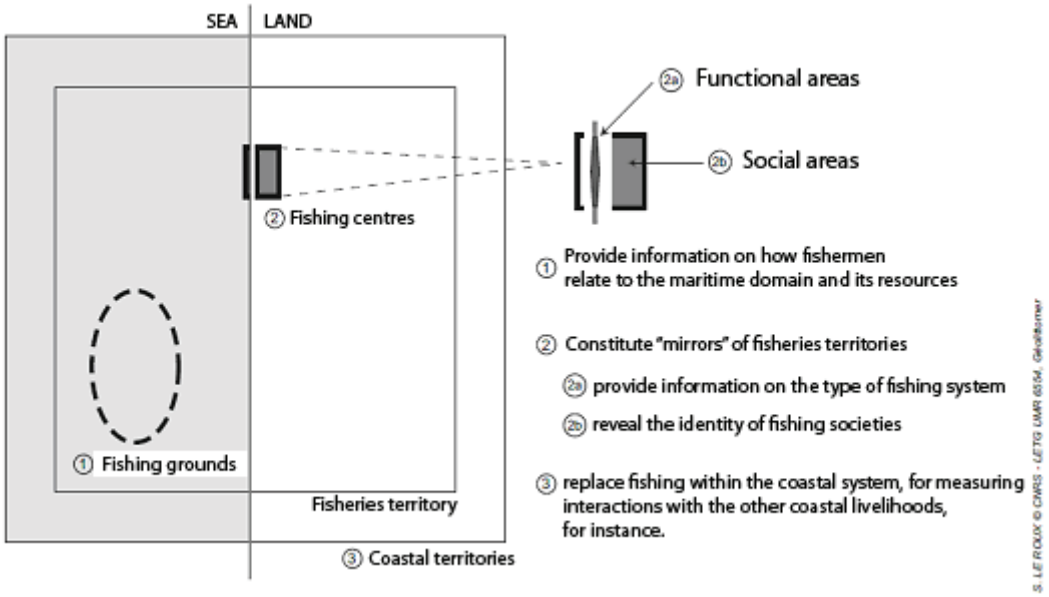


Figure 9. Scalarity and fishing grounds. According to Leroux, 2005.

Human settlements related to canoe fishing are very diverse and largely distributed all along the coast.

Fishing villages are settlements often established long ago in proximity to the resources, not only fishing but also land and agricultural resources. There is a high number of them, but they are not characterised by rapid

change in their land footprint, except in specific situations (well-connected villages, river mouths and estuaries), in particular related to the expansion of tourism.

Fishing centres are located in situations giving precedence to connection to the markets (in particular urban markets) for the supply of input and the disposal of produce, and to processing units and sites. In certain cases, these centres were created on the initiative of development projects. They are either a development on existing fishing beaches, or the creation of a new centre from scratch (in Mauritania in particular). Three types of harbour infrastructure directly reinforce the appeal of sites: Ice factories, fishing wharves-markets and petrol stations. In these centres there is a specialisation of the use of space depending on the different business lines (ship repair, processing, etc.). These fishing wharves are placed directly facing the beaches where the canoes land and whose traditional socio-cultural, or even commercial functions (influx of merchants and small local traders), generate considerable activity and frequentation. These developments are sometimes contradictory with the concern for hygiene (also related to non-tariff export barrier) expressed when the centres are being set up. An exception is made however in the case where the abundance or the quality of the resource justifies for the fishermen a relatively large distance from the developed centres. In these cases (Mamghar in Mauritania, Djifer in Senegal), the wholesale fishmongers are the ones who travel to the catch landing points.

Fishing centres play a key role in the sedentation of migrant fishermen, with the development of a social space ("fishing towns" or "fishing districts" in the urban and Periurban areas) all the more rapid as canoe fishing plays a larger part than other sectors in demographic growth (family-based activity, revenue relatively higher than in other occupational categories).

Fishing centres are typically attractive sites, whose openness and economic activity also polarise migration from the interior to the coast of people in search of opportunities to develop commercial activities or services. If these dynamics are accompanied by corresponding effort in terms of community facilities, fishing centres may even be considered precursors of the urbanisation of the coastal area.

Migration

A detailed historical review of the migration of fishermen was recently carried out as part of the RECARGAO[20]project.

"The migration of fishermen in West Africa between 1988 and 2008 is organised around five main foyers: Saint Louis and Petite Côte in Senegal, Guinea, Sierra Leone and Ghana. These foyers are distribution areas of varying sizes, which have been continually evolving over the past two decades. The migrants are concentrated in seven main reception areas: Mauritania, southern Senegal, the Gambia and Casamance, Guinea-Bissau, northern Guinea and southern Sierra Leone. (see reference).

The image of farmer fisherman[21] is already familiar, and added to this is the image of fishing "itinerary"[22] for nomadic fishermen. Migration is omnipresent all along the coast being studied, and constitutes a fundamental characteristic of present day West African fisheries. In the major fishing centres in Senegal, the migration began a long time ago. The mobility of fishermen is first of all related to the intensification of exchanges on the coastal interface, generating both the local markets related to the development of the urban centres, and the increasing opportunities for exports also corresponding to growing demand. The devaluation of the CFA franc accelerated this dynamic trend.

Historically, migrant fishermen are mainly from Senegal and Sierra Leone. Around 1950, the migration of fishermen from Ghana increased. Coastal urbanisation was beginning to create land constraints for agriculture, which incited the farming population to convert to fishing. Generally speaking, the regions migrant fishermen leave are characterised by strong pressure on land. The development of motorisation in the 1960s also played a part in increasing the mobility of the populations of fishermen. The development of techniques and the professionalization of the activity also switched fishing pressure onto small pelagic species, with the increase of the sphere of action of the canoes. Ethnic groups who were traditionally nomadic fishermen also played a role

[20] Binet, T., Faillé. P. & R. Bayeux. 2009.**- Etat des lieux et évolution récente des migrations de pêcheurs artisans dans les pays de la CSRP.** 105p.
[21] Firth, R. 1946.**- Malay Fishermen: their peasant economy,** London, Kegan, Trench and Trubner, 349 p.
[22] Cormier-Salem ;, M.C. 2001.**- Terroirs aquatiques et territoires de pêche: enjeux fonciers halieutiques des sociétés littorales ouest-africaines.** 25p.

of incentive and distribution of modern fishing techniques for the coastal populations of sedentary farmer-fishermen.

The fishing practices of migrant fishermen are extremely varied, from the point of view of the species targeted and that of the means implemented, the occupational organisation of the migrants and the techniques employed. They are also obviously very sensitive to changes in the context, either natural, influencing the distribution of the resource, or socio-economic and political, altering the access to the resource and to the fishing grounds. Mobility determines a real capacity for economic optimisation (of the cost of inputs, for example) and of the profitability of the activity. This optimisation is also noted regarding the organisation of the industry:

⇒ The migrants are often "certified" by intermediaries with capital who buy the produce before exporting it once it has been processed.

⇒ Fishing development projects also encouraged the provisioning of migrant fishermen: Supplies of foodstuffs, ice and fuel.

⇒ Methods of processing were also specialised/professionalised, to the detriment of traditional methods (typically done by women).

This professionalised and "intensive" fishing was concentrated mainly in the upwelling zones, but also seasonally concerned other zones (in Guinea Bissau), where the fishing resources were concentrated seasonally.

Agricultural development of coastal areas

As a reminder, there is the seasonal use of coastal areas for pastoral activities in the most arid areas (“salt cure”).

Two modes of agricultural use of coastal land are widely distributed: Vegetable growing around the edges of urban concentrations (market gardens on the edges of lagoons, estuaries and low-lying land behind the dunes) and rice-growing in mangrove. This last activity is deeply rooted in the coastal landscape from Casamance to Sierra Leone, where it occupies large areas of land. Globally, three main systems for mobilising land and water resources should be distinguished:

⇒ Rice-growing on cleared, drained mangroves that are not inhabitable.

⇒ Rice-growing in sandy channels flooded in the rainy season, with settlements concentrated on the sandy rims above water.

⇒ Rice-growing in groundwater and flooding of wet zones and low-lying ground, with the population residing on nearby unwatered hills.

The future of these different types of rice growing, always sensitive due to their topography, could be called into question if there is even a modest rise in sea level. This concerns rice-growing in mangrove territory, where making and maintaining dykes is labour-intensive. The situation, which is often critical today (see Guinea case studies) would be largely aggravated on vast expanses (often the most fertile) by a rise in sea level of under 50 cm.

Mining activities

Mining activities are generally covered in the national diagnostic studies.

The extraction of sand from beaches, or of more or less rocky, crushed materials for building is legitimately considered to be one of the major causes of coastal erosion in periurban areas. It could lead, in certain cases, practically to the disappearance of urban beaches (in Conakry for example). These activities weaken the natural coastal defences and are in fact typically located in areas close to urban centres, where the stakes are therefore major.

The current tension on the market for raw materials is driving a renewal of activity in the mining sector, in under the pressure of demand from Asia. The impacts on the coastal zone are direct when the exploitations are directly located there and indirect when it is the transformation and exportation units (in harbours, in particular) that are located there.

Phosphate mining: the deposits, whether exploited or not, are typically close to the coast (Senegal, Togo), with other sites identified (Guinea Bissau). The risks of pollution related to their exploitation, but especially their transformation, is not negligible as attested by the observed state of the natural milieus in the neighbourhood of the phosphate plant in Togo[23].

Hydrocarbons: "almost the whole of West Africa's marine continental shelf is characterised by the presence of sediment formations fractured into small units (structures known as "piano keys"). These geological configurations lead to a chaotic history of oil exploration and exploitation which, outside the Nigeria river delta, has been mainly located in the sea. A series of failures, discoveries, deposits exploited or held in reserve, exploration abandoned or resumed related to fluctuations in oil prices and/or competition from other more profitable deposits, create a situation in which it is difficult to predict the future. However, it is clear that in the more or less near future:

⇒ The inevitable rise in the price of hydrocarbons will act as an incentive to taking financial risks to increase prospecting and exploitation, even for meagre deposits.

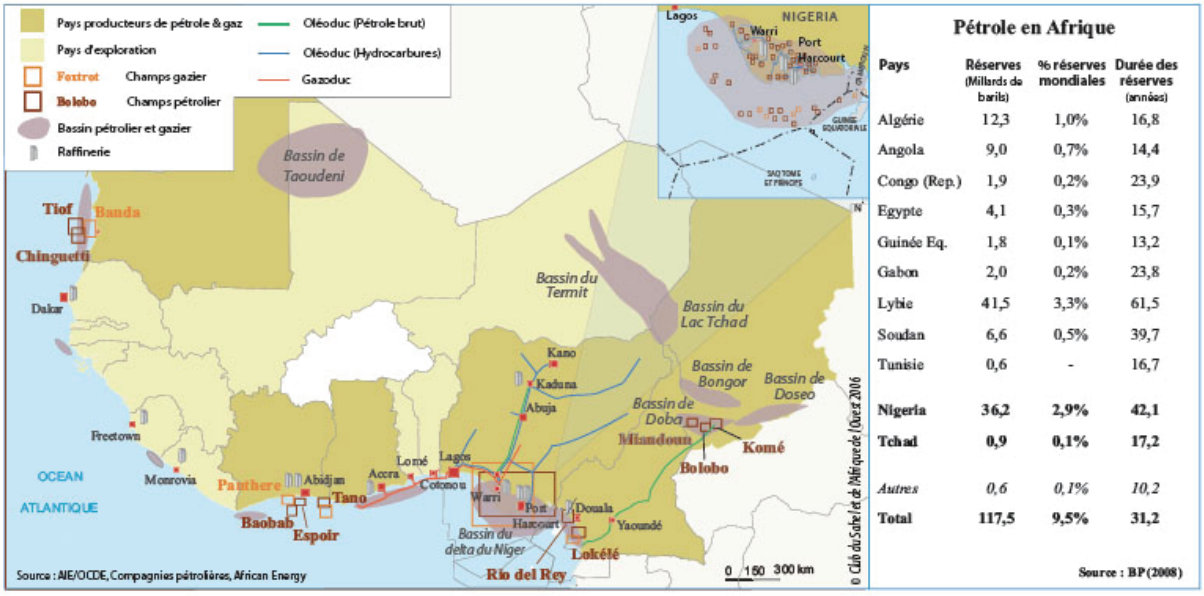
⇒ The West African seaboard and maritime continental shelf, or even deeper, is almost entirely concerned by the exploration and discovery of valuable hydrocarbons, perhaps in considerable quantities, which it is difficult to assess today. The large reserves discovered in Ghana, the exploitation of which is just starting out, attests to this.

⇒ The transition from discovery to exploitation will accelerate (*cf* the case of Equatorial Guinea and Mauritania) and the prevention or even treatment of the impact of possible pollution should take this into account.

⇒ The rising price of gas may fortunately encourage its recovery during oil exploitation, instead of it being burnt in flare stacks as is all too often the case. However, uncertainties remain regarding the recovery of gas from small offshore deposits that are dispersed as will probably be the most frequent case in West Africa. »

⇒ The multiplication of offshore installations, and the foreseeable intensification of commercial navigation traffic will lead in the long term to new needs in terms of the spatial planning of coastal waters, which should integrate all livelihood activities including industrial fishing.

[23] Note that the harbour installations here are endangered and destabilised by coastal erosion.



Pétrole en Afrique

Pays	Réserves (Millards de barils)	% réserves mondiales	Durée des réserves (années)
Algérie	12,3	1,0%	16,8
Angola	9,0	0,7%	14,4
Congo (Rep.)	1,9	0,2%	23,9
Egypte	4,1	0,3%	15,7
Guinée Eq.	1,8	0,1%	13,2
Gabon	2,0	0,2%	23,8
Lybie	41,5	3,3%	61,5
Soudan	6,6	0,5%	39,7
Tunisie	0,6	-	16,7
Nigeria	**36,2**	**2,9%**	**42,1**
Tchad	**0,9**	**0,1%**	**17,2**
Autres	*0,6*	*0,1%*	*10,2*
Total	**117,5**	**9,5%**	**31,2**

Source : BP (2008)

Figure 9. Distribution of oil and gas production in West Africa

Coastal pollution

Pollution related to industrial activities: the outlook for economic development and the reinforcing of the secondary and industrial sectors will be expressed as increased risks of pollution related to these activities. For the moment, the main risks seem to be restricted to the local hydrocarbon transformation units. Certain artisanal activities producing unmanaged solid and liquid waste concentrate the risks in dense urban areas.

Pollution related to agricultural activities: the use of inputs remains relatively modest (except for certain market gardening activities) and will remain so at least in the short and medium terms, given the agricultural potential that is economically intensifiable in coastal areas. The risks will be very localised and especially associated with intensified and diversified coastal vegetable growing which consumes large amounts of pollutant pesticides in the tropical zone, and perhaps with the agro-industries which could establish themselves.

Pollution associated with the gas-freeing of ships: Despite the monitoring resources and some progress in terms of governance, this practice still affects European shores, will affect all the more so West Africa as there is less surveillance.

Delocalisation of pollutant products to West Africa: This is the dumping of toxic waste, awareness of which was raised by an identified attempt in Côte d'Ivoire which led to the implementation of certain instruments. The dismantling of ships (practiced in India and in Pakistan) may directly concern the West African seaboard. Different cases of stranding and deliberate abandoning of ships for example have been observed in places, in particular in Mauritania.

5. ELEMENTS OF CLIMATE FORECAST

What kind of climate changes would have a direct effect on the state of the coastal sea and significant impacts on erosion phenomena?

Uncertainty of climate models for West Africa

There are systematic biases in the simulation of the African climate by most of the climate models that contributed to the 4th report of the IPCC (Intergovernmental Panel on Climate Change). 90% of these models overestimate the precipitations on a large part of the continent (Christensen et al., 2007)[24]. The temperatures simulated also show bias, but this is not significant enough to call into question the credibility of the projections. The intertropical convergence zone simulated is moved towards the equator in most of these models. The surface sea temperatures are overestimated by 1 to 2 degrees on the Gulf of Guinea. A large part of these models have no monsoon, as they cannot properly reproduce the Northward movement of precipitations on the continent. Only 4 of the 18 global ocean-atmosphere models in the 4th IPCC report examined by Cook and Vizy (2006)[25] are able to produce quite realistically the interannual variability of surfacewater temperatures in the Gulf of Guinea and the dipolar structure of precipitations between the Sahel region and the Guinean coast.

Projections to horizon 2050

Temperatures: the projections for Africa show temperature rises that will *very probably* be superior to the average global rise, with an accentuation on the arid zones. The average temperature rise for West Africa to 2050 will be between 1.5 and 3.0°C.

Precipitations: The global ocean-atmosphere model has more difficulty simulating precipitations than temperatures. In several regions of the world, these models agree on the rise or fall in precipitations, but they diverge greatly in their projection of precipitations in West Africa and the signal for variations in precipitations on the Sahel and Guinean coast remain uncertain. The overall average of the various models presents a downward trend in precipitations in JJA (June July August) on the West African coast to the North of the 10th degree of latitude, which is approximately the domain of the maritime trade wind and the North of the Liberian-Guinean domain. This decrease will be accompanied by an increase in the intensity of precipitations and a reduction in the number of rain events (Tebaldi et al., 2006)[26]. In the South, on the domain of the permanent Atlantic monsoon, the models do not agree on the signal of change, even though the average presents a slight upward trend.

The increase in the intensity of precipitations and the reduction in the return periods of certain extreme events could cause the flooding of coastal zones and aggravate erosion phenomena (which could in certain specific cases lead to increased siltation). The global reduction of rainfall in the course of the 21st century would cause a decrease in the flow rates of the major rivers such as the Senegal and the Volta, which would be accompanied by a sediment deficit and an aggravation of coastal erosion. To this should be added the influence of works such as dams on these watercourses, which only aggravate the phenomenon.

The Southern Oscillation (ENSO)

The El Niño phenomenon affects climate in places all over the world including Africa, where it is accompanied by extreme events such as drought in West Africa. Van Oldenborgh et al. (2005)[27] estimated the changes in the variability of ENSO in a future climate. The projected changes differ from one model to another, however. Based on the 6 models out of 19 the most apt to reproduce the current variability of El Nino, they found no statistically significant change. The uncertainties are too high to permit an estimation of the future intensity of

[24] Christensen, J.H. et al., 2007. **Regional Climate Projections**.
[25] Cook, K.H. and Vizy, E.K., 2006. Coupled Model Simulations of the West African Monsoon System: Twentieth-and Twenty-First-Century Simulations. **Journal of Climate, 19:** 3681-3703.
[26] Tebaldi, C., Hayhoe, K., Arblaster, J. and Meehl, G., 2006. Going to the extremes. **Climatic Change, 79(3):** 185-211.
[27] Van Oldenborgh, G., Philip, S. and Collins, M., 2005. El Nino in a changing climate: a multi-model study. **Ocean Science Discussions, 2(3):** 267-298.

the El Nino La Nina phenomena. The models however project a future weakening in the pairing between El-Nino and the monsoon (Philip and Van Oldenborgh, 2006)[28].

Frequencies of extreme events

Among the most important extreme events affecting the coasts of West Africa, the episodes of intense precipitations, depressions and tropical storms can cause considerable damage. There is disagreement between the different studies on the projected the frequency of extreme events (including cyclones) as a result of global warming. There seems to be more of an agreement on their increase in intensity because of a perceptible increase in the temperature of marine surfacewaters. Furthermore, storm surges depend greatly on local conditions, in particular bathymetric and related to tidal regimes. This means studies of storm surge statistics are specific to each region and can not be generalised.

Significant wave height

There are a limited number of studies on wave climatology projections (Weisse and von Storch, 2010)[29]. Most of the studies use statistical disaggregation to project the significant height of waves in a future climate (Caires et al., 2006[30]; Wang et al., 2004[31]). These studies allow for a considerable increase in the significant height of waves in the North Atlantic, consistent with the deviation of storm paths towards the poles. These studies do not predict an upward trend in low latitudes. For West Africa, the change will therefore come especially from the increase in the frequency and duration of tidal wave events, in particular related to extreme events.

Trend: rising sea level and storm surges

The fact that sea level is rising seems to have been largely confirmed. **The historical tide gauges show a rise in the average level of the sea of 20 cm over the past 100 years.** Current estimates for the end of this century are between 20 and 50 cm. Much more dramatic estimates evoke (on a conservative hypothesis) a rise of 3.3 metres should the West Antarctic plaque disintegrate completely[32].

The spatial distribution of the sea rise signal is nonetheless far from uniform. First of all, the surface of the oceans is not regular and for example in the subtropical Atlantic we note a convex area of approximately 1 metre in elevation. This spatial distribution also depends on climate variability and the hazards of marine circulation. These spatial disparities were already observed in the data for the decade 1993-2003.

At regional level, this rise can significantly deviate from the global average due to little know local factors such as land subsidence, the change in atmospheric circulation and wind regime, the redistribution of atmospheric pressure or the unequal distribution of thermal expansion. Our current state of knowledge does not allow more accurate estimations.

According to the IPCC's 2007 report, in 2009- 10 average sea level will have risen by around 18 to 59 cm compared to 1890-1999. By 2050 the rise will be in the order of 10 to 20 cm. This rise does not take into account the probable acceleration of ice melt, which could add a further 10 to 20 cm. There is a lot of uncertainty surrounding these values, which could be exceeded (Meehl et al., 2007)[33].

Alarming conclusions

The erosion and flooding (submersion) of coastal areas which largely contributes to the receding shoreline will be aggravated in the course of the 21st century following an increase in average sea level.

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[28] Philip, S. and Van Oldenborgh, G., 2006. Shifts in ENSO coupling processes under global warming. **Geophys. Res. Lett, 33.**

[29] Weisse, R. and von Storch, H., 2010. **Marine Climate Change**: **Ocean Waves, Storms and Surges in the Perspective of Climate Change.** Springer Verlag.

[30] Caires, S., Swail, V. and Wang, X., 2006. Projection and analysis of extreme wave climate. **Journal of Climate**, 19(21): 5581-5605.

[31] Wang, X., Zwiers, F. and Swail, V., 2004. North Atlantic ocean wave climate change scenarios for the twenty-first century. **Journal of Climate, 17:** 12.

[32] Bamber. J.L. 2009.- Reassessment of the Potential Sea-Level Rise from a Collapse of the West Antarctic Ice Sheet. **Science.** 324: 901-903.

[33] Meehl, G.A. et al., 2007. Global Climate Projections.

Africa is one of the regions in the world whose coastal zones and deltas are the most exposed to risks of flooding due to the rise in mean sea level (Nicholls and Tol, 2006[34]). This rise in sea level, combined with increased intensity or frequency of extreme events, will have serious consequences for the development of the coastal zone. Many coastal or island areas will be submerged or subject to increasingly frequent flooding causing considerable damage.

In West Africa, although this rise cannot be estimated accurately, a rise greater than the global average is expected. There could be dramatic consequences for several regions, such as around Nouakchott which is already below sea level. Major conurbations are greatly at risk. **The destructive effect of this rise in water level will lead to an increase in the frequency of storm surges and their destructive potential, in particular in river deltas. There will be more frequent intrusions of saline waters which will gradually make aquifers unfit for consumption and agriculture (the advancement of the salt-water wedge and alteration of freshwater lenses).**

The consequences are extremely difficult to evaluate and should only be envisaged through a **detailed study of local situations**. The fact remains that the hypothesis of a 1 metre rise in sea level would significantly aggravate coastal hazards. The most sensitive coasts are clearly low sandy coasts and mangroves, as well as coastal zones composed of sandstone or marno-limestone cliffs. The major lagoon systems will obviously also be affected. The lowest-lying sectors will be subject to increased erosion or temporary or permanent submersion.

Coastal systems are not in fact passive with regard to the rise in sea level, and there are numerous threshold effects, for these systems also react and adapt to the new configurations**.** For example in the case of submersion hazard, coastal plant formations can trap sediment, river flow rates can be modified by the variability of continental precipitations, lagoon or estuary outlet streams can be partially closed by the advance of sand spits, etc. Any evaluation of the impacts of the rise in sea level should therefore remain cautious and avoid swinging into simplistic, reductionist or "mechanical" calculations or representations, in particular in the field of economics. **The submersion hazard, when the stakes justify this, can only be properly considered through a detailed local hydraulic approach.**

⇒ **Sandy coastline:** Increasing erosion of sand systems is expected, aggravating the risks of submersion, in particular in type 3 units of the cartography typology (see document 3), causing the shoreline to recede as has already been observed.

⇒ **Dune ridges and lidos:** lidos and dune ridges will migrate inland, at least for the narrowest lidos. Certain lidos will become fragmented. A tracking programme should enable local identification of the lidos able to migrate and those likely to fragment.

⇒ **Lagoon systems:** the hydrology of lagoons comprises exchanges with continental waters, but also with the sea. In addition, these are located at a height close to sea level. The ecology of lagoons is based on two main parameters: depth and salinity. If the former is slightly modified[35] salinity would be altered (i) following the rise in sea level; (ii) by the salinisation of aquifers; (iii) by a possible decrease in the freshwater supply consecutive to a reduction in rainfall and therefore in flood peaks. On the other hand, the tendencies for lagoons to fill in by terrigenous supply could be partially counteracted. Note also that the multiplication of dams, by removing the very small spates, may contribute to reducing the salinity of certain brackish waters.

⇒ **Closing of lagoon outlets:** the closure or strangling of lagoon outlets due to the development of spits and local accretions lead to the eutrophication of the aquatic milieus concerned. The filling in of these outlets also implies flooding in periods of spate.

These different elements of climate forecast must be however be balanced by the recognition of the non-linear and chaotic nature, and the threshold effects that characterise the different manifestations of climate change. The combination of permanent shoreline monitoring with the monitoring of changes in climate conditions

[34] Nicholls, R. and Tol, R., 2006. Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. Philosophical Transactions A, 364(1841): 1073.
[35] The migration of lagoons, if this is possible, should conserve the initial depth gradient in most cases, even if the depth of the lagoons increases slightly.

should enable the production of scenarios to be updated regularly to reduce the uncertainty that today besets any forecasting in terms of climate.

6. RESPONSES

The social, political and technical responses to coastal erosion are multiple, ranging from the planning of coastal improvements to independent adaptation strategies implemented by the local populations under threat. These responses can also be regulatory or legal. In the future, they will above all be based on the precautionary principle and the awareness of risky areas when locating human settlements. We know in fact that rights do not always create facts, and that regulations are no substitute for a change in the behaviour of individuals, local authorities, institutions and politicians. Note that this study is part of the response on a regional scale.

The provisions related to the applicable law in coastal spaces can only be broached as part of the findings of the national diagnostic studies. However, it may well be useful at this stage to remember the three inter-State bodies likely to play key roles in response to the impacts of coastal dynamics.

6.1. SUPRA NATIONAL BODIES

UEMOA

Article 4 of the UEMOA Treaty of 10 January 1994, at the initiative of which the present study is conducted by IUCN, mentioned the necessity of taking the environment into account as part of the coordination of national sector policies, without considering it a priority. Additional Protocol no. II approaches the environment on the basis of "sector", as mentioned din chapter IV. Combating coastal erosion is listed as one of the Union's environmental improvement goals.

Recommendation no.02/97/CM of 21 June 1997 adopted in Lomé is relative to the implementation of a first generation environment programme. It determines different components and the measures to be developed to undertake the harmonisation of national policies in these domains. There are eight identified sub-programmes, including combating coastal erosion. The 1999 study relative to erosion problems, validated in 2005, led the Council of Ministers of UEMOA to adopt rule 02/2007/CM/UEMOA aimed at implementing a coastal erosion programme.

The implementation of a community policy for environmental management (UEMOA - PCAE *politique commune d'amélioration de l'environnement* – common policy for improving the environment), rendered by legal instruments (directives, rules, decisions) remains a necessity, given the observed divergences between the environmental policies of the member countries.

The framework offered by UEMOA is certainly adequate for rationalising the development of coastal areas and encouraging in the long term the sharing of certain large infrastructure systems, and encouraging solidarity and reciprocity between coastal territories. This framework remains limited to Member countries, however, and should be reinforced by the effective, cooperative action of other regional organisations such as the Abidjan convention.

Guinea Current Large Marine Ecosystem (GCLME):

There have been two phases of the GCLME project since 1995, broaching multiple aspects of the integrated management of coastal zones, including coastal erosion One of the important contributions of the project is the existence of a shared diagnostic conducted on all the countries concerned, the number of which has increased from 6 to 16 (Guinea Bissau to Angola). The project took place within the framework of the application of the provisions of the Abidjan convention and the implementation of its Strategic Action plan. The GCLME also gave rise to the setting up of an, interim commission (Interim Guinea Current Commission), whose first ministerial meeting took place in Abuja in 2006.

The valorisation of the results from the numerous workshops GCLME has conducted on a range of topics (fishing and fish stocks, prevention of the impacts of pollution, particularly hydrocarbons; coastal erosion; urban and domestic effluent management, etc.) was envisaged as part of the present study, but was not carried out in-depth due to the lack of access to detailed items over and above the regional summary reports.

Canary Current Large Marine Ecosystem (CCLME):

The programme of the Canary Current Large Marine Ecosystem (CCLME): this programme, also financed by the GEF, is in the start-up phase and will include Mauritania, Senegal, the Gambia and Guinea Bissau in particular.

The Abidjan convention

The Abidjan Convention on cooperation for the protection and development of marine milieus and coastal areas of West and Central Africa, (here known as the Abidjan Convention) and the Protocol relative to cooperation in terms of combating pollution in the event of a critical situation (here designated as the Abidjan Convention Protocol) were adopted on 23 March 1981 in Abidjan and entered into force on 5 August 1984. The Convention was signed as part of the UNEP regional seas programme.

The Abidjan convention is the benchmark legal instrument for the governance of coastal and marine milieus in West and Central Africa (from Mauritania to Namibia). This geography covers three major marine ecosystems: The Canary Current, the Gulf of Guinea Current and the Benguela Current. Only fourteen countries out of 22 potentially concerned satisfied the conditions that place them officially in a position as Parties to the convention (in the table below countries noted in grey are not Parties to the convention).

Country	Date of signature of the convention	Date of ratification
MAURITANIA		
SENEGAL	23 March 1981	10 May 1983
THE GAMBIA	13 June 1981	December 6 1984
GUINEA BISSAU		
GUINEA	23 March 1981	4 March 1982
SIERRA LEONE		7 June 2005
LIBERIA	23 March 1981	22 March 2005
COTE D'IVOIRE	23 March 1981	15 January 1982
GHANA	23 March 1981	20 July 1989
TOGO	23 March 1981	16 November 1983
BENIN	23 March 1981	17 October 1997

The initial foundation of the convention mentions two objectives: (i) the fight against forms of pollution; (ii) the building of regional cooperation to protect the marine and coastal environment. However, unlike many regional conventions, the Abidjan convention does not place constraints and in this sense is closer to the spirit of the major Multilateral Environment Agreements.

There is an interesting item in the fight against pollution, consisting in inviting the countries to use rational management for environmental questions, by not taking any measures that would result in the "direct or indirect transfer of prejudice or risks from one zone to another ...". In the case of coastal erosion, the application of such a disposition would certainly have made it possible to balance the transboundary effects of certain developments (ports, dams, etc.). Additional protocols expressing concrete measures (such as the Protocol relative to "existing or potential situations critical for the marine environment which constitute a significant threat of pollution") are examples of provisions that could be envisaged in relation to coastal erosion.

Harmonisation of environmental policies concerning the marine environment is also the concern of other regional institutions such as UEMOA. The value added of regional coordination of environmental policies is also derived from scientific and technical collaboration. The possibility of exchanging data on the monitoring and evaluation of pollutions could also be applied to the problematic of coastal erosion and coast line development. Useful regional studies were conducted within the framework of the UNEP regional seas programme - WACAF - (1982-1988), although today the effective use made of their results should be assessed.

The Convention's revitalisation programme, voted at the 8th conference of the contracting parties in Johannesburg in November 2007, comprises different sections, including the improvement of the financial viability of the convention.

In conclusion, **the Abidjan convention could well be an adequate framework for improving regional governance in terms of combating coastal erosion**, for example through the adoption of a specific protocol. In the light of the structural nature of many of the provisions to be adopted, which are aimed in particular at

land-use planning, in this additional protocol the convention should effectively target the domains of interest that are actually within its jurisdiction.

Regional projects and programmes

The regional programme Adaptation to Climate and Coastal Change in West Africa (ACCC[36]): the adaptation to climate change programme is financed by the GEF and covers Cape Verde, the Gambia, Guinea Bissau, Mauritania and Senegal. It allows for the implementation of pilot protection and adaptation operations in the five countries concerned. The implementation of the current phase will end in 2010.

The West African Regional Coastal Zone and Marine Conservation Programme (PRCM). the second phase of the PRCM began in 2008. On the basis of basket fund financing, the programme includes more than twenty projects concerning biodiversity, the networking of marine protected areas in West Africa, and the sustainable development of fisheries in West Africa.

Lastly, there is **RAMPAO** (set up in 2007), the Network of Marine Protected Areas in West Africa, endorsed by the Regional Strategy for Marine Protected Areas in West Africa developed in 2002, and consolidated by the Declaration of General Policy signed in 2003 by 10 ministers in charge of the environment, protected areas and fishing in 6 countries in the region (from Mauritania to Guinea). In 2007, this network of protected areas (initiated in 1996 through the regional coastal planning network) comprised 24 marine protected areas. Despite the numerous programmes and projects in support of these protected areas in terms of management, knowledge of the ecological, biological and cultural heritage of these natural or social systems or even in terms of networking, considerable progress remains to be made in terms of the territorial integration of these protected areas, and in the drawing up and presentation of basic knowledge materials, cartographic particular.

[36] Adaptation to Coastal and Climate Change in West Africa

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8. ANNEX 1. CLIMATIC CONDITIONS [37]

Shoreline dynamics are produced by complex phenomena resulting from the interaction between the continental sediment supply (from rivers or the wind) and morphogenic agents (ocean waves, currents, tides, winds, precipitations), which transport and redistribute sediment supply. The force and way these morphogenic agents act are, to a large extent, governed by meteorological phenomena.

8.1. CLIMATE SYSTEMS

Pluviometric regime

Climate varies enormously from the North to the South of the study zone and to a lesser extent from East to West. The climate of West Africa is primarily modulated by the seasonal movements of the intertropical convergence zone (**Erreur ! Source du renvoi introuvable.**1, CEDEAO-SWAC/OECD 2008), which separates the continental mass of hot, dry air with North-Easterly winds (Harmattan) and the mass of moist sea air originating from the Gulf of Guinea (monsoon).

Precipitations constitute one of the most determining factors of the different types of climates in this region. Their distribution reflects a gradient that decreases from the south to the north. The annual total precipitation rate is used to distinguish between several different pluviometric regions (Leroux, 2001):

- ⇒ Regions with very low precipitations (0 to 100 mm)
- ⇒ Regions with low precipitations with cumulative totals between 100 and 500 mm
- ⇒ Regions with moderate precipitations with cumulative totals between 500 and 1000 mm
- ⇒ Regions with an annual cumulative total precipitations of between 1000 and 1500 mm
- ⇒ Regions with high precipitation rates with annual cumulative totals of over 1500 mm.

The cumulative total precipitations are in a gradual scale from North to South from 100 mm at the latitude of Nouakchott to more than 4,000 mm in Conakry, Monrovia or Robertsfield (see figure 3). This gradient differs, however, in the eastern part of the study zone, with cumulative totals of precipitation being more limited in the South of Togo and Benin (1200 to 1500 mm). The annual total is not enough, however, to characterise the pluviometric system. However, the analysis of monthly totals is used to distinguish two types of pluviometric systems:

- ⇒ **Unimodal regimes** with an annual maximum (**Erreur ! Source du renvoi introuvable.**2a) on the coastal zones from Sierra Leone to Mauritania.
- ⇒ **Bimodal regimes,** with two maxima respectively in April-May-June and September-October-November, separated by a minimum in July-August known as "small dry season", although it is not a true dry season (**Erreur ! Source du renvoi introuvable.**2b) on the coastal zones from Benin to Liberia.

Temperature ranges are typically small at less than 10°C.

[37] This annex is drawn from work conducted as part of the SDLAO study by ACMAD: Centre Africain des Applications Météorologiques pour le Development, based in Niamey, Niger.

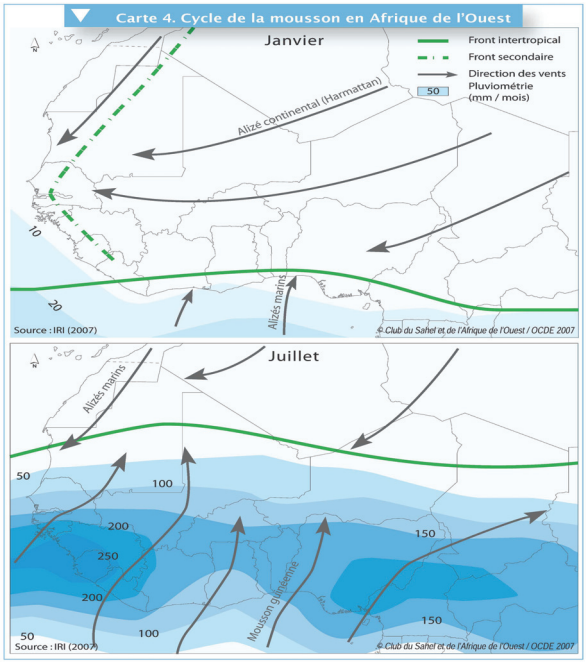

Figure 1: Monsoon cycle in West Africa (ECOWAS-SWAC/OECD, 2008)

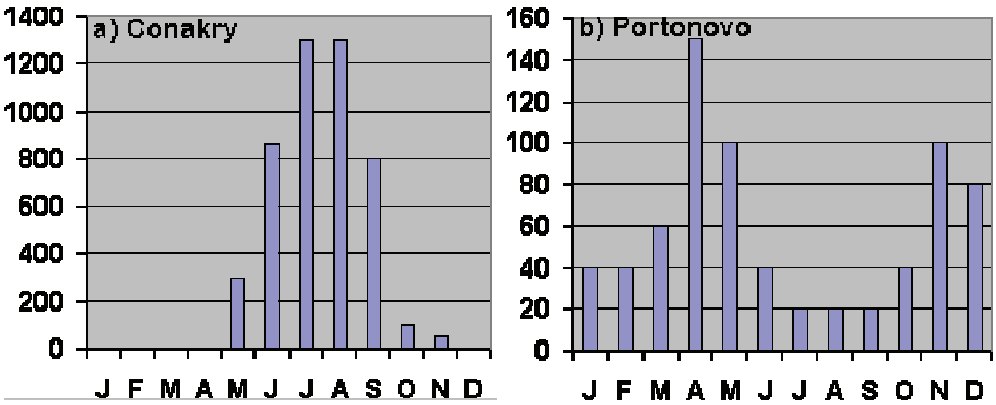

Figure 2: The two types of pluviometric regimes on the coastal region a) unimodal regime in Conakry, Guinea and b) bimodal regime in Porto Novo in Benin with the "small dry season" in July.

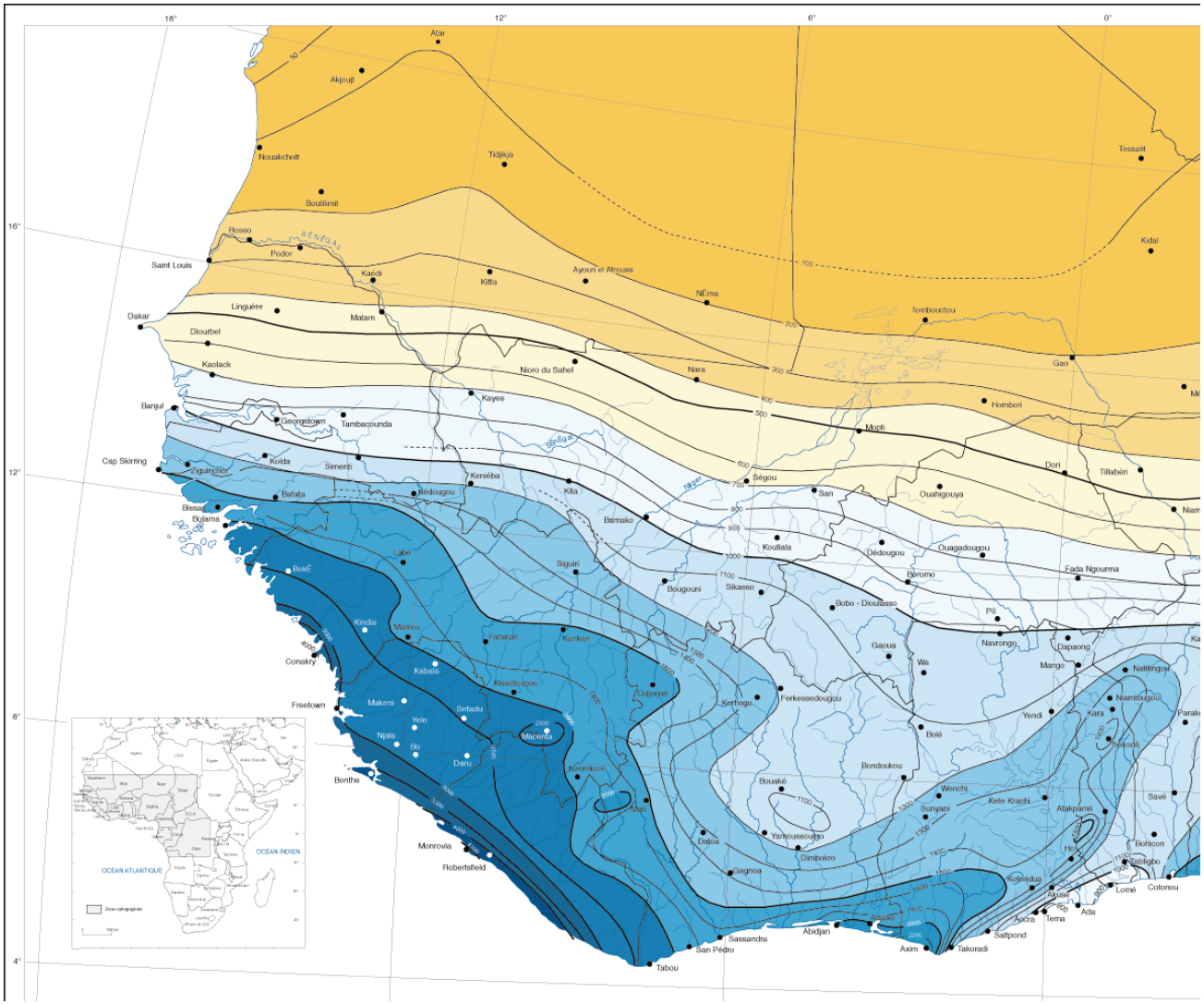

Figure 3. Distribution of precipitation in West Africa (annual averages) - Source: ORSTOM

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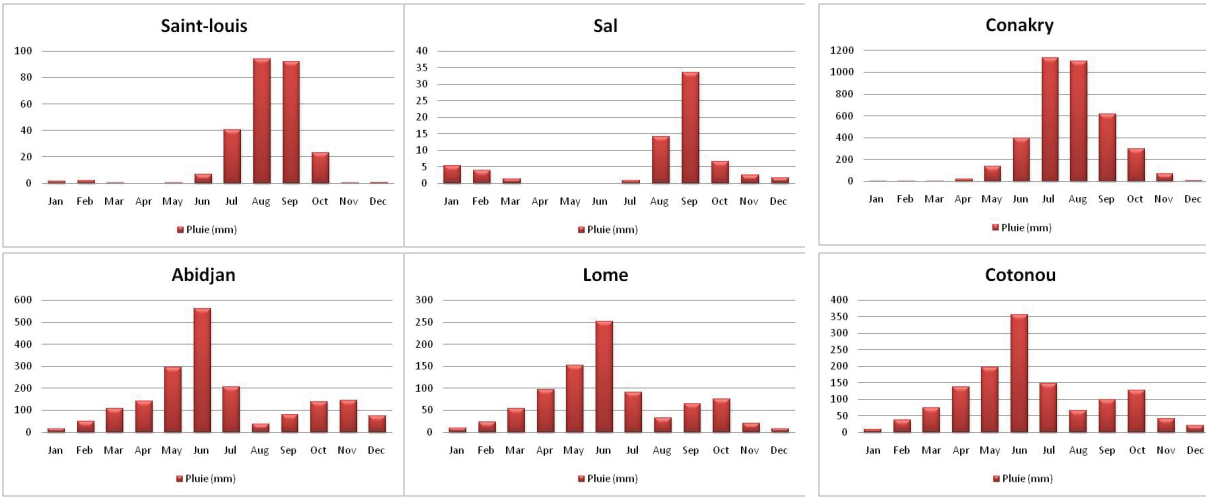


Figure 4: Average monthly precipitations of a few coastal stations in West Africa for the period 1961-1990.

Temperature regime

The coastal areas in West Africa have small temperature ranges with diurnal ranges typically lower than 10°C and annual temperature ranges of often less than 8°C (Leroux, 2001), as the thermal inertia of oceanic waters has a regulating effect.

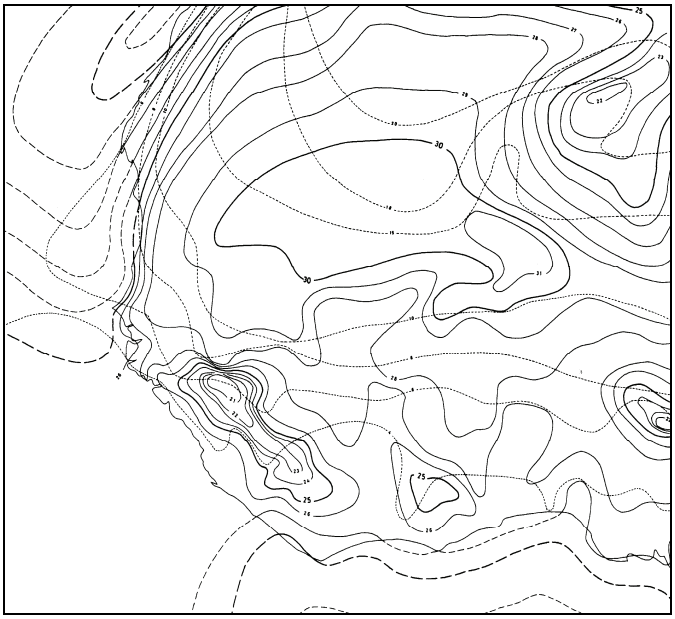


Figure 5. Map of average annual temperatures
(unbroken line on the continent) and average annual amplitudes in degrees (dotted lines) Celsius.

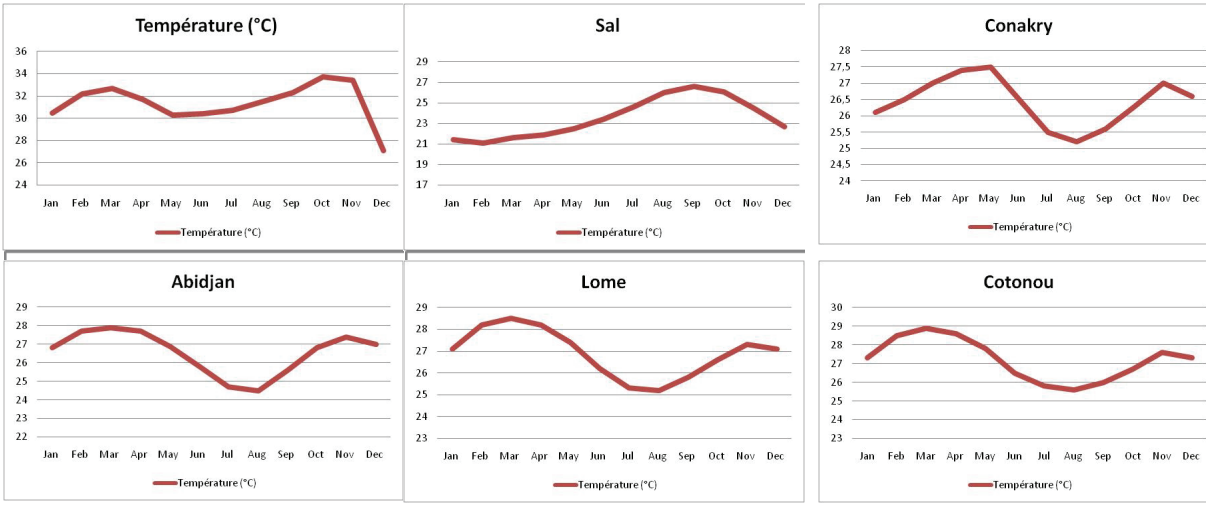


Figure 6: Monthly average temperatures of a few coastal stations in West Africa for the period 1961-1990.

Climate zoning

There are many ways of classifying the climate regions in West Africa (Hayward and Oguntoyinbo, 1987; Leroux, 2001). Often based on the Koppen and Thornthwaite classification (Gentilli, 1958), or other, less well-known systems.

Some of the methods are complex and require the use of observation data. In the case of West Africa, more subjective methods, based on the amalgam of regions which have the same climatic conditions, have also been used. Grandidier (1934) divided Africa into 14 climate regions, based on temperature. Aubréville[38] (1949) uses the number of rainy months, the number of dry months, the humidity rate, average temperatures and temperature ranges to produce a complex map that divides the region into four major zones: Saharan, Sahelian, Sudanian and Guinean. These major zones are in turn divided into smaller climatic regions. Harrison Church (1961) created a map of the climatic regions of West Africa based on the seasonal precipitation regimes.

Leroux (2001) produced a map of the climate zones in Africa based on six classes of humidity, seven classes of temperatures and seven classes of precipitations. The coastal domain is divided into three major zones:

1. **maritime trade wind type I,** comprising the Cape Verde archipelago and the coastal regions of Mauritania and North Senegal;
2. **Libero-Guinean** encompassing the coastal regions in southern Senegal, Gambia, Guinea, Sierra Leone and Liberia**;**
3. **Permanent Atlantic monsoon** comprising the coastal regions extending form the south of Liberia to Benin**.**

This division approximately matches the one proposed by Mahé et. al (2001) the corresponding zones of which are called North West Sahel, Guinea and North Coast.

[38] Aubréville's classification, although dated, remains valid and can be used to rally not only climatologists, but also specialists of agriculrural and forest systems, etc. to the same approach. (Aubréville. 1949.**- Climats, Forêts et Désertification de l'Afrique tropicale.** 351p.)

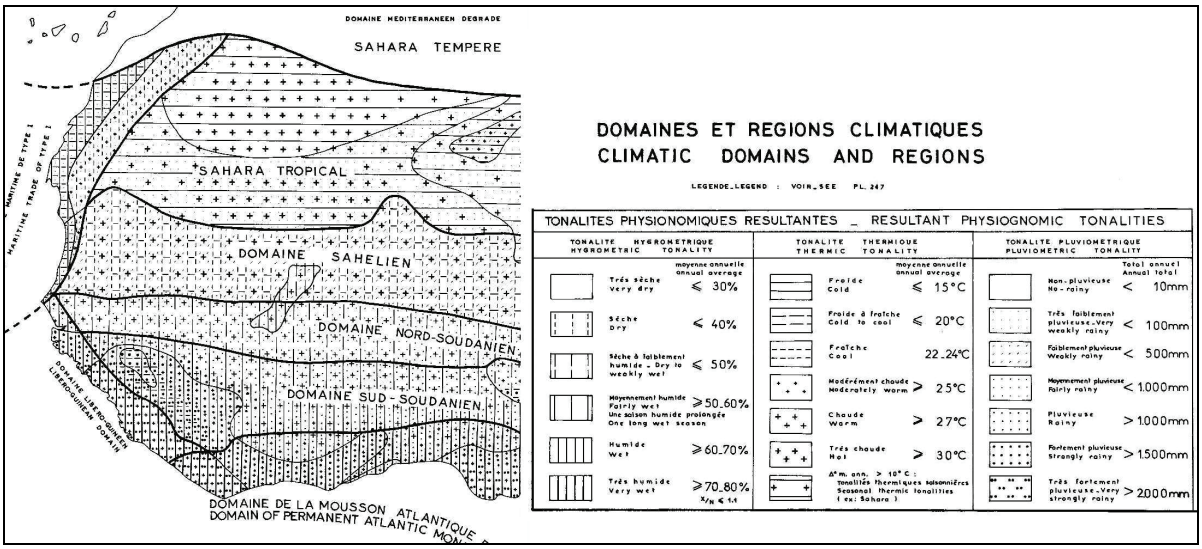


Figure 7: Climate domains and regions of West Africa (Adapted from Leroux, 2001).

Hayward (1987) proposes a classification based on pluviometrics including, among other things, the seasonal cycle of temperatures. This classification is based on the length and start date of the rainy season. A further subdivision was made based on annual pluviometric totals. Analysis of the Climate Research Unit (CRU)'s database of temperatures and precipitations[39] can also be used to suggest climate zoning. The study zone can be divided into five major climate zones based on the average annual total precipitations (figure 7) during the reference period 1961-1990:

1. **Desert-type climate** with annual precipitations of under 100 mm encompassing the whole Mauritanian coast north of 18 degrees North latitude**.**

2. **Sahelian type climate** with precipitations between 100 and 500 mm encompassing the south of Mauritania and the coast of Senegal north of 15 degrees latitude**.**

3. **Sudanian type climate** with precipitations between 500 and 1000 mm covering the Senegalese coast and Gambia between 13 and 15 degrees North**.**

4. **Tropical humid type of climate** covering the coastal regions of southern Senegal, Guinea Bissau, Ghana, Coast d'Ivoire, Togo and Benin where precipitations are between 1000 and 2000 mm.

5. **Equatorial type climate** with annual precipitations exceeding 2000 mm on the coastal zone of Guinea, Sierra Leone and Liberia**.** This breakdown and zone naming is not absolute and differs depending on the author.

This breakdown can be examined in depth by considering the pluviometric regimes in order to differentiate between:

1. **a zone where there is no real dry season,** with a typically bimodal regime covering the coastal region from Benin to Liberia;

2. **a zone with a single, very clear dry season** concerning the coastal region from Sierra Leone to Mauritania.

[39] This data is provided for landmass on a regular grid of 2.5° latitude by 3.75° longitude (Mitchell and Jones, 2005).

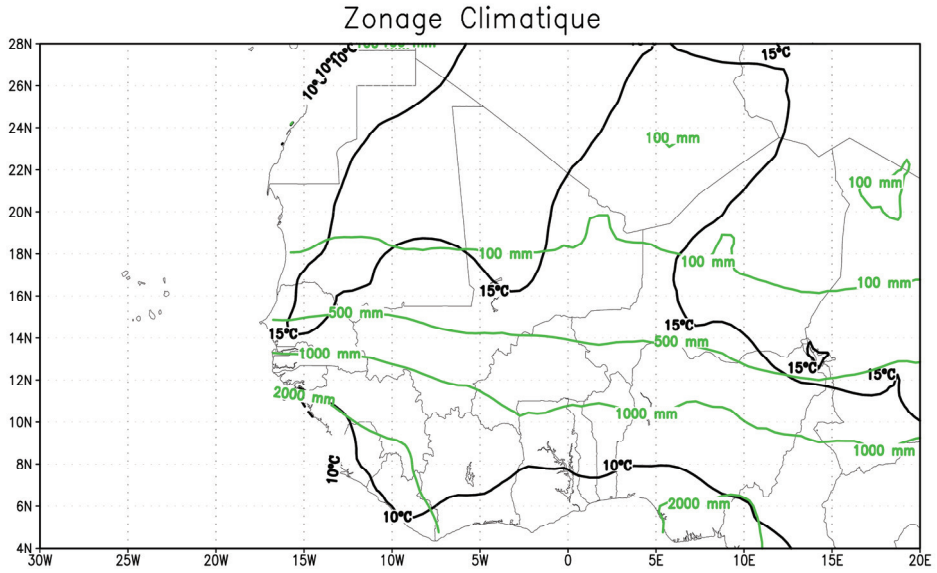


Figure 8: Average annual total precipitations (green)
and average diurnal temperature range for the period 1961-1990, according to interpolated data from the CRU.

The diurnal temperature range can be used to distinguish between two zones in the coastal fringe of West Africa:

1. The whole coastal zone from Benin to Guinea, where the average diurnal temperature range is less than 10°C.
2. The coastal zones of Guinea Bissau, Senegal, Gambia and Mauritania where the diurnal temperature range is between 10°C and 15°C.

On the basis of these different studies we can select, as did Mahé et al. (2001) and Leroux (2001), the division into three major climate zones given in figure 7.

8.2. OCEAN-ATMOSPHERE INTERACTIONS

Wind regime

Seasonal variations in the wind regime are governed by the movements of the intertropical convergence zone that separates the north-westerly Harmattan from the south-westerly monsoon circulation. The south coast of Benin to the South of Senegal is continuously under the influence of the Atlantic monsoon circulation and the dominant winds are south to south-westerly in all seasons.

In summer, the coastal areas of North Senegal and Mauritania are subject to prevailing North-North-westerly winds. The rest of the year the prevailing winds come from the North (Dakar) and North-east (Nouakchott). In Conakry, the winds are mainly westerly. This component is also remarkable in Abidjan where the predominant South-Westerly wind is more marked than in the zones further to the East of the Gulf of Guinea

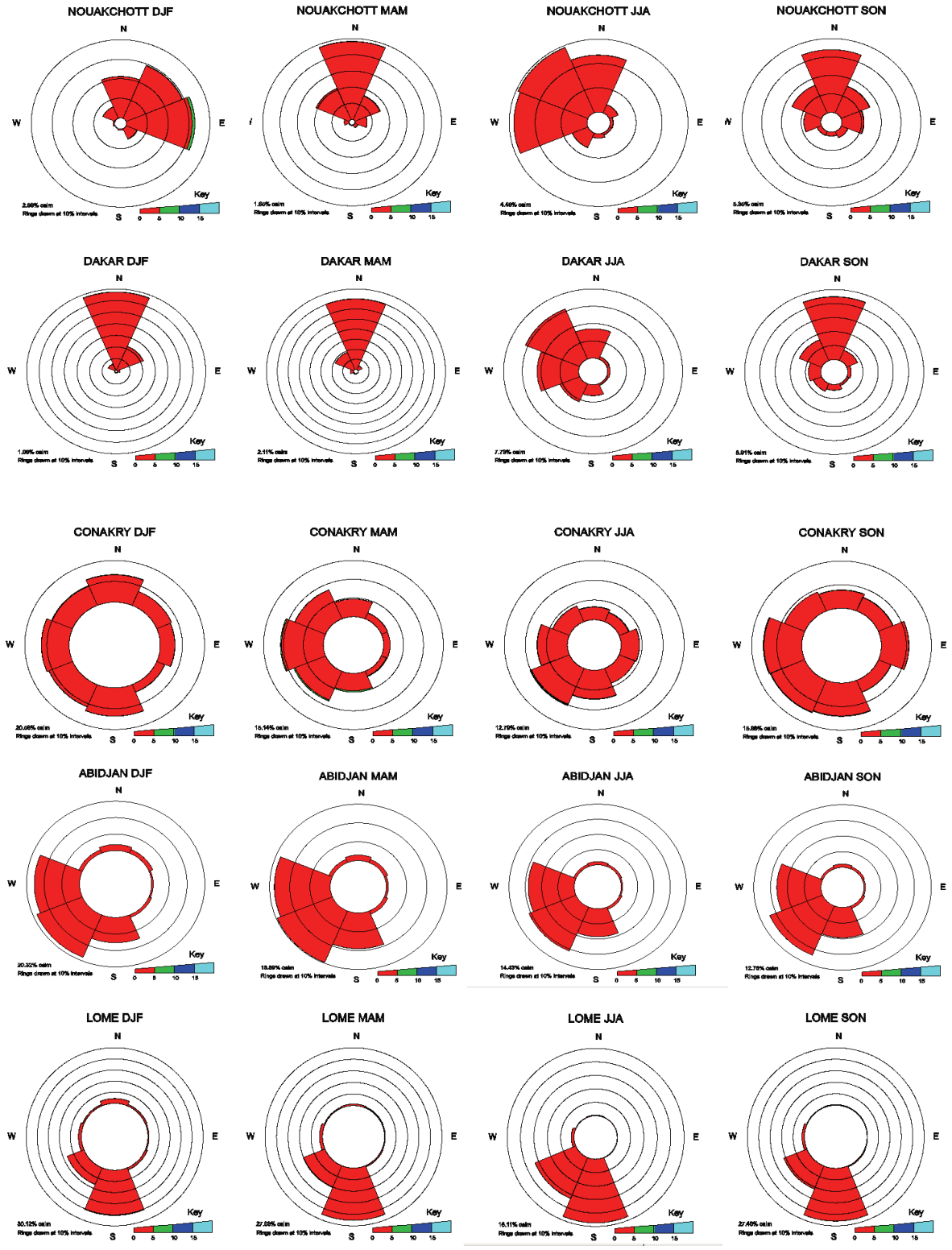


Figure 9. Wind roses for the principal cities on the West African coast, from top to bottom: Nouakchott, Dakar, Conakry, Abidjan and Lomé. 4 periods for each city: January-February-March, April-May-June, July-August-September, October-November-December. Source: ACMAD.

The seasonal variations of the trade wind regime have a strong effect on those of the ocean. Along the coasts of Western Africa, the prevailing trade winds are south-westerly, generating the phenomenon

of African monsoon during the northern summer. The seasonal variability of the temperature of the ocean surface is particularly important due to the thinness of the homogeneous surface layer and the rising of cold water along the coasts (principal upwellings of the coast of Mauritania and Senegal and to a lesser extent, Benin).

The Gulf of Guinea is the principal source of water vapour that feeds a large part of the precipitations on the continent. The surface temperature of the sea governs the heat exchanges between the ocean and the atmosphere, and therefore the evaporation, temperatures and humidity of the lower layers of the atmosphere.

9. ANNEX 2 - ELEMENTS OF OCEANOGRAPHY

9.1. OCEANOGRAPHY

Principal currents

Two major currents correspond to major marine ecosystems that concern the region: the Canary current and the Gulf of Guinea current.

The Canary current (figure 2) is situated at an average depth of 500 metres, with a speed in the order of 10 to 15 cm per second**.** The current includes coastal upwellings. It is classified as a class I current, with highly productive waters (more than 300g C/m3/year) conditions that are particularly favourable for the development of small pelagic species. It follows the West African coast from North to South between 30°N and 10°N. In winter, the current is at its strongest, with the force of the trade winds.

- ⇒ 10a: It moves in parallel to the coast to 20°N. At latitude 15°N, it turns westward under the influence of the equatorial current. In spring, the current weakens with the trade winds, while the equatorial counter-current grows stronger.
- ⇒ 10b: In summer, the trade winds grow weaker still, reducing the supply of water mass emanating from the North.
- ⇒ 10c: The Canary Current weakens further. The equatorial countercurrent, which is then at its maximum, forks Northward, away from the Canary Current on the coast.
- ⇒ Figure 10d: In autumn, the Canary Current is at its weakest level.

The pilot charts for the North and South Atlantic confirm this data[40].

The Guinea currant (figure 3) is a West- East superficial current situated at an average depth of 25 metres[41]. The speed varies and can exceed 50 cm per second. It constitutes a prolongation of the North Equatorial Countercurrent. This currant, reinforced by the winds, comprises a zone of important upwellings from July to October, which have a cooling effect and therefore stabilise the lower layers of the atmosphere and attenuate the convection and quantity of water vapour.

[41] Abe. J. & al. Guinea Current - **GIWA Regional Assessment.** 42.

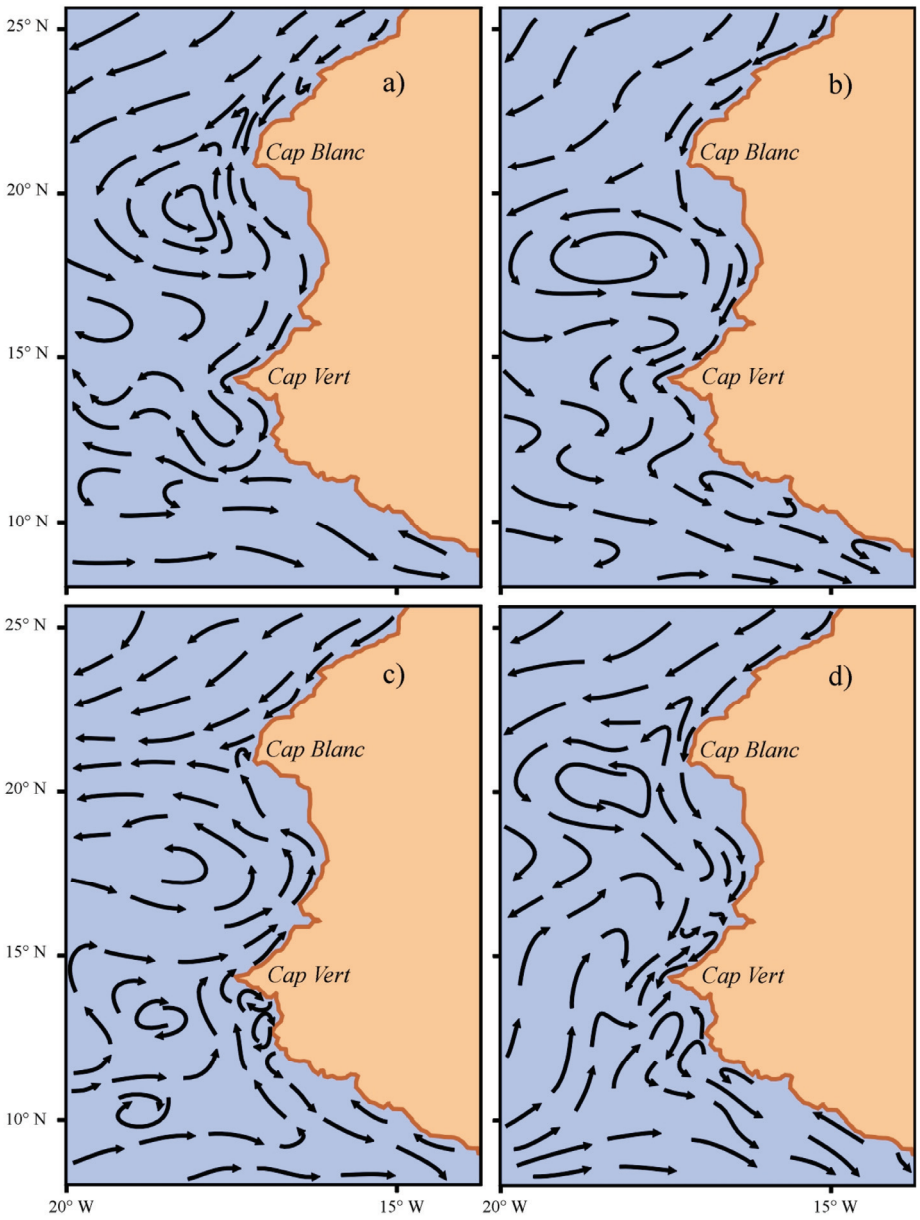


Figure 1. Surface ocean circulation for the North-West coast of Africa
(a) in northern winter, (b) spring, (c) summer and (d) autumn (Mittelstaedt, 1991)

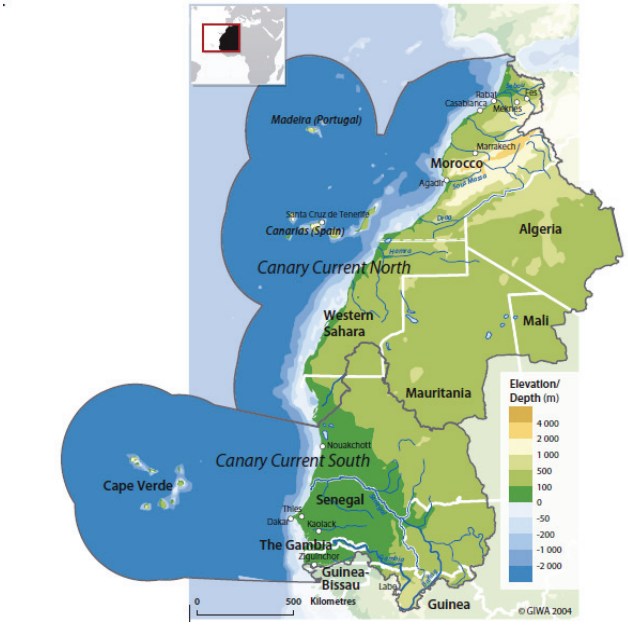
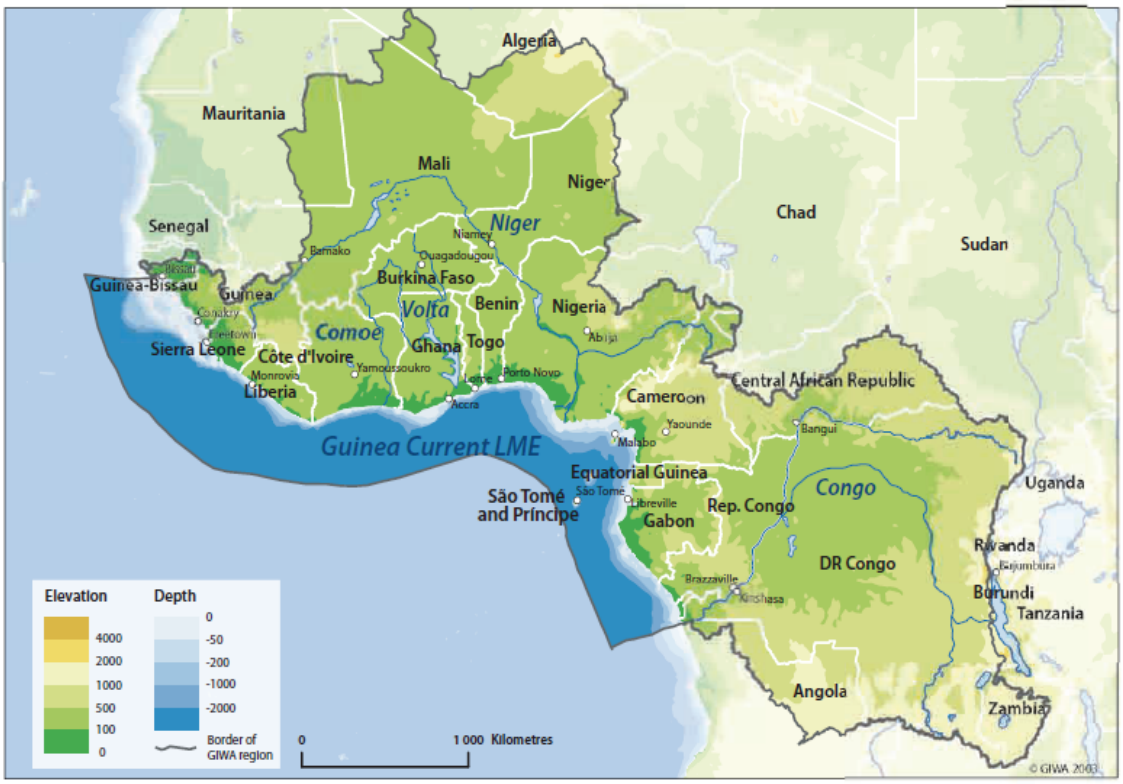


Figure 2: Boundaries of the Canary Current region (source: GIWA Regional Assessment 41)



3. Boundaries of the Guinea Current region

Water temperatures

The waters of the Guinea current are highly stratified, with a surface layer temperature varying from 25 to 29°C covering a layer of very salty subtropical water whose temperature varies between 19 and 28°C. The waters of the Canary current are also highly stratified and combine masses of water with different temperatures and salinity levels (warm tropical waters, cold waters, warm Guinean water with low salinity in the rainy season).

The increase in temperature of surface waters observed in the tropical Atlantic contributes, in particular, to increasing the frequency and intensity of tropical cyclones in the Caribbean and the Gulf of Mexico (an anomaly of 0.5°C can lead to an increase in cyclone activity of around 40%)[42]. This increase in water temperature is due to a number of factors including the density of aerosols[43].

The Southern Oscillation: The equatorial Pacific is the seat of a coastal upwelling which drives cold, deep water up to the surface. However, each year, when the month of December approaches, the South Westerly winds that blow on the coast decrease, which weakens this rising of cold water and therefore heats up the surface waters. This phenomenon lasts for a few months and the cycle resumes. But it sometimes happens that the warm waters accumulate to an abnormal extent on a large surface to the East and Centre of the Pacific Ocean. This is the El Niño phenomenon which brings destructive precipitations to regions that are usually dry such as the North of Peru, or droughts to regions that are usually wet, such as West Africa. In fact, El Nino is the warm phase of the El Nino Southern Oscillation (ENSO) which is a cyclical variation of the global atmospheric pressure between the East and West of the Pacific Ocean. The cold phase, called la Nina, also causes extreme events in the world.

Several studies have shown that El Nino is an important factor for inter annual variability in low latitudes. Recent climatology studies show that strong El Niño episodes are related to a low cyclonic activity in North Atlantic and vice versa. (Bove et al., 1998; Donnelly and Woodruff, 2007). The influence of El Nino in Africa is still disputed, although several studies have highlighted the relation between the very powerful el Nino episodes which are accompanied by a weakening of the African monsoon (Donnelly and Woodruff, 2007; Janicot et al., 1996; Otto-Bliesner, 1999). **The southern oscillation probably contributes to a large extent to the uncertainty that characterises the climate simulations in West Africa**.

9.2. OCEAN WAVES

The ocean waves are essentially oriented depending on the dominant wind regime, and are therefore oblique for a large part of the coast, outside the divergence zone between the Canary current and the current of the Gulf of Guinea (Guinea Bissau particularly), where it is difficult to pinpoint general trends, given the importance of the tidal flows related to the depth contours of the continental shelf, which is widens considerably at this location.

Wave heights

[42] Saunders. A. & A.S. Lea. 2008 - Large contribution of sea surface warming to recent increase in Atlantic hurricane activity. **Nature.** 451: 557-561p.
[43] Amato T.A & al.. The role of aerosols in the evolution of tropical North Atlantic Ocean Temperature Anomalies. **Science.** 324: 778-781p.

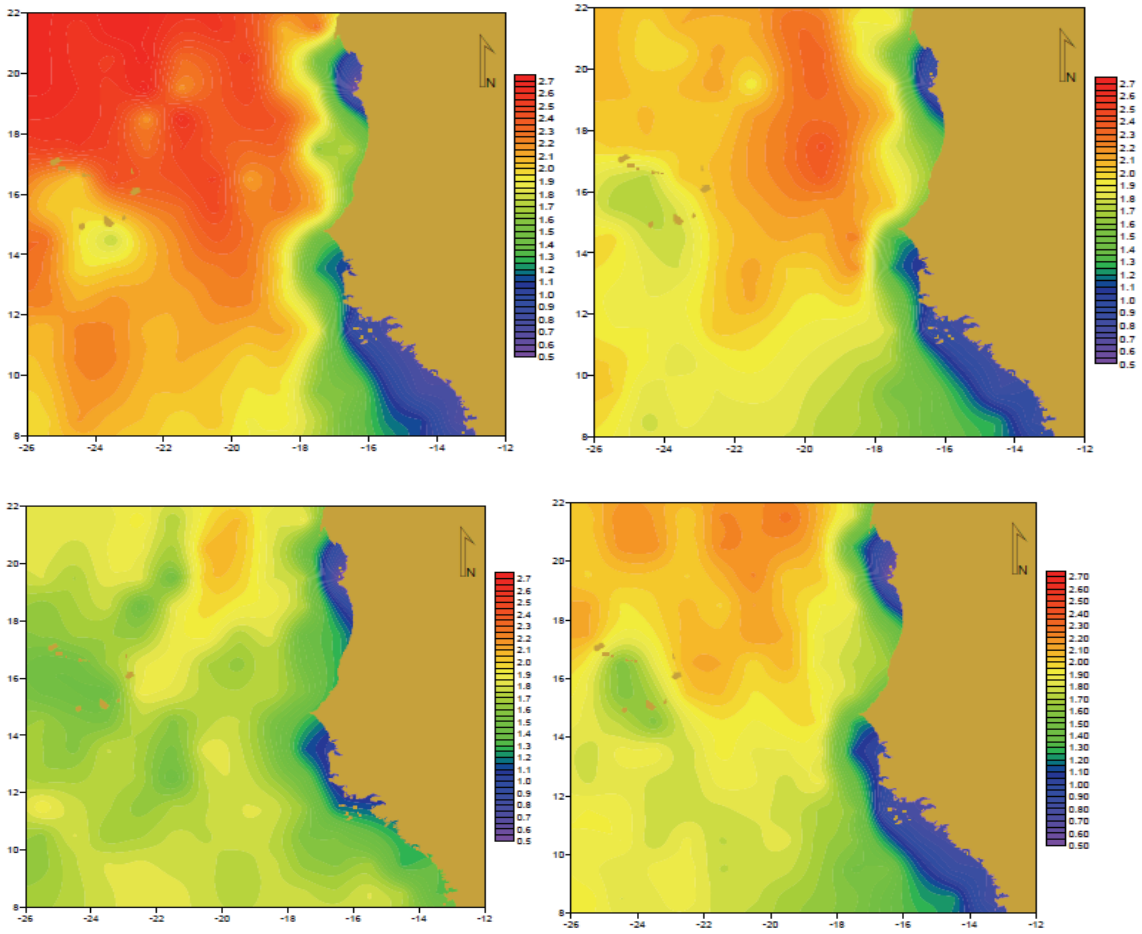


Figure 4. Map of the average value of significant wave height for the month of January (analysis of SSHA Topex Poséidon data for the period between 1st January 1992 and 15 Mars 2005 at the nodes of a 1° x 1°mesh): January, April, August, November. According to THOMAS. Y-F. 2005.- Climatologie de la hauteur significative (h1/3) des vagues sur le littoral d'Afrique de l'ouest 8° to 22° n- 12° to 26° w. fascicule 1: Topex - Poseidon data.

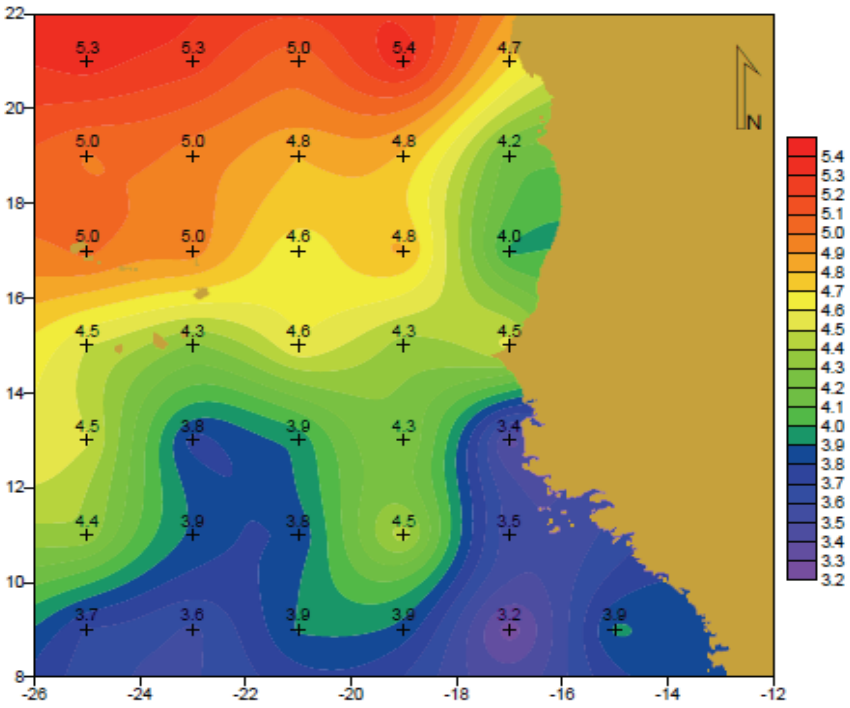


Figure 5. Estimation of significant wave height
of decennial occurrence. According to THOMAS. Y-F. 2005.

The maximal height of annually occurring significant wave is in the order of 3.5 metres to the North of Dakar, 2.8 m to the South. The significant wave of decennial occurrence varies from 4 m-4.7 m to the North of Dakar and 3.5 metres to the South. The significant wave of centennial occurrence is estimated at 4.7 to 5.7 m to the North of Dakar, 3.7 m to 4 m off the coast of Guinea Bissau and in the order of 5 m off the coast of Guinea and Sierra Leone.

Tides

The tides are mainly semi-diurnal for the whole of the zone, with two daily peaks and minima.

The average tidal currents are very variable, essentially depending on the morphology of the continental shelf: in the order of 1.2 m from Mauritania to Senegal, reaching 5 metres in Guinea Bissau, decreasing steeply in Côte d'Ivoire (1m). They are slightly higher in Togo and Benin (1.4 m). Where tidal ranges are wide, tidal currents can reach considerable speeds, which still depend on the local morphology of the shelf.

10. ANNEX 3: SUMMARY PRESENTATION OF COASTAL SYSTEMS

This annex is completed by the elements presented in the cartography information (document 3)

"There is no other milieu in Africa as sensitive and mobile on every scale of place and time as the interface represented by the coastal fringes. This is proven by the widespread schema of coastal complexes that bar the rias that are being filled up: low-lying valleys, marshes, lakes, witnesses to quaternary submergings, ancient rims and mudflats where mangroves and grassy salt-marshes mingle with coastal lagoons that are deep in places but often a thin film of water, spits and coastal rims battered and reshaped by the ocean waves and the winds from the sea, the whole solidarily and alternatively swept by the spates of coastal rivers and invasions of seawater constitute the natural framework the most accidentally changing and the most vulnerable to human manipulation".[44]

10.1. LITHOLOGY OF THE COASTAL ZONE

The major part of the current coastal region is typified by the contact of the ocean with sandy formations offering little resistance to the action of the coastal drift currents. Even the granite or sandstone rocks along the shore edge from Liberia to Ghana, since they are profoundly altered, only emerge locally in small rocky headlands.

Recent soft formations (Plioquaternary)

⇒ **Sandy, dune formations and clay depressions:** these extend over the whole coast from Mauritania to Dakar, with a coastal rim and practically straight beaches. Ancient and current dune formations extend continuously in transition with the sandy coastal rim. Narrow in places, they border the saline depressions occasionally flooded by the sea or salt flats (sabkhras).

⇒ **Coastal rim and sandy terraces:** the most extensive parts are located at the level of the Sherbro Islands, from the East of Cote d'Ivoire from the Volta delta down to Benin. However, there are other, similar deposits of lesser dimensions from the South of Senegal to Liberia. These deposits of variable thickness and continental extension correspond to several phases of fluviomarine siltation, often in continuity with the alteration coverages in place.

⇒ **Sandy-mud sediments:** these deposits result from the interaction between the tidal currents and the trapping of sediments by the mangroves, leading to a flood-prone coastline, dotted in places with sandy spits. They are largely presents at Siné Saloum in lower Casamance and on the whole of Guinea Bissau and Guinea, round to the Sherbro islands in Sierra Leone. The coast in contact with the ocean is doubled with an "interior coast" reached by the tides, but not exposed to ocean waves.

Sediment formations (Cretaceous and Tertiary)

These are profoundly altered, subject to a long evolution of the soil that included the formation of ferruginous cuirass of a variety of ages and dimensions. The relict rocks that have not been altered and the ferruginous cuirasses offer a certain amount of resistance to marine erosion, determining small headlands and rocky shallows, thereby structuring the coast into sandy coves bounded by these headlands.

⇒ **Limestone, marl-limestone and relicts of ferruginous cuirasses:** these are present close to the coastal area of Dakar at Joal Fadiout, or at the level of the marine continental shelf.

Often masked by sandy coverage or relicts of cuirasses, they are only rarely visible on the coast. Deposits in the marine environment, they contain significant reserves of phosphates and of small deposits of hydrocarbons.

⇒ **Sandstone and sandy-clay sediments:** Contrary to the previous types, these correspond to deposits on the continental milieu, "continental terminal", tertiary sands in Côte d'Ivoire, argillaceous soils ("terres de barre") in Togo and Benin, and border the coastal zone from Southern Senegal to Liberia.

Sandstone formations from the Primary and Precambrian eras

Except in the Accra region of Ghana and in a small number of places in Guinea Bissau, they are not in contact with the ocean. They appear as coastlines with alternating sandy coves and small rocky headlands.

Intrusive and metamorphic rock from the Precambrian era

Present in the coastal zone of almost the whole of Liberia, the west of Cote d'Ivoire and eastern of Ghana. Whatever type they are, these rocks have been subject to a long period of geological alteration and the soils and thick alterites that result offer little resistance to marine erosion. Some veins of harder rock escape this situation, however (dolerite, pegmatites, quartzites) or weathered granite in preserved, separate "balls". The coast is structured in small rocky headlands, portions of a few hundred metres of rocky coast, with alternate sandy coves and creeks.

⇒ **Granite and metamorphic rocks:** these dominate from Monrovia to Fresco in Cote d'Ivoire, with the frequent presence of blocks of rock on the foreshore or reefs in the sea.

⇒ **Metamorphic rock and basic rock:** These characterise the coast of Ghana at the Cape Three Points, with portions of true rocky coast.

Intrusive rock form various periods (basalt, dolerite, gabbros)

These are rare on the coastal area with a rocky cost and the occasional sandy creek (Cape Verde peninsula at Dakar, Cape Verga in Guinea, Conakry peninsula in Guinea, rocky breakwater in Freetown, Sierra Leone and Robertsport in Liberia). Despite their slight extension, these rock outcrops largely protruding into the sea play a very important role in the organisation of coastal currents.

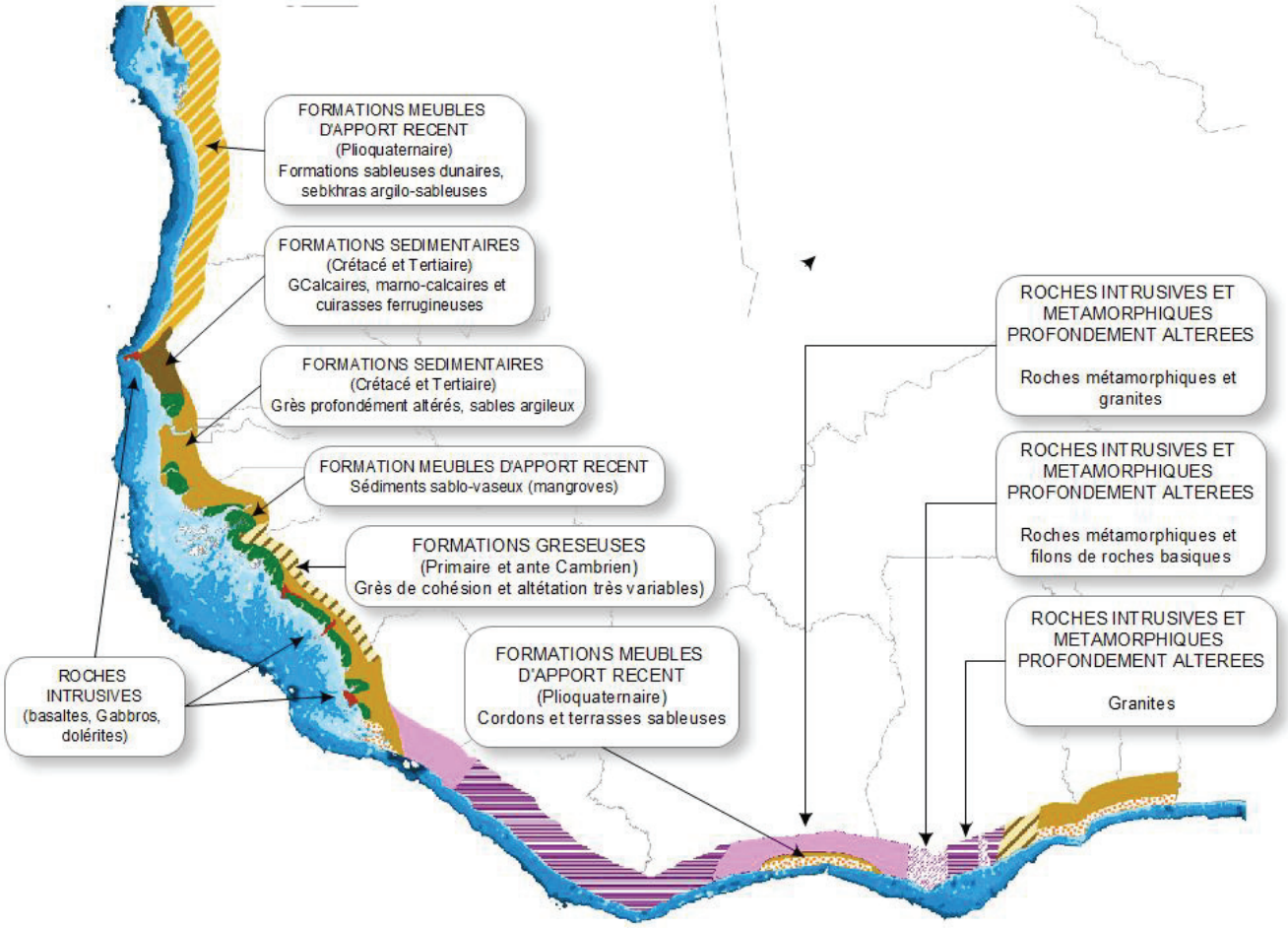


Figure 1: Indication of the localisation of the principal lithological units of the coastal region of West Africa.

The continental shelf

The morphology of the continental shelf varies from one sector of the coast to another. It is narrow and deeply dissected by canyons that cut into the shelf edge from Mauritania to the latitude of Dakar in Senegal.

It then widens and constitutes a vast reservoir of sediment opposite Guinea Bissau and Guinea, and becomes less important down to Sierra Leone facing the Sherbro islands. Related to this extension of the shelf, the tidal ranges are extreme in this zone, and may exceed 5 metres in Guinea Bissau.
It then narrows down and remains narrow extending round to Benin.
This shelf presents some notable features, including Khayar canyon in Senegal (South of the Grande Côte) and the "Bottomless Hole (*trou sans fond*)" situated exactly opposite Abidjan in Cote d'Ivoire. These features constitute zones that trap the sediment transported by longshore drift.

Figure 2. Continental shelf from Mauritania to Benin (blue shading from 0 to -300 metres)

10.2. CARTOGRAPHIC INVENTORY OF TYPES OF COAST AND APPROACH TO THEIR GEODYNAMICS IN RELATION TO COASTAL EROSION

This cartographic inventory has four objectives:

⇒ Define a **uniform reference framework** based on a typology applicable to the whole of the West African coast, in order to place in context and compare the various local manifestations of coastal erosion.

⇒ In the selected typology, take into account the criteria of exposure to potential natural risks to human settlements on the edge of the coastal area or likely to be built there in the future.

⇒ Diagnose the methods of sediment transport from the continent to the coastal area and their contributions to the conditions of equilibrium or disequilibrium in interaction with the coastal drift and sediment transport currents.

⇒ Highlight elements of reflection on the possible impact on coastal geodynamics resulting from hypotheses about rising sea levels.

The cartography work has been presented on a scale of 1:250,000 (which means, for the study zone, approximately 16 metres of map) and a summary work on a scale of 1:500,000 is planned. Aware that a scale of 1:250,000 does not provide the accuracy of satellite image interpretation required on a number of sites to present the context of erosion, the diagnostic study was completed (as it was impossible to locate all the information on the map) by means of a systematic "zoom" of the coast at a scale of +/- 25,000 (using tools such as Google Earth, among others).

The layers of information used for this inventory were stipulated in the methodology memo presented in September 2009.

The proposed typology of the coastal systems centres around two complementary readings expressed on the 1/250,000 provisional geodynamic analysis map accompanying this report:

⇒ A classification of the shoreline by segments defined in accordance with the typology chosen.

⇒ On a coastal rim approximately 20 km deep, zoning carried out in accordance with the sediment characteristics and methods of potential transfer of sediment to the coastal area.

The two typologies implemented (map information) are presented in document 3.

10.3. DIFFERENTIATED SEDIMENT SUPPLIES

Sediment flows determine not only how coastal systems evolve, but many other aspects as well, in particular the productivity of the waters. It was demonstrated[45] that humanity has increased global continental sediment flows by a volume in the order of 0.6 +/- billion tonnes through erosion, agriculture and deforestation. On the other hand, the multiplication of reservoirs has decreased these flows by a volume in the order of 1.4 +/- 0.3 billion tonnes. An estimated 100 million tonnes (including 3 billion tonnes of carbon) are sequestered in these reservoirs today.

Aeolian sediment input zones

The coastal zone stretching from Nouadhibou to Dakar, with the exception of the mouth of the Senegal river, is typified by a wide stretch of sandy, predominantly dune coverage**.** The continent-coastal interface is highly subject to erosion and Aeolian transport under the action of winds from substantially different directions:

⇒ The North-South to North/East– South/West Harmattan which blows continuously during more than six months of the year.
⇒ The West-Easterly sea wind and occasional monsoon winds during the short rainy season which are South/Westerly - North/Easterly.

[45] Syvitski. J.P. & al. 2005.- Impact of Humans on the Flux of Terrestrial Sediment to the Global Coastal Ocean. **Science.** 308, 376-380p.

The Harmattan is the driving force behind the coastal drift currents (CDL) and sediment transport from continent to coast, but the role of winds in the opposite direction is far from negligible in reconfiguring the dune formations along the edge of the littoral and sediment transfers towards the continent. Starting from June in particular a South-North current cell forms opposite the Senegalese Grande Côte.

This global schema should be nuanced however with the increasing importance of sand transfer from the coast to the continent gradually descending towards the South, in particular from the mouth of the Senegal River.

With the exception of the Senegal River and the very occasional coastal wetland outlets, no watercourses, even temporary, reach the coast in this area.

Note also the existence of the Khayar canyon to the north of the Cape Verde peninsula, whose role in trapping the sediment transported by the coastal drift should be taken into account.

Fluvial sediment input zones

Fluvial sediment input is conditioned by (i) pluviometrics; (ii) the extent of the catchment areas; (iii) morphology and their lithological and pedological types. Figure 4 schematises the principal catchment areas in relation with the rainfall.

Principal rivers in West Africa[46].
(Transboundary catchment areas and shared rivers are shown in bold).

Country	Name	Surface area drained In km²	Water supplied to the sea from rivers (Qsp)[47]
MAURITANIA	-		
SENEGAL	**Senegal**	440 000	774
	Siné-Saloum	200 000	2000
	Casamance		
THE GAMBIA	**The Gambia**		
GUINEA BISSAU	**Konkouré**		
GUINEA	**Konkouré**		
	Corubal		
SIERRA LEONE	Kolente	200 000	6750
	Moa		
LIBERIA	**Sassandra**		
	St Paul		
	St. John		
	Cestos		
	Senghuen		
	Cavalli		
COTE D'IVOIRE	**Sassandra**	295 000	1465
	Davo		
	Bandama		
	Comoé		
GHANA	**Tano**		
	Pra		
	Volta	394 000	1260
	Densu		
	Ancobra		

[46] UNEP. 1980.- **River inputs in West and Central African marine environment**. Programme des Mers Régionales. 62p.
[47] Specific flow rate: number of litres of water flowing per second on 1km² of catchment area.

	Argensu	135 000	1 080
TOGO	Maho		
	Mono		
BENIN	**Mono**		
	Ouémé		
	Couffo		
	Zou		

The biggest, most extensive catchment areas are in areas with low rainfall. Reciprocally, in the regions with the highest rainfall, the catchment areas are smaller. This observation holds true for Liberia particularly, where the weathered, basement topography is rugged, even dissected into multiple small catchment areas. This remark goes hand in hand with the observation of coastal **sediment compartmentalisation** which is obviously accentuated in those coastal facies with headlands and sandy coves, which characterise rocky coasts (of limited extension in the case of West Africa). A large proportion of the catchments area of the Niger, and globally in the Fouta Djallon part with the heaviest rainfall, does not contribute to sediment input in the zone considered by this study.

For the regions with high pluviometrics, the importance of flood peaks is noted, which are reflected in (i) marked desalination of coastal waters (Guinean waters); (ii) the expulsion and remobilisation of the sandbar at the estuary mouth, in particular in the mangrove areas. This removal effect is also essential in the dynamics of lagoon outlets.

It would obviously be extremely contingent to produce figures regarding sediment transport in this hydrographic network. The existing data, even for the rivers the most extensively studied, remains quite unreliable, and the **inter-annual variability of the precipitations regime** is also major. The droughts in the 1970s marked a break in the pluviometric series, with a reduction in average flow rates in the order of 15 to 20%, sometimes even higher, as in the case of the Senegal river. Severe low water flows have become frequents, with occasional drying up of flows in certain streams in the Sudan-Sahelian zone.

It should, however, be observed that these sediment transports are largely trapped (i) by dams[48]; (ii) through the multiple, more or less functional developments of low-lying ground for agriculture, which occupy a high proportion of fluvial valleys, including the perimeters of irrigated agriculture. The marked regression of gallery forests in the Sudanian zone and crop growing on the banks also alter the river profiles and in the long term contribute to filling up the river beds.

[48] Even through there are a lot fewer dams in West Africa than in other parts of the continent, such as East Africa. Note, however that several dams are currently in the planning stage.

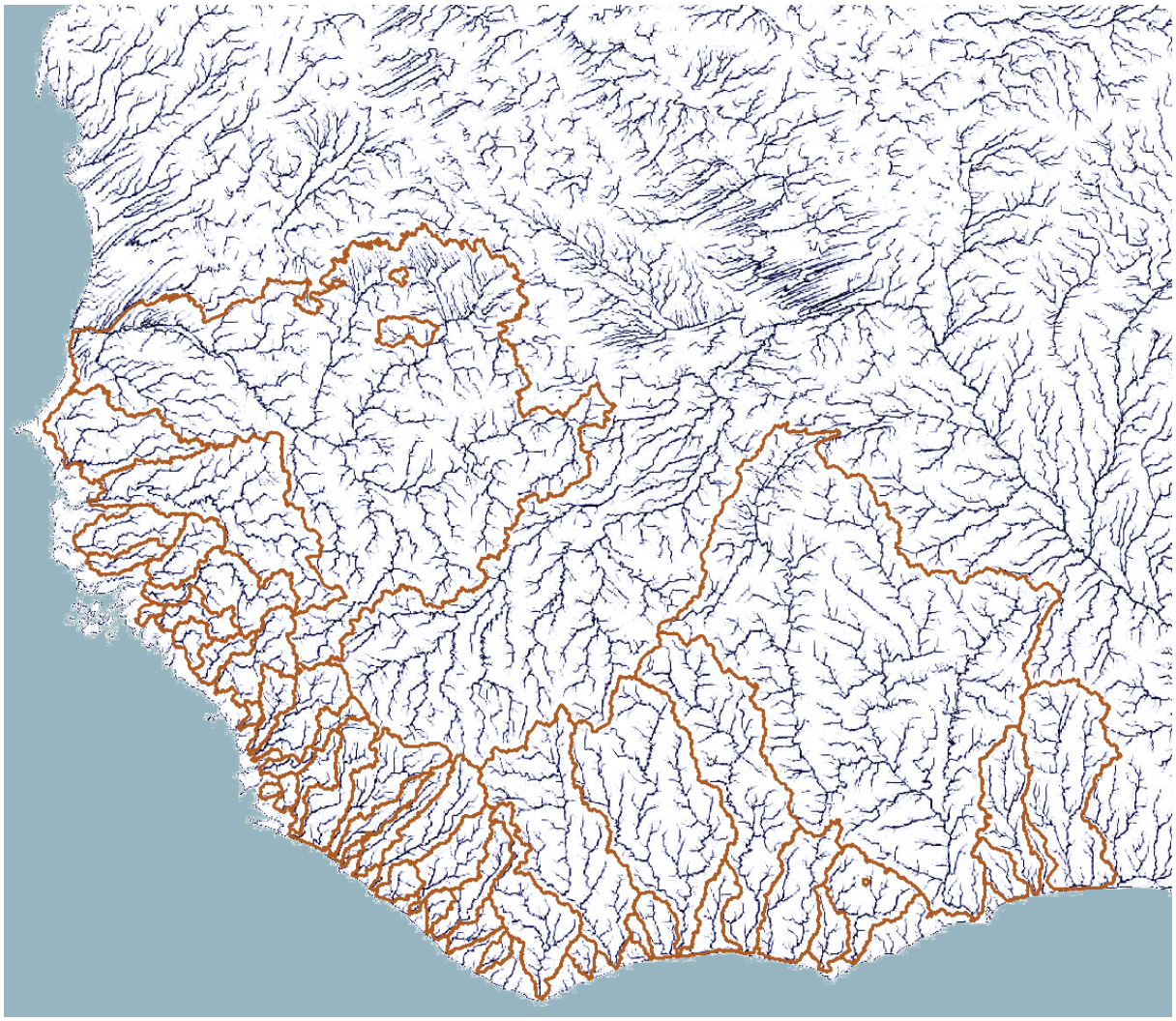


Figure 3. Distribution of the hydrographic network and principal catchment areas (according to Hydrosheds data)

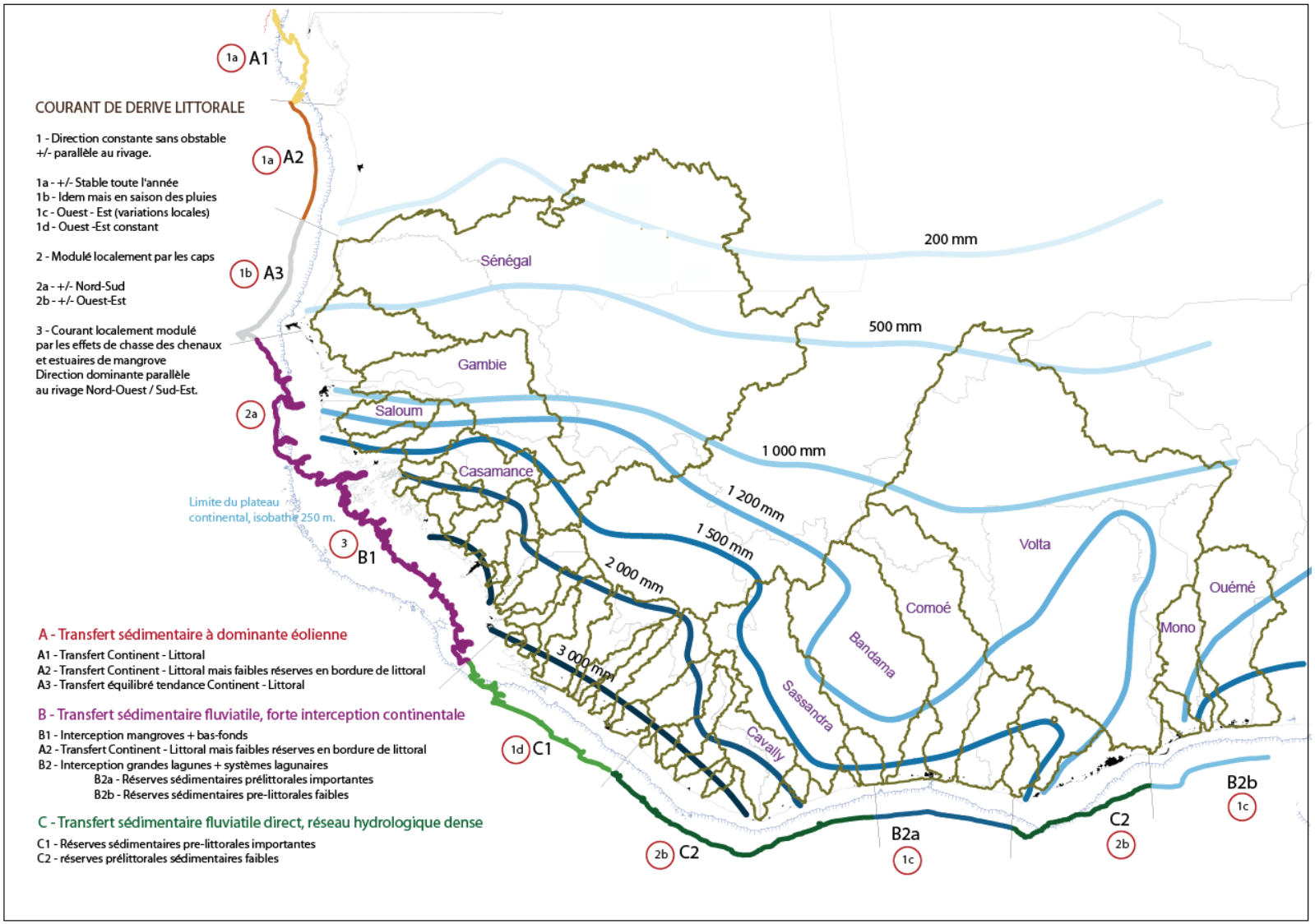


Figure 4. Catchment areas, isohyets and sediment transfer modes in West Africa

These hydrologic constraints have led to the building of dams on the majority of large rivers, often for hydroelectric power (50% of dams), but also for agricultural purposes. In certain cases, there are several purposes; the Senegal River Basin Development Organization for example tries to reconcile agricultural production goals with the production of hydro-electric power and navigation. There are approximately 150 dams in West Africa, with several more scheduled. This number is relatively low when compared to Southern Africa, however, which has the majority of dams (there is a total of 1,300 dams in Africa and 45,000 worldwide). The two largest dams in West Africa are the Akosombo on the Volta in Ghana, built in 1964, which stands 134 metres high (4th highest in Africa) and has a capacity of 150 billion cubic metres (3rd in Africa) and the Kossou on the Bandama in Côte d'Ivoire, which has a capacity of 28 billion cubic metres (6th in Africa).

The consequences of these developments are multiple, in particular in terms of conserving biodiversity, but also in reducing sediment load and the speed of flows particularly during flood peaks. The consequences in the coastal zone and the deltas are often major: salination of soil and waters, erosion related to sediment deficits, accretion and delta formation related to energy deficits for the annual expulsion of silt plugs.

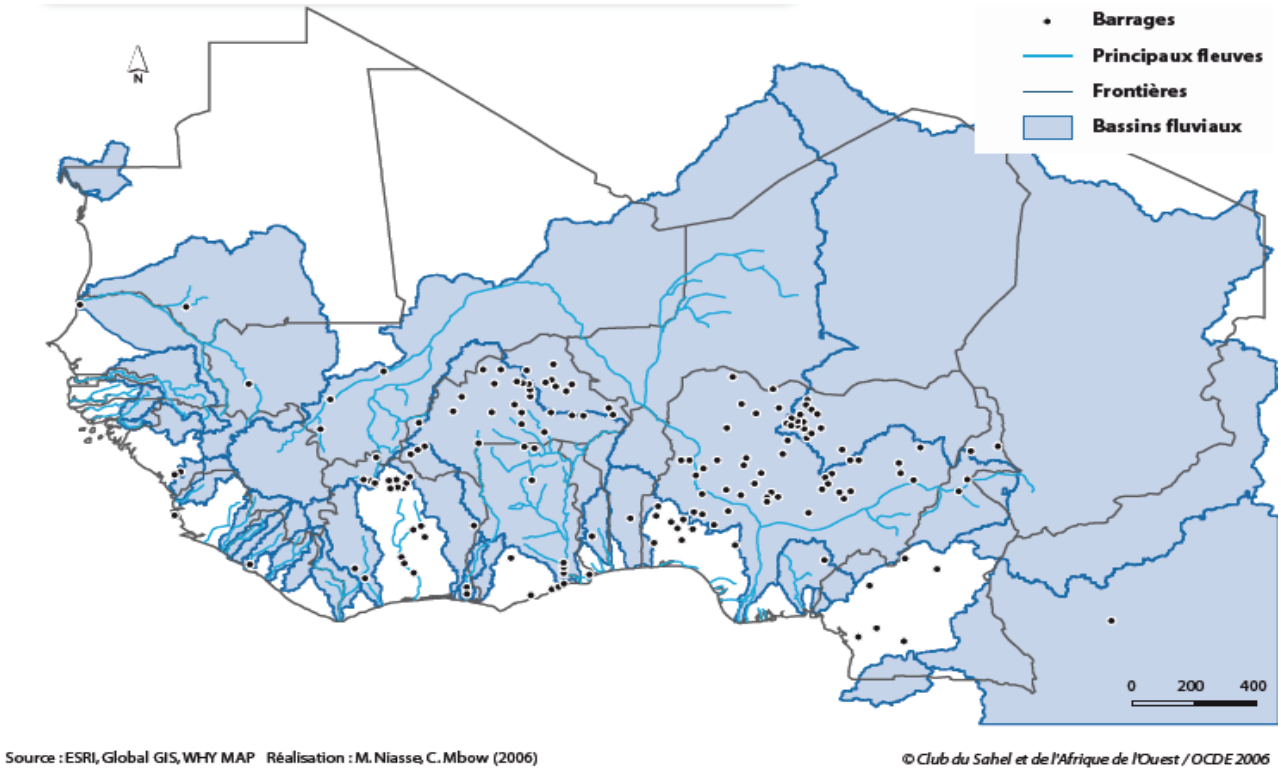


Figure 5. Localisation of major dams (over 15 metres) in West Africa. Source: SWAC/OECD.

With the exception of special cases such as the Gambia and Senegal, which have regional river development organisations (OMVG, OMVS), the majority of these dams were designed at national level, and therefore often without taking into account in depth the remote impacts of the developments, which should be considered on a sub-regional scale.

11. ANNEX 4. DEMO-ECONOMIC PERSPECTIVE FOR WEST AFRICA: PROJECTIONS TO 2030 - 2050[49]

11.1. DYNAMIQUES DE PEUPLEMENT, CROISSANCE ECONOMIQUE ET AMENAGEMENT DU LITTORAL D'AFRIQUE DE L'OUEST

L'objectif des scénarios démo-économiques à moyen et à long terme proposés dans ce volet particulier de l'étude du SDLAO est de fournir aux décideurs des éléments d'appréciation des transformations structurelles profondes auxquelles la région Afrique de l'ouest et donc sa zone littorale seront probablement soumises au cours des deux générations à venir. En un siècle (1950- 2050), cette région en voie de peuplement aura en effet vu sa population totale décupler et sa population urbaine multipliée par plus de cinquante.

La zone littorale, dont le Produit Régional Brut devrait plus que décupler entre 2010 et 2050, restera très probablement aux avant-postes des bouleversements attendus, et ne pourra que difficilement être mise à l'abri des pressions de tout ordre sur ses sols, ses ressources naturelles, ses écosystèmes et ses paysages.

L'un des défis du SDLAO consistera à définir le meilleur compromis possible entre les impératifs de la prévention des risques et de la protection de l'environnement d'une part et les impératifs tout aussi pressants du développement, dont le rythme sera largement imposé par les dynamiques démographiques.

La première partie de cette étude consiste donc à décrire aussi succinctement que possible le processus de peuplement non seulement de la zone littorale concernée par le SDLAO, mais aussi des douze pays auxquels appartient cette zone littorale, ainsi que des autres pays d'Afrique de l'Ouest, qui sont situés à l'intérieur de cette région. Tous ces pays sans littoral font en effet partie de **l'espace de peuplement** de cette partie de l'Afrique sub-saharienne, au sein duquel il faut s'attendre, comme par le passé, à de profondes restructurations. Cette approche macro-régionale est nécessaire pour comprendre ce qui s'est passé sur la frange littorale au cours du demi-siècle passé et ce qui risque de s'y passer dans le futur.

Le peuplement est l'une des variables clefs qui doit être prise en compte, mais ce n'est évidemment pas la seule. La seconde variable concerne l'activité économique et ses implications en termes d'infrastructures et d'équipement du territoire. Les données disponibles sur la géographie économique sont malheureusement quasi inexistantes : les comptes nationaux ne fournissent que des macro-agrégats sans aucune indication de localisation et à peu près inutilisables pour l'analyse des évolutions sur le temps long. Nous nous efforcerons cependant de donner des ordres de grandeur de la densité d'activité économique de la zone côtière du SDLAO en utilisant la méthodologie développée dans l'étude WALTPS, en confortant cette analyse très macroscopique par des images démo-économiques spatialisées d'un des douze pays de la région et de sa zone côtière, en l'occurrence le Bénin, dans l'esprit du programme ECOLOC.

Cet essai d'analyse et de prospective économique spatialisée fait l'objet de la deuxième partie de cette étude. Comme pour le peuplement, les considérations sur l'activité économique proche du littoral seront replacées dans le contexte de la région Afrique de l'Ouest et plus généralement de l'Afrique sub-saharienne, car l'avenir du littoral et de la frange côtière est évidemment lié à celui de toute la région à laquelle ce littoral appartient.

Le processus de peuplement

L'Afrique sub-saharienne (ASS) est la dernière région du monde à accomplir sa transition démographique. Ce processus implique une multiplication par près de dix de la population entre 1950 (environ 180 millions d'habitants) et 2050 (plus de 1.7 milliard d'habitants selon les projections des Nations Unies).

[49] This annex was written by Jean-Marie Cour, Consultant, demo-economist.

Population totale en millions d'habitants

Region name	1950	1960	1970	1980	1990	2000	2025	2050
Sub-Saharan Africa	178	224	290	382	509	659	1137	1748
North Africa	43	54	69	89	114	138	204	245
Rest of the world	2294	2743	3317	3959	4629	5257	6599	7250

Taux de croisssance de la population totale

Region name	50-60	60-70	70-80	80-90	90-2001	2001-2025	2025-2050
Sub-Saharan Africa	2.3%	2.6%	2.8%	2.9%	2.6%	2.2%	1.7%
North Africa	2.4%	2.5%	2.5%	2.6%	1.9%	1.6%	0.7%
Rest of the world	1.8%	1.9%	1.8%	1.6%	1.3%	0.9%	0.4%

Un tel décuplement de la population totale de l'ASS n'est évidemment pas possible dans chacune des parties qui la constituent, qu'il s'agisse de zones subdésertiques aux confins du Sahel, qu'il s'agisse de certaines zones rurales déjà densément peuplées où la contrainte foncière est forte, qu'il s'agisse de pays enclavés et aux potentialités limitées comme le Niger – en dépit de son potentiel minier- , qu'il s'agisse enfin de sous-ensembles de pays membres d'institutions régionales comme le CILSS qui ne correspondent pas à des espaces de peuplement.

Avec des taux de croissance naturelle de l'ordre de 2 ou 3 % par an, l'ajustement du peuplement aux contraintes et potentialités physiques mais aussi et surtout aux forces du marché implique des taux de migration nette qui dépendent évidemment de la taille des entités considérées. A l'échelle des 47 Etats de l'ASS dont les frontières sont artificielles, ces taux de migration sont de l'ordre de un pour mille à un pour cent par an de la population totale, et impliquent donc des flux migratoires nets entre Etats de plusieurs millions de personnes par an. Mais ces migrations entre Etats ne sont qu'une petite fraction des flux migratoires entre entités territoriales plus petites comme les districts ou les communes, entre milieu rural et milieu urbain, entre zones enclavées, hors marché, et les pôles de croissance qui sont souvent associés aux points de contact entre l'Afrique et le reste du monde et sont donc souvent tout proches du littoral : « un fait patent est que le développement ne s'opère pas partout en même temps ni à la même vitesse » (François Perroux).

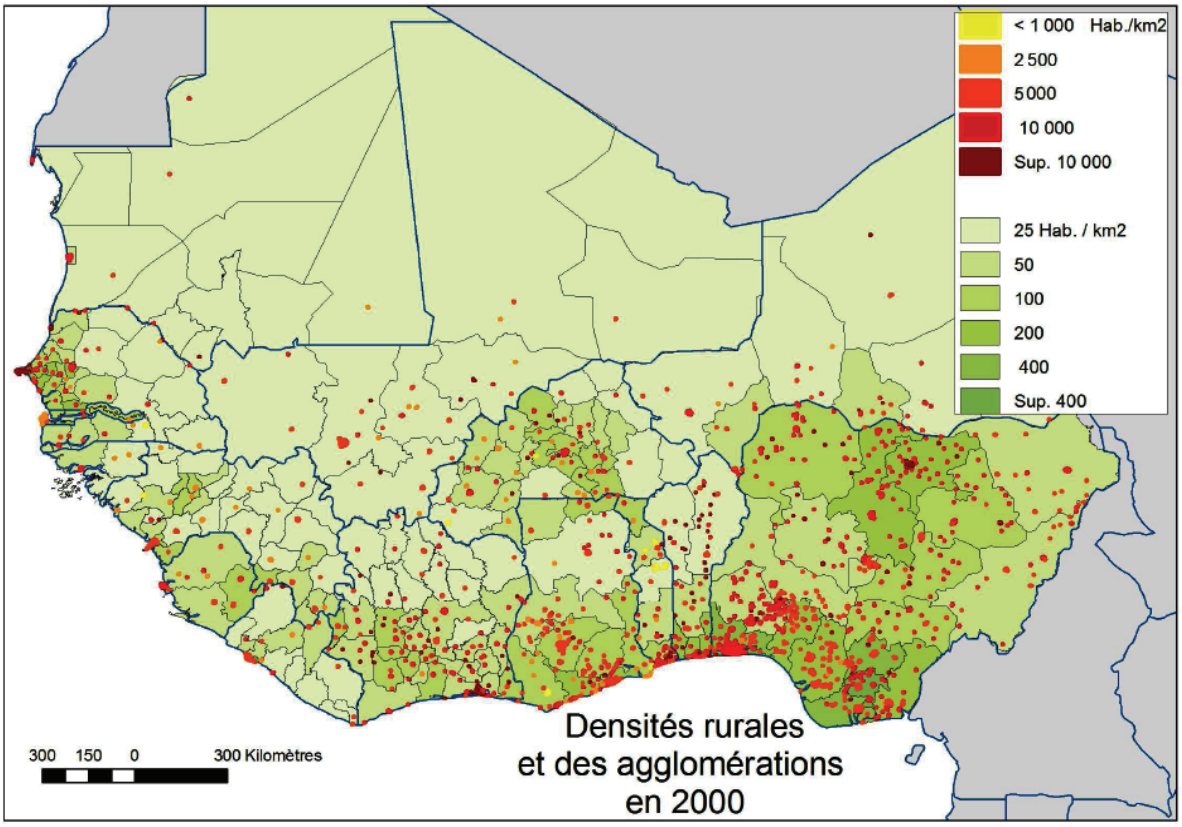


Figure 1. Densités rurales et des agglomérations en 2000 (d'après le programme AFRICAPOLIS).

Redistribution du peuplement entre pays côtiers et pays enclavés d'Afrique de l'Ouest

Les tableaux ci-après donnent la population totale passée des sous-ensembles régionaux suivants inclus dans l'Afrique de l'ouest au sens large, avec un rappel pour l'Afrique sub-saharienne dans son ensemble :

⇒ l'Afrique de l'ouest côtière au sens de l'étude SDAL (en abrégé WA Littoral), composée des 12 pays suivants : Cape Verde, Mauritanie, Sénégal, Gambie, Guinée Bissau, Guinée, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Bénin ; ce sous-ensemble comprend logiquement trois pays côtiers hors UEMOA (Sierra Leone, Liberia et Ghana) mais ne comprend pas le Nigeria, qui fait pourtant partie du même ensemble géographique ;

⇒ l'Afrique de l'ouest au sens de l'étude WALTPS qui comprend ces mêmes pays plus le Nigeria, le Cameroun, le Mali, le Burkina Faso, le Niger, le Tchad et la Centrafrique. Cette région WALTPS qui rassemble 19 pays a pour épicentre le Nigeria qui concentre près de la moitié de la population totale, et inclut donc naturellement son voisin le Cameroun, habituellement rattaché à la région Afrique centrale ;
⇒ l'ensemble des 7 pays enclavés de la région WALTPS ;
⇒ et la CEDEAO (ECOWAS) qui comprend ces mêmes pays moins la Mauritanie, le Tchad, la Centrafrique et le Cameroun.

Au cours du demi-siècle passé, la fraction de la population totale d'Afrique de l'ouest vivant dans les douze pays de la région WA Littoral s'est accrue de 27% à 31%, alors que le taux de croissance naturelle (natalité moins mortalité) de ces pays côtiers est en général plus faible que celui des pays enclavés, moins avancés. La croissance passée de ce ratio résulte donc des migrations nettes de l'intérieur de la région vers les pays côtiers. En dépit des troubles qui ont affecté plusieurs pays côtiers, comme la Côte d'Ivoire, le Liberia et la Sierra Leone, ces migrations se sont poursuivies au cours des deux dernières décennies.

	Population totale en millions d'habitants. Source : UN Pop. Division							
Région	**Composition**	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**2006**
WA Littoral	**12 pays**	**19**	**26**	**33**	**44**	**60**	**79**	**94**
WA pays enclavés	**7 pays**	**52**	**63**	**80**	**106**	**142**	**186**	**208**
WALTPS	**19 pays**	**72**	**89**	**114**	**149**	**201**	**265**	**302**
ECOWAS	**15 pays**	**62**	**78**	**101**	**132**	**179**	**236**	**267**
Sub-Saharan Africa	**49 pays**	**178**	**224**	**290**	**382**	**510**	**661**	**766**
Littoral en % de la région WALTPS		***27%***	***29%***	***29%***	***29%***	***30%***	***30%***	***31%***

Taux de croissance de la population totale par région selon les données UN						
Région	**Période**	**50-60**	**60-70**	**70-80**	**80-90**	**90-2006**
WA Littoral	**12 pays**	**2,9%**	**2,6%**	**2,7%**	**3,2%**	**2,9%**
WA pays enclavés	**7 pays**	**1,9%**	**2,5%**	**2,8%**	**3,0%**	**2,4%**
WALTPS	**19 pays**	**2,2%**	**2,5%**	**2,7%**	**3,0%**	**2,6%**
ECOWAS	**15 pays**	**2,3%**	**2,6%**	**2,8%**	**3,1%**	**2,5%**
Sub-Saharan Africa	**49 pays**	**2,3%**	**2,6%**	**2,8%**	**2,9%**	**2,6%**

Les migrations au sein de la région ont affecté de manière non négligeable la répartition de la population entre les pays et entre les zones écologiques. Ainsi, par exemple, entre 1930 et 1990, la population de l'actuel Burkina Faso a triplé, de 2.8 à 8.7 millions d'habitants, cependant que la population de la Côte d'Ivoire a été multipliée par huit, de 1.4 à 11.4 millions d'habitants. Deux fois moins peuplée que l'actuel Burkina Faso en 1930, la Côte d'Ivoire est aujourd'hui plus peuplée d'un tiers. Si ces migrations intra-régionales n'avaient pas eu lieu, la situation économique et sociale et les problèmes d'environnement des pays du Sahel seraient sans doute bien pires qu'ils ne le sont aujourd'hui.

On pourrait tirer de cet exemple la conclusion que la population d'Afrique de l'Ouest jouit d'une forte mobilité. Pour apprécier l'importance réelle de ces flux migratoires inter-Etats nets et comparer la mobilité en ASS et dans d'autres régions du monde, il faut tenir compte de la taille des entités considérées. Les migrations nettes entre pays d'une région sont d'autant plus importantes que les pays en question sont petits, ce qui est le cas en Afrique. Compte tenu de ce facteur, il apparaît en fait que la mobilité entre pays de l'Afrique de l'ouest a été et reste très inférieure à celle constatée dans d'autres régions du monde.

Ainsi, aux Etats Unis, la population et les activités répondent sans délai aux opportunités et aux forces du marché et se déplacent librement au sein de l'Union, avec des taux de migration nette entre Etats allant de -5 % à +5% par an en longue période, sans drame. Ces mouvements sont de toute évidence facilités par la politique d'infrastructure et d'équipement du territoire suivie avec une belle constance par le Gouvernement Fédéral, et ce depuis plus de deux siècles. La Chine et l'Inde offrent deux autres exemples intéressants de gestion du peuplement à l'échelle de sous-continents. Dans un cas comme dans l'autre, la mobilité régionale a été facilitée par l'unité de gouvernement, dont l'ASS ne dispose pas.

Migrations locales

Les migrations internationales ne sont que l'un des aspects de la redistribution de la population dans l'espace régional. L'étude WALTPS a permis d'estimer que, après un laps de temps d'une génération, 30 à 40 % des habitants de l'Afrique de l'Ouest ne résident plus dans leur district ou leur commune d'origine. Sur cette analyse des migrations locales au sein de l'espace ouest africain, le lecteur est prié de se reporter à l'étude WALTPS où cette question est abondamment traitée, ainsi qu'aux diverses notes sur les interactions entre ville et milieu rural citées en référence. Contentons nous ici de présenter la carte du Golfe de Guinée. Cette carte montre que les zones de densité rurale forte (supérieure à 50 habitants par km²) se développent préférentiellement à la périphérie des villes (figurent sur cette carte les villes de plus de 50 000 habitants en 1990). Les cartes des tensions de marché de l'étude WALTPS montrent aussi l'importance des réseaux de villes et d'infrastructures dans la structuration de l'espace rural et du secteur primaire.

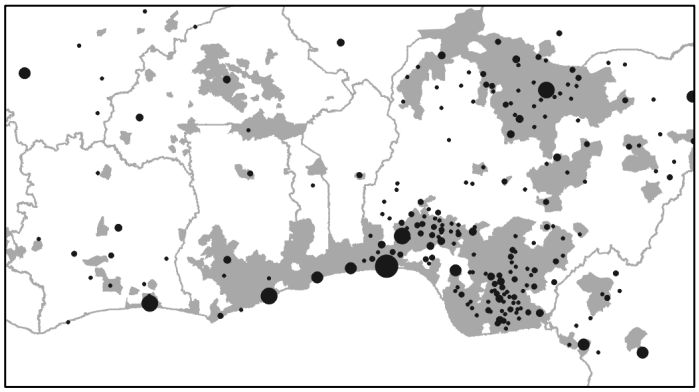


Figure 2. Environnement et occupation du territoire (source : AFRICAPOLIS)

Redistribution du peuplement et urbanisation

Un des aspects les plus visibles de la redistribution du peuplement est l'urbanisation. Entre 1950 et 2006, la population urbaine de l'ASS a été multipliée par un facteur 14, contre 6 en Afrique du nord et 4 dans le reste du monde. Les raisons de cette croissance urbaine plus rapide que partout ailleurs et leurs implications multiples ont été clairement expliquées dans les études ILTA (1984) et WALTPS (1995), puis dans le programme ECOLOC, auxquels il est recommandé de se référer.

De temps à autre, on voit resurgir l'argument du biais urbain, selon lequel ce processus d'urbanisation résulterait de mauvaises politiques, et serait dangereux et insoutenable. Il est temps de regarder la réalité en face et d'arrêter de répéter que les économies de la plupart des pays africains sont essentiellement agricoles et rurales et que les villes sont des ramassis de pauvres enclins à la débauche.

Suivre le processus d'urbanisation : le cadre conceptuel démo-économique et spatial de l'étude WALTPS

L'interprétation des données nationales concernant le processus d'urbanisation est compliquée par le fait que la définition de la population urbaine varie d'un pays à l'autre et même d'une décennie à l'autre dans certains pays. La réévaluation de la population urbaine à l'échelle des 19 pays de l'Afrique de l'ouest sur la période 1950-1990 a été l'une des tâches les plus difficiles et l'un des apports les plus substantiels de l'étude WALTPS. L'agrégat U (population urbaine) est défini dans cette étude comme la somme de la population de toutes les localités ayant à la date considérée plus de 5000 habitants agglomérés. Le nombre de localités incluses dans l'agrégat U et leurs limites géographiques varient donc avec le temps, contrairement aux entités administratives (districts, communes,. ;) auxquels les Etats se réfèrent pour calculer la population urbaine : le découpage du territoire en communes « urbaines « ou « rurales » ne suit jamais la réalité. Toutes les localités incluses à une date donnée dans l'agrégat U étant classées par taille, les bases de données de l'étude WALTPS permettent de calculer non seulement l'agrégat « U5 » (population des « villes « de plus de 5000 habitants) mais aussi « U10 », « U20 »,.. ou « Ux », correspondant aux villes de plus de 10 000, de 20 000 ou de x milliers d'habitants.

L'importance accordée dans l'étude WALTPS au suivi le plus précis possible du **processus** d'urbanisation trouve sa justification dans le cadre conceptuel démo-économique et spatial qui sert de base à cette étude. Le lecteur est prié de

se référer à cette étude, ainsi qu'aux documents du programme ECOLOC, pour une présentation détaillée de cette question. En un mot, WALTPS s'efforce de suivre toutes les implications pour les individus et pour la société du processus d'agglomération, qui a pour conséquence une multiplication par un facteur de l'ordre de 100 à 1000 de la densité d'activité locale et des changements radicaux dans la nature des activités et le comportement de tous les acteurs. L'étude WALTPS et le programme ECOLOC ont ainsi montré que la division du travail entre consommateurs et producteurs de denrées alimentaires, entraînée par l'urbanisation, est le principal moteur de la transformation du secteur primaire et de l'économie rurale, et que cette urbanisation, convenablement gérée, constitue une condition nécessaire de la sécurité alimentaire et du développement durable. Les statistiques les plus récentes confirment le bien fondé de cette analyse, qui ne peut plus guère être réfutée de bonne foi.

Exploitation et réinterprétation des données de l'étude AFRICAPOLIS

L'approche pluridisciplinaire adoptée dans l'étude AFRICAPOLIS, qui combine données des recensements à l'échelle du découpage le plus fin possible de la région en entités administratives et la délimitation du contour des agglomérations par interprétation à l'aide des photos satellites, fournit la meilleure mesure possible de la population agglomérée de chaque localité à la date où l'on dispose à la fois des données censitaires et de ces couvertures satellites.

Pour la période antérieure à 1980, où l'on ne dispose pas de couvertures aériennes comparables, la méthodologie suivie par AFRICAPOLIS n'est guère utilisable. Pour cette période, les écarts entre les distributions urbaines par taille de ville et les niveaux d'urbanisation donnés par cette étude AFRICAPOLIS sont, à quelques exceptions près, assez cohérents avec le contenu des bases de données de l'étude WALTPS, avec toutefois des évaluations de la population urbaine totale un peu supérieures. Faute de données sur l'extension réelle des superficies urbanisées dans les années passées, il n'est pas possible de savoir laquelle des deux sources WALTPS et AFRICAPOLIS est la plus fiable pour ces périodes lointaines.

Pour la période 1980-1990, l'étude AFRICAPOLIS conduit à des estimations de la population urbaine (au sens de l'agrégat U5 défini précédemment) et de la croissance urbaine sur cette période un peu plus fortes que celles donnée par l'étude WALTPS, la différence résultant sans doute d'une meilleure prise en compte de l'effet de la croissance spatiale des grandes villes et notamment des capitales.
Pour la période 1990-2000, les données brutes de l'étude AFRICAPOLIS sont les seules disponibles, puisque l'étude WALTPS ne pouvait tenir compte des recensements postérieurs à 1994. Pour certains pays, les distributions rang-taille des localités repérées par l'étude AFRICAPOLIS doivent cependant être complétées pour les villes de moins de 10 000 habitants, (et même de moins de 20 000 habitants dans le cas du Nigeria), ce que permet la méthodologie de l'étude WALTPS et du programme ECOLOC. On en verra dans la deuxième partie une application détaillée dans le cas du Bénin.

12 pays côtiers	**Population urbaine selon AFRICAPOLIS, WALTPS et Nations Unies**								
en millions d'habitants	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**2008**	**2010**	**2020**
AFRICAPOLIS	**1,7**	**3,7**	**7,9**	**13,8**	**21,5**	**32,7**	**42,4**	**45,3**	**64,5**
WALTPS		***4,3***	***7,7***	***12,9***	***20,4***				***77,2***
UN POPULATION DIVISION	***2,2***	***4,6***	***7,9***	***12,7***	***20,4***	***30,5***			

Dans ce qui suit, nous prenons comme base d'analyse du passé (période 1950-2008) les données fournies par l'étude AFRICAPOLIS, qui se prête bien à une analyse du processus d'urbanisation de la zone littorale. La population urbaine que nous retenons ici est, à toute date, celle des localités de plus de 5 000 habitants agglomérés repérées dans cette étude, majorée dans certains pays de celle des localités de 5000 à 10 000 habitants non identifiées dans cette étude mais dont l'étude de la distribution rang taille des agglomérations permet de soupçonner l'existence[50].

[50] Dans tous ces tableaux, les taux de croissance annuels inscrits en ligne sont calculés sur la période comprise entre l'année de la colonne et celle de la colonne précédente (par exemple, pour la dernière colonne, sur la période 2000-2008).

12 pays côtiers	Population totale, urbaine et rurale						
en millions d'habitants	1950	1960	1970	1980	1990	2000	2008
Populaton totale	19	26	33	44	60	79	97
Population urbaine	2	4	8	14	22	33	42
Population rurale	18	22	26	30	38	46	54
Ratio U/R	0,10	0,17	0,31	0,47	0,56	0,71	0,78
Taux de croissance de U/R		5,7%	6,3%	4,3%	1,9%	2,3%	1,3%
Taux de croissance de P		2,9%	2,6%	2,7%	3,2%	2,8%	2,6%
Taux de croissance de U		8,1%	7,8%	5,8%	4,5%	4,2%	3,3%
Taux de croissance de R		2,3%	1,4%	1,5%	2,5%	1,9%	2,0%

Croissance démographique et urbanisation de la zone littorale

Dans cette étude, la zone littorale est définie comme la fraction du territoire des 12 pays côtiers située à moins de 25 km de la côte. Cette zone littorale couvre 115 000 km², soit environ 5% de la superficie totale de ces pays. Rappelons que la zone d'étude ne s'étend que jusqu'au Bénin, et qu'elle exclut donc le Nigeria et le Cameroun.

Les villes appartenant à cette zone littorale peuvent être identifiées grâce à l'étude AFRICAPOLIS qui fournit les coordonnées géographiques de chacune des localités identifiées. En revanche, la mesure de la population totale de cette zone littorale n'est possible que si cette zone est constituée d'un nombre entier d'entités administratives, dont les recensements donnent la population. Ce calcul implique donc de disposer, pour chaque pays, des données des recensements au niveau le plus fin possible du découpage administratif du territoire, ce qui n'a pas été possible ici[51]. Faute de ces données, on s'est contenté d'une évaluation grossière de la population rurale du littoral, dérivée des analyses de l'étude WALTPS. Il conviendrait donc de demander à chaque équipe nationale de réévaluer, à partir de recensements, la population totale de la zone littorale aux années 1950 à 2010, ce qui permettra de réviser en conséquence les bases de données de cette étude.

12 pays côtiers	Population de la zone littorale						
Superficie de la zone littorale :	115000 km², soit:		5%	de la superficie totale des 12 pays côtiers			
en millions d'habitants	1950	1960	1970	1980	1990	2000	2008
Population des villes littorales	1,1	2,1	4,3	7,7	11,8	17,2	21,6
dont les métropoles des 12 pays côtiers	*0,8*	*1,5*	*3,4*	*6,2*	*9,6*	*14,0*	*17,5*
Villes littorales en % de la pop urbaine totale	62%	57%	55%	56%	55%	53%	51%
Taux de croissance de la pop urbaine littorale		7,2%	7,5%	5,9%	4,3%	3,9%	2,9%
Population rurale littorale	1,9	2,4	3,0	3,8	5,3	6,9	7,9
Population totale littorale	2,9	4,5	7,4	11,6	17,1	24,2	29,5
Niveau d'urbanisation du littoral	36%	46%	59%	67%	69%	71%	73%
Pop. littorale en % de la pop. des 12 pays côtiers	15%	17%	22%	27%	29%	31%	31%
Densité de population du littoral (hab/km²)	26	39	64	101	149	210	257

Le tableau ci-dessus montre que la zone littorale ainsi définie concentre un peu plus de la moitié de la population urbaine totale des pays côtiers sur un vingtième de la superficie totale de ces pays. Cette proportion a est en décroissance lente sous l'influence de deux facteurs opposés : ouverture aux échanges extérieurs, avec ses conséquences sur le tropisme côtier, et progression du maillage urbain des territoires nationaux (multiplication des « préfectures » et sous préfectures), qui renforce le poids démographique de l'intérieur. A ces deux facteurs structurels, s'ajoute depuis les années 1990 la crise des Etats et l'ajustement dit « structurel » qui a plus particulièrement frappé les capitales politiques des pays côtiers.

[51] Sauf pour le Bénin, pour lequel des comptes démo-économiques détaillés ont été élaborés en suivant la méthodologie du programme ECOLOC : voir la deuxième partie.

Population des villes littorales

en milliers d'habitants	1950	1960	1970	1980	1990	2000	2008
Bénin	60	170	280	610	880	1290	1750
Côte d'Ivoire	100	260	680	1460	2470	3680	4610
Cap Vert	17	32	50	70	130	210	280
Ghana	310	650	1150	1550	2170	3480	4450
Guinée	39	100	370	690	970	1320	1580
Gambie	26	34	70	170	320	540	690
Guinée Bissau	50	50	120	150	230	350	480
Liberia	23	80	210	410	640	940	1190
Mauritanie	0	5	50	210	480	650	770
Sénégal	290	490	850	1510	2160	2820	3320
Sierra Leone	80	130	230	420	610	830	1010
Togo	60	100	280	470	730	1160	1490
12 pays côtiers	1100	2100	4300	7700	11800	17200	21600

Population des métropoles

en milliers d'habitants	1950	1960	1970	1980	1990	2000	2008
Bénin	20	90	160	400	610	910	1260
Côte d'Ivoire	90	230	600	1290	2180	3150	3900
Cap Vert	10	13	20	40	60	90	120
Ghana	160	370	740	1040	1500	2520	3240
Guinée	40	100	360	670	920	1250	1500
Gambie	5	9	30	100	240	410	540
Guinée Bissau	50	50	120	120	180	300	420
Liberia	20	60	150	320	530	760	1000
Mauritanie	0	5	40	180	420	560	670
Sénégal	250	400	730	1270	1770	2260	2640
Sierra Leone	70	110	210	380	550	740	880
Togo	40	80	230	420	650	1030	1320
12 pays côtiers	760	1520	3390	6210	9620	13970	17500

Densité de population du littoral (hab/km²)

	1950	1960	1970	1980	1990	2000	2008
Bénin	100	160	210	350	490	710	940
Côte d'Ivoire	24	40	80	140	230	330	410
Cap Vert	50	50	70	70	80	110	130
Ghana	50	90	140	190	270	390	490
Guinée	17	33	70	110	150	210	250
Gambie	39	50	90	160	260	410	520
Guinée Bissau	9	11	16	21	30	40	60
Liberia	10	18	29	50	70	100	120
Mauritanie	0	3	8	21	40	60	70
Sénégal	37	50	80	130	180	240	280
Sierra Leone	25	33	50	70	100	130	150
Togo	90	120	220	360	560	860	1080
12 pays côtiers	30	40	60	100	150	210	260

En dehors des capitales, les taux de croissance de la population des villes côtières sont du même ordre que ceux des villes de l'intérieur. Ces taux de croissance urbaine sont en décroissance régulière, de 7.5% en

1960-1970 à 3.9% en 1990-2000. Cette décroissance tendancielle des taux de croissance urbaine a été bien analysée dans l'étude WALTPS, elle est à la fois structurelle (liée à la baisse de l'importance relative du réservoir de population rurale) et conjoncturelle (crise de l'économie moderne, ajustement structurel, freinage des flux migratoires, etc.). La baisse apparente de un point du taux de croissance urbaine au cours de la dernière décennie 2000-2008 s'explique sans doute en partie par un biais statistique et méthodologique (non prise en compte des extensions urbaines postérieures aux derniers recensements et aux dernières photos disponibles).

Le poids relatif de la zone côtière dans la population urbaine totale des pays et l'évolution dans le temps de ces ratios varient évidemment selon les pays, leur superficie et morphologie, et le caractère plus ou moins embryonnaire (comme en Mauritanie) ou mature (comme au Ghana et en Côte d'Ivoire) des réseaux urbains nationaux. Dans la plupart des pays côtiers de faible superficie, les taux de croissance urbaine ont à certaines époques atteint ou dépassé les 10 % par an. Les données détaillées par pays figurent dans la maquette Excel jointe à l'étude [52].

Consommation d'espace urbain

Selon une étude récente de la Banque Mondiale reposant sur l'interprétation des photos Landsat, la surface construite des villes aurait cru en moyenne de 3.2 % entre 1990 et 2000 alors que la population des villes de l'échantillon croissait au taux de 1.5 %. La taille des villes interviendrait peu dans les différences de taux de croissance : de 1 à 2% pour la population et de 2,5 à 3,6% pour les surfaces. Pour les villes africaines incluses dans cette étude, le différentiel de croissance entre surface construite et population urbaine serait supérieur à celui du reste du monde, et de l'ordre de 3% ou plus. La surface construite par habitant urbain serait de l'ordre de 150 m² par urbain en Afrique, pour une moyenne des PVD de 125 m² (les villes d'Asie étant en général plus densément construites que dans le reste du monde en développement).

Surface construite et urbanisée par habitant urbain (m²/hab.)

Surface construite (1)	1990	2000	Tx de crois. 1990-2000
ASS	105	150	3,6%
PVD	105	125	1,8%
Moyenne mondiale	155	185	1,8%
Surface totale urbanisée (2)		*210*	

Nota 1 Source : The Dynamics of Global Urban Expansion World Bank 2005

Nota 2 : d'après données AFRICAPOLIS

Il résulte de cette étude que la surface urbanisée par habitant est essentiellement fonction du niveau de revenu. Cette relation traduit globalement l'incidence de plusieurs facteurs de consommation d'espace évoluant avec le revenu : accroissement de la taille des logements mais surtout de l'espace associé au logement (baisse de la densité nette) ; développement de l'utilisation de véhicules notamment individuels et accroissement corrélatif de l'espace de circulation et de stationnement ; augmentation des équipements publics, des surfaces tertiaires…etc. Une croissance de 1 % du PIB/habitant se traduit par une croissance de 1% de la consommation moyenne d'espace urbain par habitant urbain.

Retenons comme ordre de grandeur pour l'Afrique de l'ouest une norme moyenne de 150 m² construits par habitant urbain (hors espaces verts, plans d'eau, zones non constructibles ou non encore équipée et habitées).

L'emprise occupée par les agglomérations est supérieure à la surface bâtie. Selon l'étude AFRICAPOLIS, la surface totale occupée par les agglomérations était en 2000 de l'ordre de 200 m² à 300 m² par habitant, et

en moyenne de 210 m² par habitant pour les agglomérations côtières identifiées dans cette étude, si l'on ne tient pas compte d'Abidjan qui est créditée d'une consommation d'espace anormalement faible.

Le rapport AFRICAPOLIS précise : *« La densité moyenne des agglomérations n'a pas cru de 1950 à 2000 autant que nous puissions l'estimer (??) dans l'état actuel de nos travaux à partir d'un échantillon de 97 villes dont nous avons la surface en 1960. Cette échantillon compte pour 1/9ème du total des agglomérations de plus de 10.000 habitants d'Afrique de l'Ouest mais 44% de la surface urbanisée. Il s'agit surtout des plus grandes agglomérations…Entre 1950 et 2000, la surface urbanisée de notre échantillon est passée de 766 à 6 381 km2, l'extension moyenne annuelle de la surface urbanisée a donc été de 5,1% contre 4,3 pour la population. »*

Nous retiendrons pour les villes côtières la norme moyenne de 210 m² en 2000, avec un taux moyen de croissance passée de 1 % par an que nous retiendrons pour le futur.

Surface agglomérée et consommation d'espace par habitant des villes côtières en 2000 (source Africapolis)

Pays	Nombre de centres côtiers	Pop totale (millions)	Surface totale(km²)	Surface par hab (m²/h.)
Bénin	11	1,31	258	198
Côte d'Ivoire	20	3,65	331	91
Cap Vert	9	0,21	39	184
Ghana	42	3,47	890	257
Guinée	4	1,30	298	229
Gambie	6	0,53	238	451
Guinée Bissau	7	0,35	83	238
Liberia	8	0,89	269	304
Mauritanie	2	0,63	113	179
Sénégal	19	2,82	304	108
Sierra Leone	7	0,82	113	137
Togo	11	1,15	206	180
12 pays côtiers	146	17,12	3142	184
12 pays côtiers hors Abidjan	145	13,97	2890	207

Emprise urbaine de toutes les villes de Côte d'Ivoire et du Ghana selon l'étude AFRICAPOLIS en 2000

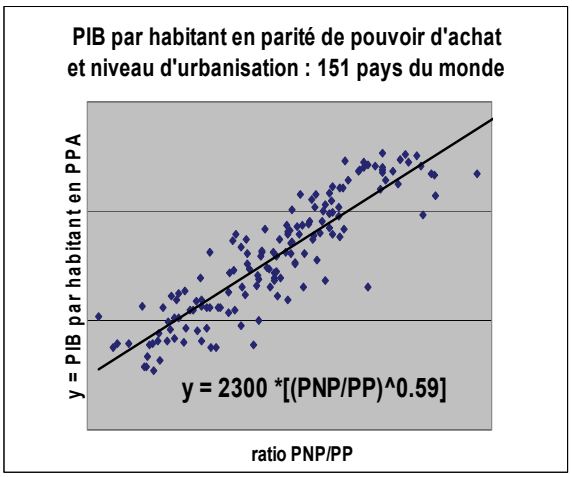
		Surface totale occupée (km²)	Population 2000 (1000 hab)	Surface occupée par habitant (m²/hab)
Côte d'Ivoire	196 centres	994	7624	130
	Abidjan	253	3148	80
	Autres centres	741	4475	166
Ghana	218 centres	2128	7852	271
	Accra	574	2516	228
	Autres centres	1554	5336	291

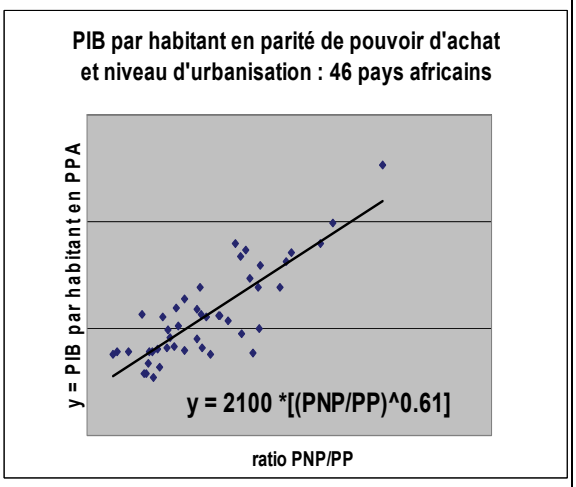
L'Afrique de l'ouest et l'Afrique sub-saharienne sont-elles sur-urbanisées ?

Cette question revient fréquemment, et nombre d'experts semblent convaincus que la croissance « exponentielle » des villes africaines est la conséquence de mauvaises politiques, inutilement couteuse et insoutenable et qu'elle est appelée à s'arrêter, voire à régresser.

Les deux graphiques ci-dessous, basés sur les données officielles (WDI et FAO) montrent en fait que la corrélation entre le PIB par habitant en parité de pouvoir d'achat et l'indicateur d'urbanisation -représenté par le rapport entre le nombre de consommateurs PNP (population non primaire) et le nombre de producteurs PP de denrées alimentaires- est la même en ASS que dans le reste du monde : l'ASS n'est pas sur-urbanisée pour son niveau de développement. En Afrique comme ailleurs, l'urbanisation est à la fois une implication et un moteur de la croissance économique.

Urbanisation et PIB par habitant : le monde et l'Afrique





Perspectives démographiques à moyen et à long terme

Les projections officielles de population établies par les Nations Unies ne tiennent pas compte des migrations futures entre pays. Du fait des différences de taux de croissance naturelle rappelés précédemment, sans ces flux migratoires, la région WA Littoral ne rassemblerait plus en 2050 que 29% de la population de la région WALTPS. Cette hypothèse irréaliste ne peut être retenue, car on ne peut faire abstraction des différences de potentiel agroclimatique et d'accès au marché entre les pays sahéliens enclavés et les pays côtiers. Même si tous les gisements de minerais, de produits pétroliers et autres ressources naturelles situés dans les pays enclavés étaient mis en valeur, la majeure partie des activités indirectes et induites par l'exploitation de ces ressources naturelles se retrouverait localisée dans les pays côtiers. En dépit de ses richesses minières (dont l'uranium et sans doute le pétrole), le Niger n'aura certainement jamais les 58 millions d'habitants annoncés par les Nations Unies pour 2050 ! L'arrêt, voire le renversement des flux migratoires nets entre les pays enclavés et les pays côtiers pourrait faire de l'Afrique de l'ouest une des régions du monde les plus instables et les plus soumises à des conflits internes et intra-régionaux.

Gérer le peuplement c'est prévoir et faciliter les mouvements futurs de population, ou tout au moins ceux de ces mouvements qui sont de nature structurelle et non conjoncturelle. Dans cette phase de transition démographique que traverse l'ASS, la gestion du peuplement est une question essentielle, on serait tenté de dire LA question numéro 1 à laquelle doivent s'atteler les gouvernements, 1es institutions régionales et leurs partenaires extérieurs. La pauvreté, la désertification, la dégradation de l'environnement et la plupart des conflits récurrents dont l'Afrique sub-saharienne est le théâtre sont en grande partie la conséquence de la mauvaise gestion passée du peuplement. Aucune solution durable ne pourrait être trouvée à ces deux problèmes en l'absence de toute stratégie de gestion du peuplement.

Les projections de population par région figurant dans la suite de cette étude intègrent donc une hypothèse de migrations nettes des pays enclavés d'Afrique de l'ouest vers les pays côtiers, de même nature et d'ampleur comparable à celles suggérées dans l'étude WALTPS. Avec cette hypothèse, les pays côtiers rassembleraient 32 % de la population d'Afrique de l'ouest en 2020 et 33% 2050. Cette hypothèse concernant les migrations a évidemment des répercussions sur la croissance de la population des pays enclavés et sur la croissance de la population urbaine et de la population rurale des pays côtiers et de la zone littorale.

	Population totale en millions d'habitants. Source : UN Pop. Division corrigées pour les migrations entre pays enclavés et pays côtiers						
Région	**Composition**	**1990**	**2000**	**2006**	**2020**	**2025**	**2050**
WA Littoral	12 pays	**60**	**79**	**94**	**131**	**148**	**231**
WA pays enclavés	7 pays	**142**	**186**	**208**	**281**	**313**	**476**
WALTPS	19 pays	**201**	**265**	**302**	**412**	**461**	**707**
ECOWAS	15 pays	**179**	**236**	**267**	**366**	**409**	**629**
Sub-Saharan Africa	49 pays	**510**	**661**	**766**	**1032**	**1151**	**1748**
Littoral en % de la région WALTPS		***30%***	***30%***	***31%***	***32%***	***32%***	***33%***

Taux de croissance de la population totale par région selon les données UN corrigées pour migrations					
Région	**Période**	**90-2006**	**2006-2020**	**2020-2025**	**2025-2050**
WA Littoral	12 pays	**2,9%**	**2,4%**	**2,4%**	**1,8%**
WA pays enclavés	7 pays	**2,4%**	**2,2%**	**2,2%**	**1,7%**
WALTPS	19 pays	**2,6%**	**2,2%**	**2,3%**	**1,7%**
ECOWAS	15 pays	**2,5%**	**2,3%**	**2,3%**	**1,7%**
Sub-Saharan Afric	49 pays	**2,6%**	**2,2%**	**2,2%**	**1,7%**

Quel scenario d'urbanisation à moyen et à long terme ?

Toute vision à moyen et à long terme de l'évolution urbaine dépend évidemment de thèses et d'hypothèses plus ou moins arbitraires, et l'avenir n'est évidemment pas écrit d'avance. Mais tous les scenarios concevables n'ont pas la même valeur, en tant qu'outils d'aide à la décision en matière de stratégie et d'orientation des politiques à mener dès demain.

Les images à moyen terme (horizon 2020) qui suivent dérivent à la fois du cadre conceptuel de l'étude WALTPS, dont le bien fondé a été largement confirmé par les évolutions constatées au cours des quinze dernières années, postérieures à la parution de cette étude, et des données ville par ville établies par l'étude AFRICAPOLIS. Les projections faites par cette étude sur la période 2010-2020 ne concernent évidemment que les seules agglomérations repérées par cette étude et procèdent d'hypothèses de taux de croissance par ville souvent très modestes (à peine supérieurs aux taux de croissance naturelle). Ces projections ne tiennent pas compte des implications de la redistribution de la population au sein de la région Afrique de l'ouest, ni de la multiplication de petits centres urbains « nouveaux » de 5 000 à 20 000 habitants, non encore apparents sur les photos aériennes mais dont on peut prévoir l'émergence, aux carrefours des réseaux de transport, à la périphérie des grandes villes et dans les zones rurales denses.

Le scenario présenté ici, tout en tenant compte de ces divers facteurs, reste relativement conservateur. Ce scenario de croissance urbaine aux horizons 2020 et 2050, est cohérent avec les images démo-économiques qui sont présentées dans la deuxième partie. Une croissance économique nettement plus faible que celle admise dans ces images (soit environ 6 % par an) impliquerait évidemment des taux de croissance urbaine plus faibles.

Ensemble des pays côtiers

Le tableau ci-après montre que les taux de croissance de la population urbaine future devraient décroître d'environ 4 % par an en 2000-2010 (correction faite de la probable sous-estimation précédemment mentionnée de l'étude AFRICAPOLIS) à 3.6 % d'ici 2020 puis 2.5% en moyenne sur la période 2020-2050.

12 pays côtiers	Population totale, urbaine et rurale						
en millions d'habitants	1950	1980	2000	2010	2020	2050	Tx de cr. 2008 - 2050
Populaton totale	19	44	79	102	131	231	2,1%
Population urbaine	2	14	33	45	64	137	2,8%
Population rurale	18	30	46	56	67	94	1,3%
Ratio U/R	0,10	0,47	0,71	0,80	0,96	1,45	1,5%
Taux de croissance de U/R		4,3%	2,3%	1,3%	1,8%	*1,4%*	
Taux de croissance de P		2,7%	2,8%	2,6%	2,6%	1,9%	
Taux de croissance de U		5,8%	4,2%	3,3%	3,6%	2,5%	
Taux de croissance de R		1,5%	1,9%	2,0%	1,7%	1,2%	

Notons que la population rurale continuera à croître à un taux supérieur à 1% par an jusqu'au-delà de 2050, ce qui nous rappelle que, sauf cas particuliers (comme la Mauritanie ou les Iles du Cap Vert) on ne peut parler en Afrique d'exode rural : avec un doublement de la population rurale totale entre 2000 et 2050, le peuplement rural se poursuivra, en se restructurant.

Le ratio U/R, dont la croissance est en gros proportionnelle à celle du nombre de consommateurs urbains de denrées alimentaires par agriculteur, devrait croître à 1.8 % par an d'ici 2020, puis à 1.4% au-delà. C'est aussi à ces taux que devraient croitre la productivité marchande et les revenus monétaires des agriculteurs.

Le scenario d'urbanisation future présenté ici paraitra sans doute excessif à certains, et notamment à ceux qui prônent toujours le ralentissement ou même l'arrêt de l' « exode rural » ou qui, sur la base d'études économétriques, prédisent que le seuil de saturation urbaine en ASS pourrait être atteint avec des niveaux d'urbanisation de l'ordre de 40 %. Mais il est compatible avec le scenario de croissance économique future à des taux de l'ordre de 6% par an en longue période, ce qui n'a rien d'aberrant. Sauf si les pays côtiers d'Afrique de l'ouest et plus généralement l'ASS sont le siège de crises politiques et économiques généralisées et à répétition, les gouvernements et les collectivités locales de ces pays devraient donc avoir à gérer d'ici à 2020 une croissance de plus de 40 % de leur population urbaine actuelle, puis encore plus du doublement de cette population urbaine entre 2020 et 2050.

Croissance urbaine dans la zone littorale

Les tableaux ci-après ébauchent deux scenarios de croissance urbaine dans la zone littorale, prenant tout deux comme base les mêmes images 2020 et 2050 du peuplement et de l'urbanisation des 12 pays côtiers, présentées précédemment. Le premier scenario, qualifié de tendanciel, admet que le tropisme côtier constituera à l'avenir le facteur structurant le plus important, ce qui est cohérent avec l'hypothèse de croissance économique, présenté en deuxième partie, et qui se traduit notamment par une croissance de l'économie « moderne » et des échanges des pays d'Afrique de l'ouest avec le reste du monde plus que proportionnelle au Produit Régional Brut.

Le second scenario, qualifié de « maîtrise des disparités » repose sur l'hypothèse de politiques volontaristes d'aménagement du territoire des pays côtiers, visant à accélérer le développement de ce que l'étude WALTPS appelait « Zone 2 », à distance des côtes, correspondant par exemple, pour la Côte d'Ivoire et le Ghana, à la latitude de Yamoussoukro et de Koumassi. Compte tenu des temps de réaction des dynamiques locales à de telles politiques volontaristes, le scenario de « maîtrise des disparités » ne diffère

notablement du scenario tendanciel qu'à relativement long terme, soit dans cette étude à l'horizon 2050. On verra que, même à cet horizon relativement lointain, la marge de manœuvre entre ces deux scenarios est a priori limitée.

Les résultats pays par pays de ces deux scenarios figurent dans la maquette Excel jointe à l'étude. En voici un résumé, pour l'ensemble de la zone littorale.

12 pays côtiers	Population de la zone littorale								
Superficie de la zone littorale :	115000 km²				Scenario tendanciel			Maîtrise des déséquilibres	
en millions d'habitants	1950	1980	2000	2010	2020	2050	Tx de cr. 2008 - 2050	2050	Tx de cr. 2008 - 2050
Population des villes littorales	1,1	7,7	17,2	22,9	33	81	3,2%	73	2,9%
dont les métropoles des 12 pays côtiers	*0,8*	*6,2*	*14,0*	*18,5*	*26*	*65*	3,2%	*58*	2,9%
Villes littorales en % de la pop urbaine totale	62%	56%	53%	51%	51%	59%		53%	
Taux de croissance de la pop urbaine littorale		5,9%	3,9%	2,9%	3,7%	3,1%		2,7%	
Population rurale littorale	1,9	3,8	6,9	8,1	9	14	1,4%	14	1,4%
Population totale littorale	2,9	11,6	24,2	31,0	42	95	2,8%	87	2,6%
Niveau d'urbanisation du littoral	36%	67%	71%	74%	78%	85%		84%	
Pop. littorale en % de la pop. des 12 pays côtiers	15%	27%	31%	31%	32%	41%		38%	
Densité de population du littoral (hab/km²)	26	101	210	270	367	830	2,8%	755	2,6%

La population urbaine totale de la zone littorale devrait ainsi presque doubler de 17 à 33 millions d'habitants entre 2000 et 2020, cependant que la population rurale devrait s'accroitre d'un tiers. De 2020 à 2050, la population urbaine du littoral croîtrait de 33 à 81 millions dans le scenario tendanciel et 73 millions dans le scenario de « maîtrise des disparités ». L'incidence sur le taux moyen de croissance de la population urbaine côtière serait ainsi de 0.3 % (2.9 % contre 3.2 % dans le scenario tendanciel).

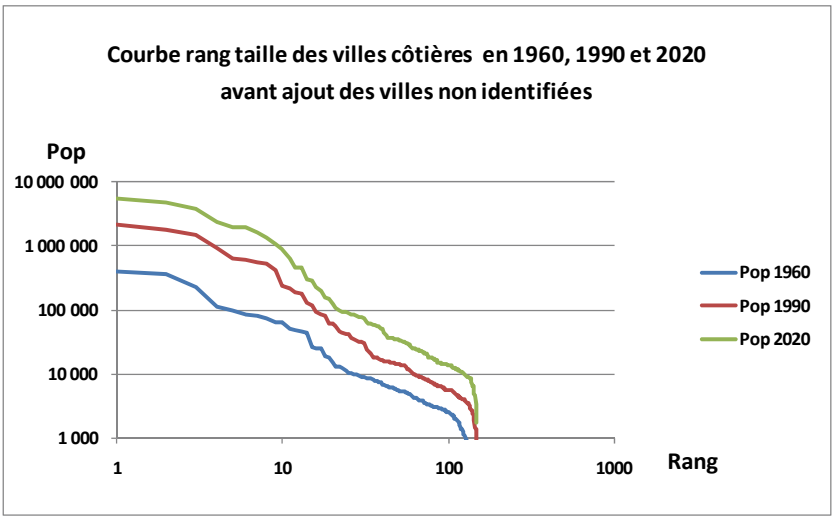
Population des villes littorales					Scenario tendanciel			Maîtrise des déséquilibres	
en milliers d'habitants	1950	1980	2000	2010	2020	2050	Tx de cr. 2008 - 2050	2050	Tx de cr. 2008 - 2050
Bénin	60	610	1290	1910	2950	7300	3,5%	6500	3,2%
Côte d'Ivoire	100	1460	3680	4880	6730	16100	3,0%	14000	2,7%
Cap Vert	17	70	210	300	390	600	1,8%	600	1,8%
Ghana	310	1550	3480	4730	6580	16700	3,2%	14300	2,8%
Guinée	39	690	1320	1650	2440	6400	3,4%	5600	3,1%
Gambie	26	170	540	730	1170	2800	3,4%	2700	3,3%
Guinée Bissau	50	150	350	520	770	2100	3,6%	2000	3,5%
Liberia	23	410	940	1260	1890	5300	3,6%	4900	3,4%
Mauritanie	0	210	650	800	1240	3000	3,3%	2800	3,1%
Sénégal	290	1510	2820	3450	5030	11100	2,9%	10200	2,7%
Sierra Leone	80	420	830	1060	1560	4500	3,6%	4000	3,3%
Togo	60	470	1160	1580	2250	5600	3,2%	4900	2,9%
12 pays côtiers	1100	7700	17200	22900	33000	81000	3,2%	73000	2,9%

Population des métropoles						Scenario tendanciel			Maîtrise des déséquilibres	
en milliers d'habitants	Métropole	1950	1980	2000	2010	2020	2050	Tx de cr. 2008 - 2050	2050	Tx de cr. 2008 - 2050
Bénin	Cotonou	20	400	910	1370	2080	5110	3,4%	4510	3,1%
Côte d'Ivoire	Abidjan	90	1290	3150	4110	5590	13340	3,0%	11640	2,6%
Cap Vert	Praia	10	40	90	130	160	220	1,5%	220	1,5%
Ghana	Accra	160	1040	2520	3450	4830	12210	3,2%	10500	2,8%
Guinée	Conakry	40	670	1250	1580	2320	6070	3,4%	5360	3,1%
Gambie	Banjul	5	100	410	580	900	2150	3,3%	2080	3,3%
Guinée Bissau	Bissau	50	120	300	460	650	1750	3,5%	1660	3,3%
Liberia	Monrovia	20	320	760	1070	1650	4650	3,7%	4270	3,5%
Mauritanie	Nouakchott	0	180	560	700	1090	2670	3,3%	2510	3,2%
Sénégal	Dakar	250	1270	2260	2750	3880	8540	2,8%	7880	2,6%
Sierra Leone	Freetown	70	380	740	920	1320	3780	3,5%	3370	3,2%
Togo	Lomé	40	420	1030	1410	1960	4860	3,2%	4300	2,9%
12 pays côtiers		760	6210	13970	18520	26430	65300	3,2%	58300	2,9%

La densité moyenne de peuplement de cette zone passerait ainsi de 270 habitants par km² en 2010 à quelque 800 habitants par km² en 2050, avec des différences considérables de cette moyenne selon les pays. Les plus fortes densités moyennes dépasseront 3000 habitants par km² au Togo (1700) et au Niger.

Densité de population du littoral (hab/km²)					Scenario tendanciel			Maîtrise des déséquilibres	
	1950	1980	2000	2010	2020	2050	Tx de cr. 2008 - 2050	2050	Tx de cr. 2008 - 2050
Bénin	100	350	710	1020	1480	3480	3,2%	3080	2,9%
Côte d'Ivoire	24	140	330	430	560	1240	2,7%	1100	2,4%
Cap Vert	50	70	110	140	160	180	0,8%	180	0,8%
Ghana	50	190	390	510	670	1550	2,8%	1360	2,5%
Guinée	17	110	210	260	350	820	2,9%	750	2,7%
Gambie	39	160	410	550	820	1800	3,0%	1770	3,0%
Guinée Bissau	9	21	40	60	90	220	3,1%	210	3,0%
Liberia	10	50	100	120	170	450	3,2%	420	3,0%
Mauritanie	0	21	60	70	100	230	2,9%	220	2,8%
Sénégal	37	130	240	290	400	820	2,6%	770	2,4%
Sierra Leone	25	70	130	160	220	540	3,1%	500	2,9%
Togo	90	360	860	1140	1550	3500	2,8%	3150	2,6%
12 pays côtiers	30	100	210	270	370	830	2,8%	750	2,6%

Distribution rang taille des villes										
Classe de taille	1980		1990		2000		2010		2020	
	Nombre	Population	Nombre	Population	Nombre	Population	Nombre	Population	Nombre	Population
>5 millions	0	0	0	0	0	0	0	0	1	5590
2 à 5 millions	0	0	1	2180	3	7920	3	10310	3	11030
1 à 2 millions	3	3590	2	3270	2	2280	4	5310	5	7720
0,5 à 1 million	1	670	5	3270	4	2970	3	2200	2	1550
200 à 500 000	4	1500	3	870	4	1230	4	1340	6	1910
100 à 200 000	5	720	4	620	5	670	5	760	4	540
50 à 100 000	4	320	6	440	8	510	10	670	18	1300
20 à 50 000	13	430	13	440	21	610	29	910	34	1010
10 à 20 000	21	270	27	390	32	470	39	550	52	720
5 à 10 000	32	220	47	300	61	430	45	360	17	140
Sous Ttotal	83	7730	108	11790	140	17090	142	22410	142	31490
Total y compris villes non identifiées	83	7730	108	11790	166	17250	195	22890	250	33000



Consommation future d'espace par les villes de la zone littorale

Pour le futur, nous admettrons, comme indiqué précédemment, que la consommation d'espace bâti par habitant croîtra deux fois moins vite que la productivité urbaine moderne (PIB urbain moderne par habitant urbain du secteur moderne), et donc au taux moyen de 1 % par an sur la longue période, conformément à la tendance passée notée par l'étude AFRICAPOLIS. Notons que cette hypothèse est modeste, car la croissance du Produit Régional Brut par habitant attendue dans le futur est sensiblement supérieure à la croissance constatée dans le passé. Selon cette hypothèse, l'emprise urbaine devrait atteindre en moyenne 260 m² par habitant urbain en 2020 et 350m² par urbain en 2050, pour des surfaces effectivement construites de 180 et 250 m².

Surface construite et urbanisée par habitant urbain (m²/hab.)				Projections		
Surface construite (1)	1990	2000	Tx de crois. 1990-2000	Taux de crois. futur	2020	2050
ASS	105	150	3,6%	1%	180	250
PVD	105	125	1,8%			
Moyenne mondiale	155	185	1,8%			
Surface totale urbanisée (2)		*210*		*1%*	*260*	*350*

Consommation d'espace des villes littorales							
(en KM² et en % de l'espace littoral)		Surface urbanisée (km²)			en % du littoral	Surface urbainsée (km²)	en % du littoral
Pays	Surface de la zone littorale	Etat actuel	Scenario tendanciel			Maîtrise des déséquilibres	
		2000	2020	2050	2050	2050	2050
Bénin	2500	270	770	2570	105%	2270	93%
Côte d'Ivoire	14300	770	1750	5620	39%	4910	34%
Cap Vert	4000	40	100	200	5%	200	5%
Ghana	12400	730	1710	5830	47%	5010	41%
Guinée	10800	280	630	2230	21%	1970	18%
Gambie	1700	110	310	980	57%	950	55%
Guinée Bissau	12600	70	200	730	6%	690	5%
Liberia	14100	200	490	1860	13%	1710	12%
Mauritanie	14600	140	320	1060	7%	1000	7%
Sénégal	15300	590	1310	3870	25%	3570	23%
Sierra Leone	11000	170	410	1560	14%	1390	13%
Togo	1900	240	590	1950	105%	1720	93%
12 pays côtiers	115000	3620	8580	28460	25%	25390	22%
consommation d'espace urbain en m²/hab		*210*	*260*	*350*		*350*	

11.2. IMAGES A LONG TERME DE L'ECONOMIE DU LITTORAL ET IMPLICATIONS

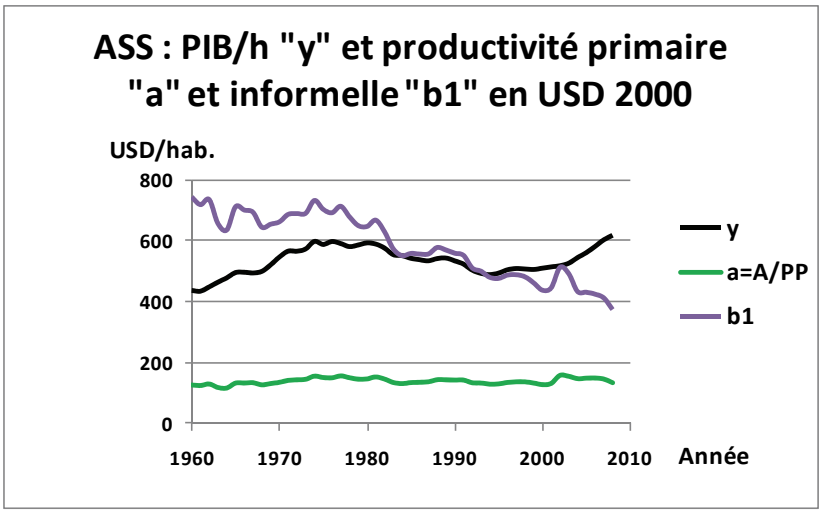
Le contexte macro-régional : quelle tendance de croissance économique à long terme pour l'Afrique sub-saharienne ?

Demandons-nous d'abord si ce que l'on dit en général des performances économiques passées de l'Afrique sub-saharienne reflète convenablement la réalité, et s'applique à tous les pays. L'image mentale que nous nous faisons des perspectives d'avenir de ce continent est en effet très influencée par les innombrables rapports qui ne parlent que de famine, de gabegie, de guerres intestines et de récession. Nous ne concevons comme seule ambition à la portée de ces pays que la sécurité alimentaire et la « lutte contre la pauvreté », mais il ne nous viendrait pas à l'idée de parler de lutte pour l'enrichissement, ni que l'Afrique puisse un jour avoir des villes, une industrie manufacturière, des infrastructures et des services publics dignes de ce nom. Si nous reconnaissons que l'ASS est riche de pétrole, de minerais, de métaux précieux, nous la voyons comme un réservoir destiné à satisfaire un jour les besoins du reste du monde, et nous avons du mal à imaginer qu'elle puisse un jour en tirer parti par et pour elle-même, et se doter, comme l'Inde ou la Chine, d'industries lourdes, d'arsenaux et de centrales nucléaires.

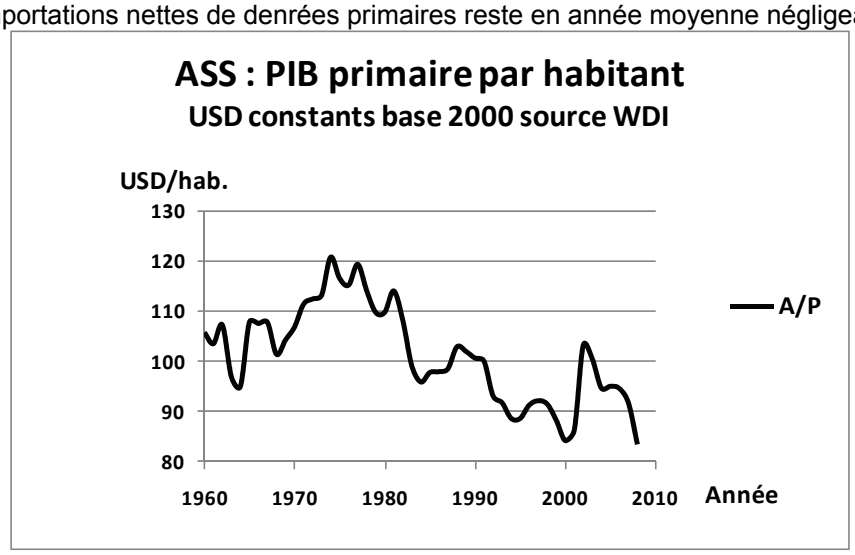
De quoi dispose-t-on pour évaluer les performances passées ? Les recensements, les études monographiques, et les photos aériennes nous renseignent convenablement sur la transformation du peuplement, sur l'occupation de l'espace, sur l'évolution du bâti, sur les conditions de vie en milieu rural et dans les quartiers populaires. Mais quid des statistiques ? On peut à la rigueur admettre que les chroniques de comptes nationaux fournissent une mesure acceptable des fluctuations conjoncturelles, pays par pays. Mais lorsqu'on s'intéresse aux évolutions structurelles, force est de constater que, en longue période, les agrégats publiés dans tous les annuaires tels ceux de la Banque Mondiale (WDI : World Development Indicators) ou des Nations Unies ne peuvent conduire qu'à une conclusion : les africains devraient depuis longtemps être soit morts de faim, soit privés des biens et services les plus élémentaires. Les deux graphiques ci-dessous, déduits des données des WDI, dernière édition (2010) illustrent simplement ce propos[53].

[53] En réalité, les indicateurs publiés par la Banque Mondiale dans les WDI donnent la valeur ajoutée primaire appelée ici A, la population considérée comme urbaine U et par différence la population rurale R, mais ils ne donnent pas la

Le premier montre l'évolution du PIB moyen par habitant de l'ASS, mesuré en dollars constants de 2000, de 1960 à 2008, ainsi que celle de la valeur ajoutée du secteur primaire par primaire par habitant primaire a = A /PP. En fait, faute de et de la valeur ajoutée informelle par habitant informel b1 = B1/PNP1



Le PIB moyen par habitant retrouverait ainsi en 2008 son niveau de 1975, avant la crise. Mais la structure du peuplement a beaucoup changé entre temps. Si le PIB moyen par habitant est effectivement passé de 400 à 600 dollars entre 1960 et 2008, cela implique que le PIB informel par habitant informel aurait chuté de près de moitié : ce n'est pas ce que montre l'observation des conditions de vie dans les villages ni dans les quartiers populaires des villes de toute taille. La quasi stagnation apparente de la valeur ajoutée primaire par agriculteur, qui peut sembler vraisemblable lorsque l'on oublie l'ampleur du mouvement d'urbanisation, aurait pour conséquence la baisse de plus d'un tiers de la production agricole par habitant depuis 1975, alors que la ration alimentaire moyenne par habitant s'est améliorée en quantité et en qualité et que les l'incidence des importations nettes de denrées primaires reste en année moyenne négligeable :

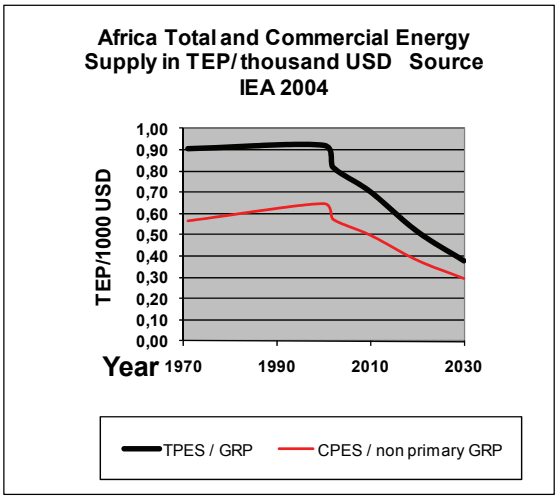


La principale raison pour laquelle les appareils statistiques existants ne sont pas capables de fournir des indications convenables sur les performances réelles des économies africaines est l'absence totale de recoupement avec ce que l'on sait par ailleurs des dynamiques de peuplement. C'est pour remédier à ce

population primaire ou agricole PP, dont on trouve une approximation dans les annuaires de la FAO. La « productivité primaire « a =A/PP mentionnée dans cette section relative à l'ASS est donc assimilée à la valeur du ratio A/R. Il n'existe a fortiori aucune source officielle de données sur la population informelle appelée ici PNP1 ni sur la contribution au PIB du secteur informel « B1 » et la productivité informelle b1=B1/PNP1 : ces indicateurs pourtant essentiels à la compréhension du fonctionnement des économies des pays en développement sont ici calculés selon la méthodologie exposée dans les études WALTPS et ECOLOC.

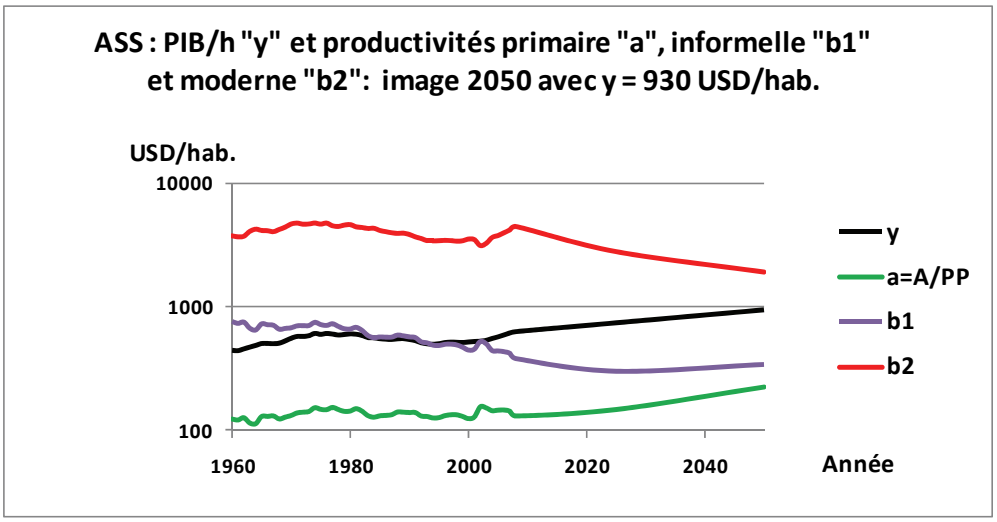
défaut structurel que les études WALTPS et ECOLOC utilisent d'autres indicateurs tenant explicitement compte des implications des dynamiques de peuplement (redistribution de la population par lieu (grande ville, petite ville, milieu rural,..) et par strate (primaire, informelle et moderne) sur les transformations économiques de chaque territoire.

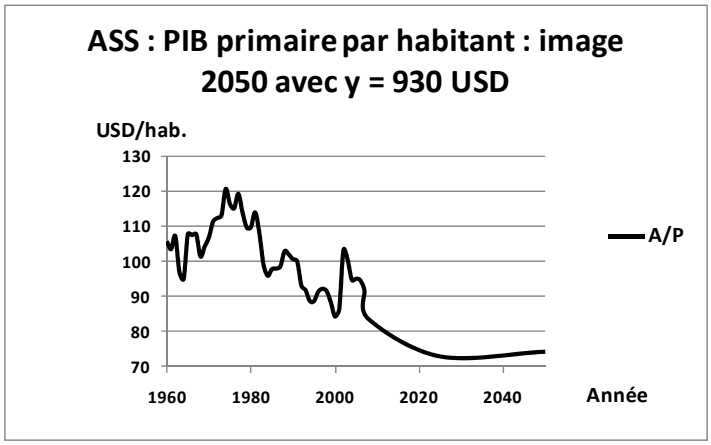
Toute projection des économies africaines à long terme qui négligerait de prendre explicitement en compte les perspectives de peuplement ne peut conduire qu'à des résultats éminemment contestables. Prenons l'exemple de l'énergie. L'Agence Internationale de l'Energie (IEA) estimait (en 2004) que les besoins en énergie primaire commerciale, hors biomasse (CPES) de l'ensemble du continent africain (y compris l'Afrique du Nord) croitront de 320 millions de TEP (tonnes d'équivalent pétrole) en 2002 de à 740 millions de TEP en 2030. Cette perspective implique une division par deux de la consommation actuelle –déjà très faible - d'énergie par unité de PIB[54], ce qui est rassurant du point de vue des émissions de gaz à effet de serre mais complètement irréaliste (voir graphique). Accorder au continent africain une consommation de moins d'un milliard de TEP en 2030 revient donc implicitement à admettre une quasi stagnation de son PIB non primaire par habitant.



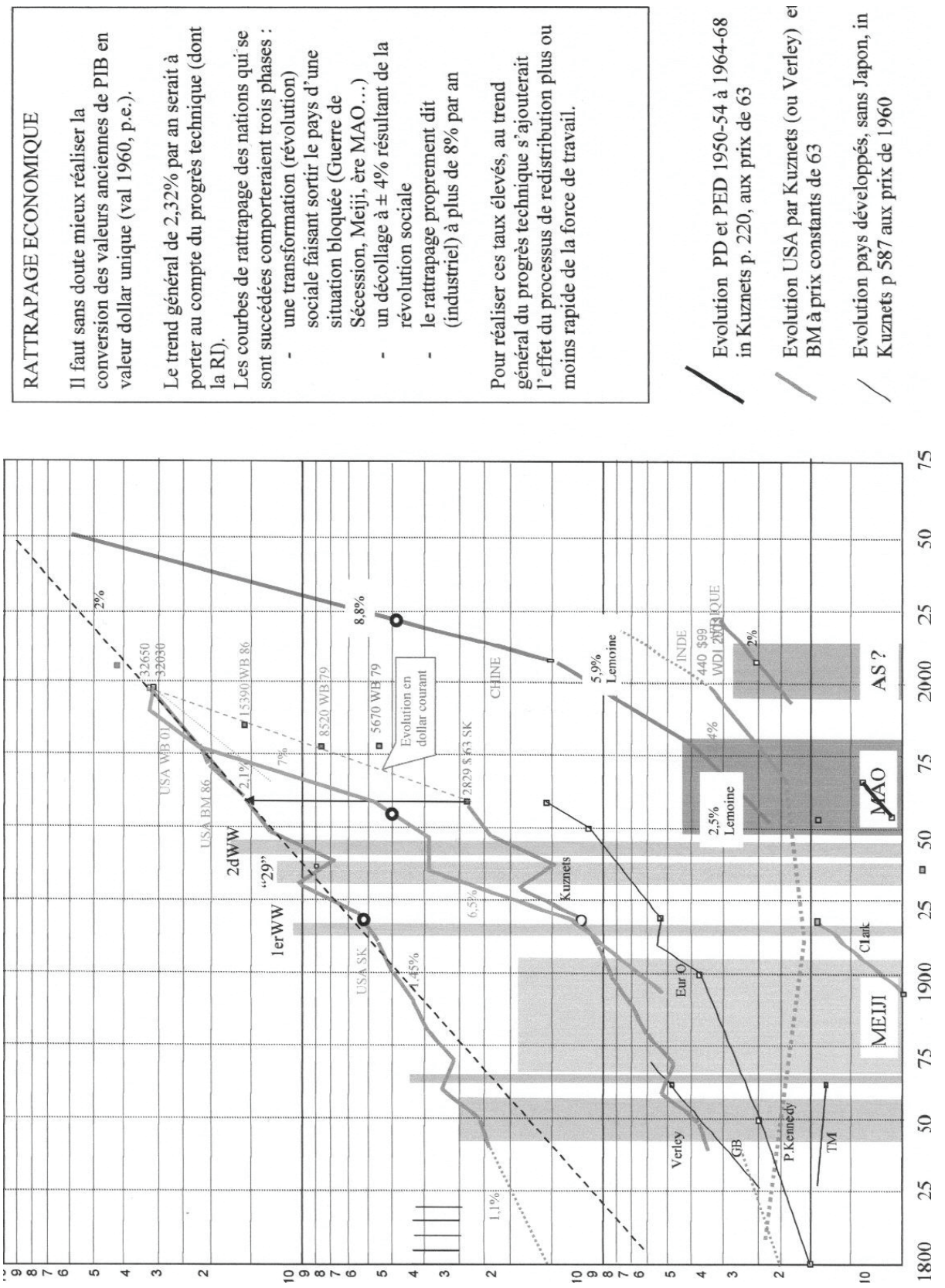
Admettons donc pour un instant que le PIB moyen par habitant de l'ASS soit aujourd'hui de l'ordre de 600 dollars, contre 400 dollars quarante ans plus tôt (en dollars constants base 2000), et qu'il ait ainsi augmenté de moitié en 40 ans, ce qui est très certainement inférieur à la réalité (voir WALTPS). Faut-il en déduire que, dans quarante ans, ce PIB par habitant pourrait encore augmenter de moitié et atteindre quelque 930 dollars en 2050 ? Nombre d'experts penseront sans doute qu'il s'agirait là d'une performance respectable. En fait, les deux graphiques ci-après montrent que ce scenario serait en fait celui d'une quasi stagnation du niveau de vie dans l'économie populaire (agricole et informelle) et d'une réduction de près de 60 % de la productivité moderne.

[54] Selon l'hypothèse d'une croissance du PIB par habitant de 3% par an entre 2020 et 2030, compatible avec les perspectives d'urbanisation de ce continent.

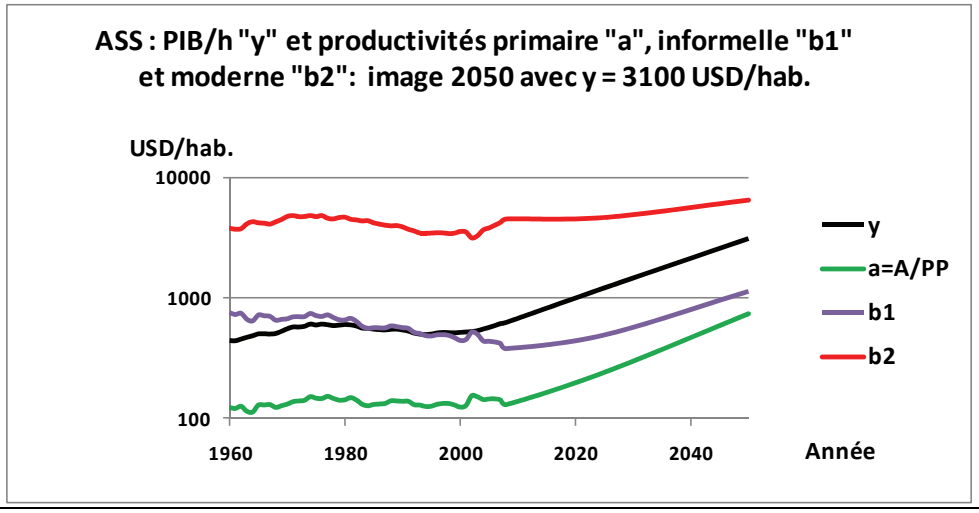




Tenir compte de l'évolution vraisemblable du peuplement est important mais ne suffit pas pour esquisser un scenario de la croissance économique future. Une base de raisonnement certes contestable mais a priori convenable consiste à faire le pari que l'Afrique fera tôt ou tard comme toutes les autres régions du monde, c'est-à-dire quelle amorcera un processus de décollage puis de rattrapage, le même que celui qu'ont successivement connu le Japon, l'Europe de l'ouest, l'ex URSS, la Chine et l'Inde. Toutes ces régions courent après le leader du moment (Grande Bretagne puis USA, puis bientôt la Chine..). : voir graphique. Pendant le décollage (début de la phase de rattrapage), toutes ces régions et d'autres ont connu des taux de croissance du PIB par habitant de 4 % ou plus, en longue période. La phase de rattrapage proprement dit se caractérise ensuite par, des taux de croissance du PIB par habitant 6 à 8 % par an.



Nous admettrons donc que, après une longue période de maturation institutionnelle, de digestion des conflits post indépendance et d'ouverture au monde, le moment est venu pour l'ASS d'entamer sa phase de décollage. La croissance du PIB de l'ordre de 6 % par an jusqu'en 2020 (soit 4% pour le PIB par habitant) puis de 5.7% de 2020 à 2050, résumée dans les tableaux ci après, n'a rien d'extravagant, elle est compatible avec l'image de redistribution du peuplement et d'urbanisation évoquée dans la première partie.



Afrique Sub-Saharienne : PIB total, primaire,informel et moderne (en milliards de dollars de 2000) et PIB par habitant. Données déduites des WDI jusqu'en 2008)								
Date	1960	1970	1980	1990	2000	2008	2025	2050
PIB total, dont :	98	158	227	274	342	506	1360	5400
primaire A	24	31	42	52	57	68	140	400
informel B1	12	22	38	56	69	82	170	500
moderne B2	62	105	147	166	217	356	1060	4500
non primaire total B	74	127	185	222	286	438	1230	5000
PIB par habitant (USD)	*437*	*547*	*593*	*534*	*510*	*619*	*1200*	*3100*

Afrique Sub-Saharienne : Productivité primaire, informelle et moderne en USD par habitant								
Date	1960	1970	1980	1990	2000	2008	2025	2050
PIB par habitant (USD)	437	547	593	534	510	619	1200	3100
Ratio PNP/PP	0,17	0,24	0,31	0,39	0,49	0,57	1,03	2,01
productivité primaire "a"	124	133	144	140	125	131	240	700
productivité informelle "b1"	744	663	648	560	438	375	490	1100
productivité moderne "b2"	3741	4670	4610	3837	3526	4456	4580	6400
non primaire total B	2243	2266	2035	1543	1303	1468	2130	4300
Production primaire par habitant (USD)	*106*	*107*	*110*	*101*	*84*	*84*	*120*	*200*

Rappel : de 1960 à 2008, les données de ces deux tableaux dérivent des statistiques officielles, non corrigées.

Selon le scenario évoqué ici, les décennies à venir devraient donc être marquées par un trend de croissance de l'ordre de 4% par an pour la productivité primaire (c'est-à-dire de la valeur ajoutée par habitant primaire), de 2 à 3 % par an pour la productivité moyenne et des revenus de la population informelle (ou plutôt populaire) et de 0.5 à 1 % par an de la productivité « moderne ».

Afrique Sub-Saharienne :	Taux de croissance			
Date	1960-1990	1990-2008	2008-2025	2025-2050
PIB par habitant (USD)	0,7%	0,5%	4,0%	3,9%
Ratio PNP/PP	2,8%	1,3%	3,5%	2,7%
productivité primaire "a"	0,4%	-0,2%	3,7%	4,6%
productivité informelle "b1'	-0,9%	-1,3%	1,6%	3,4%
productivité moderne "b2"	0,1%	0,5%	0,2%	1,3%
non primaire total B	-1,2%	-0,2%	2,2%	2,8%
Production primaire par habitant (USD)	-0,2%	-0,6%	2,1%	2,9%

Comment expliquer ces croissances futures des productivités par strate (primaire, informelle et moderne) et quels en seront les moteurs ?

Pour ce qui concerne la fraction de l'activité primaire qui répond aux besoins du marché intérieur et régional- c'est-à dire pour plus de 90 % de l'ensemble du secteur primaire-, la principale variable qui intervient dans la construction de ces images à moyen et à long terme est le rapport entre le nombre de consommateurs non producteurs de denrées alimentaires « PNP » et la population agricole « PP ».

L'évolution de ce ratio est, dans cette section relative à l'ASS prise dans son ensemble, assimilée à celle du rapport U/R du nombre d'urbains par rural, qui croît de 0.57 en 2008 à 2 en 2050. Les images 2025 et 2050 du PIB primaire A résultent de la projection de la productivité primaire proportionnelle à la croissance du rapport PNP/PP et affectée d'un terme représentatif de l'amélioration quantitative et qualitative de la ration alimentaire et du progrès technique, au taux de 0.2 % par an d'ici 2025 et de 1.2 % au delà.

De même, les images 2025 et 2050 du PIB informel B1 reposent sur l'hypothèse d'évolution du ratio b1/a entre les productivités informelle et primaire et de la population informelle. C'est parce que ce ratio est très supérieur à 1 (et aujourd'hui de l'ordre de 2 ou plus) que la redistribution de la population entre les strates primaire et non primaire et donc entre le milieu rural et les villes se poursuit. Ce ratio doit tendre asymptotiquement vers 1 à très long terme, lorsque le peuplement sera stabilisé, il devrait être de l'ordre de 1.5 en 2050. La croissance ainsi projetée de la productivité et des revenus dans l'économie populaire résultera à la fois :

- ⇒ du décollage de l'économie agricole permis par l'expansion du marché intérieur (rapport PNP/PP) et l'intensification corrélative des échanges ville – hinterland ;
- ⇒ du ralentissement relatif des flux migratoires vers les villes ;
- ⇒ de la croissance de la taille des villes et de ses effets sur la productivité urbaine ;
- ⇒ de l'accumulation de capital et de savoir faire qui s'est développée au cours des décennies passées dans une multitude de micro-entreprises et d' « unités de production informelles » ;
- ⇒ des interactions entre économie populaire et économie « moderne »;
- ⇒ enfin de la restauration du capital d'investissements publics de fonction locale (« IFL ») et de l'amélioration de la gouvernance locale qui devrait résulter de la décentralisation (cf. ECOLOC).
- ⇒

Quant aux images 2025 et 2050 de l'économie non primaire moderne B2, elles reposent sur l'hypothèse d'évolution de la productivité moderne b2 et de la population non primaire moderne PNP2. La fraction de la population non primaire impliquée dans le secteur « moderne » devrait recommencer à croître de moins de 30 % aujourd'hui (plus de 70 % étant informelle) à quelque 40 % vers 2020 et 60 % vers 2050. Nous admettons ici que la productivité moderne retrouvera en 2025 son niveau de 1980, soit quelque 4600 USD, et qu'elle croîtra d'un peu plus d'un tiers entre 2025 et 2050 pour atteindre alors quelque 6400 USD.

Le regain d'importance du secteur « moderne » privé sera impulsé par l'énorme effort d'investissements publics de peuplement et d'équipement des territoires évoqué plus loin et qui rendra possible le développement du tissu d'entreprises répondant aux besoins des économies locales urbano-centrées (cf. ECOLOC), des marchés nationaux et régionaux et des entreprises travaillant pour le marché africain (près de 2 milliards de personnes !) et pour le marché mondial. La Chine, l'Inde et le Brésil, dont les avantages comparatifs en termes de coûts de main d'œuvre devraient commencer à diminuer d'ici une décennie et qui,

au moins pour les deux premiers, seront confrontées à des problèmes environnementaux croissants, devraient à leur tour délocaliser certaines de leurs industries de main d'œuvre à faible technologie. Ce sera alors le tour de l'Afrique de bénéficier de ce processus de délocalisation, mais celui-ci ne profitera qu'à quelques pôles les mieux dotés en infrastructure et services et les plus accessibles, ce qui, comme en Chine, accentuera les pressions migratoires.

On notera que dans les images 2025 et 2050 ci-dessus, le Produit Régional Brut non primaire « moderne » de l'ASS croîtrait de 360 milliards de dollars en 2008 à quelque 1100 milliards de dollars en 2020 et 4500 milliards de dollars en 2050 (en dollars constants 2000) : c'est ainsi qu'il faut voir l'Afrique, et non comme un territoire en marge de l'économie monde, que l'on peut traiter comme un « résidu » dans les modèles macro-économiques mondiaux (référence aux termes employés dans un modèle mondial de l'OCDE).

La dualité persistante de l'économie urbaine, à la fois populaire (informelle) et « moderne » aura évidemment sa traduction dans les structures urbaines : business districts et quartiers résidentiels aux standards des pays développés et vastes périphéries au niveau d'équipement minimum compatible avec les capacités d'investissement et de gestion des collectivités locales et avec le niveau de vie des habitants.

Dans cette phase intermédiaire de la transition démographique, les disparités de productivité et de revenus entre les strates (modernes, informelles, primaires) des métropoles, des villes moyennes, des petites villes et du milieu rural baisseront mais resteront encore fortes.

Quelle tendance de croissance économique à long terme pour la zone côtière?

Pour élaborer des esquisses d'images à moyen et à long terme de l'activité économique de la zone littorale de l'Afrique de l'Ouest, qui présentent un degré raisonnable de vraisemblance, on doit commencer par avoir une idée de la croissance économique des 12 pays côtiers, tenant notamment compte de l'évolution de leur peuplement (et intégrant donc les migrations entre pays de la région évoquées dans la première partie), puis il faut réfléchir à l'évolution du poids relatif de la zone côtière de chaque pays dans l'économie nationale.

La méthodologie décrite dans le programme ECOLOC et rappelée en annexe permet d'effectuer ce travail, pays par pays, et par entité territoriale au sein de chaque pays, puis, par agrégation, pour l'ensemble de la zone littorale du SDAL, et ce avec un niveau raisonnable de prise en compte des spécificités de chaque pays, des diverses entités territoriales (à l'échelle des communes ou des départements), et du milieu urbain et du milieu rural.

La construction de ces maquettes démo-économiques spatialisées représente un travail qui dépasse largement les moyens et le temps affectés à cette étude. Cependant, il a semblé nécessaire d'illustrer l'ensemble de la démarche en l'appliquant à un pays de la région, en l'occurrence le Bénin, à la fois pour montrer ce que cette méthodologie peut apporter comme éléments de cadrage des SDLAO dans chaque pays, et pour fournir des éléments d'extrapolation pour une ébauche d'image démo-économique de l'ensemble de la zone littoral ouest africaine.

11.3. IMAGES DEMO-ECONOMIQUES SPATIALISEES DU BENIN AUX HORIZONS 2020 ET 2050

Voici donc, à peu près sans commentaires, quelques courts extraits des maquettes démo-économiques spatialisées du Bénin et de la zone littorale. Les dates auxquelles ces maquettes sont esquissées sont, pour le passé, 1990 et 2008, et pour le futur, 2020 et 2050 (les données de peuplement, mais non les agrégats économiques, sont aussi données pour les années 1960 et 1975). Le modèle utilisé ici permet d'esquisser diverses images du futur correspondant à diverses hypothèses concernant le poids futur de la zone littorale dans l'ensemble national. Seule est présentée ici l'image « tendancielle », qui ne présuppose pas de politique volontariste de freinage de la concentration vers la côte. La section suivante ébauche une image alternative, dite de « maîtrise des disparités » entre la côte et l'hinterland.

De façon à pouvoir exploiter les données de référence présentées dans la dernière édition des WDI et faciliter les comparaisons entre pays, les agrégats économiques sont exprimés, non en monnaie locale (le

FCFA), mais en une monnaie de référence commune à tous les pays concernés par cette étude, en l'occurrence le dollar constant de l'année 2000.

Le découpage du territoire béninois utilisé dans ces maquettes est celui des 77 communes (plus deux parce que les communes situées à l'ouest et à lest de Cotonou ont été subdivisées en deux parties, « urbaine pour les banlieues de la capitale et rurale pour le reste). Et le nombre de localités considérées (identifiables à partir des recensements et comptant plus de 5000 habitants en 2008) est de 85[55].

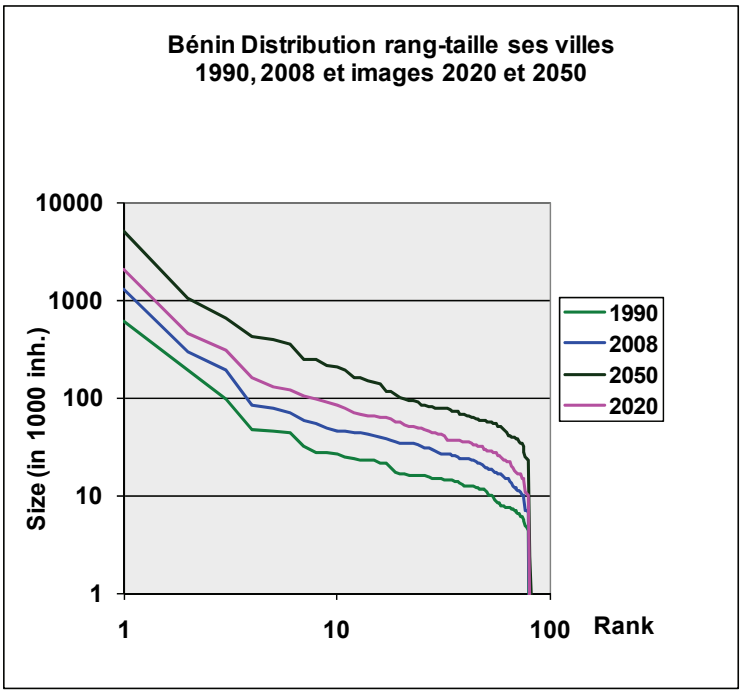
Selon ce découpage territorial, on peut retenir comme définition de la « zone littorale» l'ensemble constitué par 13 communes littorales ou immédiatement voisines du littoral. Ces 13 communes ont une superficie totale de 2453 km², soit 2.1 % de la superficie du Bénin, et comptent en 2008 environ 2,3 millions d'habitants, soit 27 % de la population totale du Bénin, dont 570 000 ruraux, soit 12 % de la population rurale totale. La zone littorale ainsi définie est un peu plus petite que celle évaluée en première approximation par l'étude SDAL (2453 km² contre 2664).

Bénin — Distribution rang-taille des villes

Population en milliers d'habitants	2008		2020 u=52 %		2050 u=60 %	
Classe de taille	*Nombre de centres*	Population	*Nombre de centres*	Population	*Nombre de centres*	Population
> 5000					*1*	5 109
2000 à 5000			*1*	2 076		
1000 à 2000	*1*	1 265			*1*	1 022
500 à 1000					*1*	655
200 à 500	*1*	297	*2*	749	*7*	2 095
100 à 200	*1*	190	*4*	506	*9*	1 277
50 à 100	*5*	343	*16*	1 058	*40*	2 771
20 à 50	*40*	1 237	*43*	1 413	*21*	754
10 à 20	*25*	381	*32*	446	*53*	751
5 à 10	*44*	283	*61*	395	*122*	650
Population urbaine	*117*	3 996	*159*	6 643	*255*	15 083
Population rurale		4 605		6 182		10 056
Population totale		8 601		12 825		25 139
Niveau d'urbanisation		46%		52%		60%

Nota : l'image 2020 des villes s'inspire des données AFRICAPOLIS, avec cependant quelques ajustements, dont le principal concerne la métropole de Grand Cotonou. Le tableau ci-dessus tient compte comme expliqué précédemment de l'accroissement progressif du nombre de localités dont la population agglomérée dépasse 5000 habitants. La procédure suivie repose sur une extension de la distribution rang-taille des villes (graphique ci-après) au delà de la centaine de centres connus aujourd'hui.

[55] L'extrapolation de la distribution rang-taille des villes permet d'estimer le nombre total de localités de plus de 5000 habitants en 2008 à près de 120. Il devait donc y avoir en 2008 quelque 35 localités de 5000 à 10000 habitants réparties dans les communes qualifiées de rurales et donc non identifiées comme telles par es recensements, dont certaines ont sans doute échappé à l'étude AFRICAPOLIS. On verra que le nombre total de localités de plus de 5000 habitants pourrait être de l'ordre de 250 en 2050. Le modèle utilisé tient compte de ces «villes non identifiées ».



Revenu en USD par personne et par jour et par milieu						
Bénin	Grand Cotonou	Villes moyennes	Petites villes	Milieu urbain	Milieu rural	Moyenne nationale
2008 u=46 %	1,8	1,2	0,9	1,3	0,7	1,0
2020 u=52 %	2,6	1,9	1,2	1,8	1,0	1,4
2050 u=60 %	5,9	4,9	3,1	4,5	2,2	3,5

Bénin	Valeur ajoutée et PIB						
Valeurs en milliards de USD année de base 2000							
	Grand Cotonou	Villes moyennes	Petites villes	Milieu urbain	Milieu rural	Bénin	Taux de croissance
1990 u=42 %	0,5	0,2	0,2	0,9	0,6	1,4	
2008 u=46 %	0,9	0,5	0,5	1,9	1,3	3,2	4,5%
2020 u=52 %	2,1	1,1	1,3	4,5	2,1	6,6	6,3%
2050 u=60 %	11,5	7,5	7,1	26,1	7,8	33,9	5,6%

Ce tableau montre que le Produit Local Brut de l'agglomération du Grand Cotonou devrait, selon cette image, être multiplié par 13 d'ici 2050. Les flux de transport de personnes et de biens et services entre la métropole et le reste du pays pourraient doubler tous les sept ans (soit un taux de croissance de l'ordre de 10 % par an). Le stock d'infrastructures reliant la métropole au reste du pays devrait être développé à un rythme du même ordre pour suivre la croissance de ce trafic.

Les deux tableaux ci-après, relatifs à l'année 2008, montrent la contribution de chacune des treize communes de la zone littorale à la population et au Produit Local Brut de cette zone, ainsi que les densités de population primaire (rapportées à la surface totale du littoral) et de la population totale. La zone littorale apparaît ainsi comme dix fois plus densément peuplée que le reste du pays. L'annexe fournit des tableaux analogues existent pour 1990, 2020 et 2050.

Zone littorale — Population par commune en milliers d'habitants

Commune	Grand Cotonou	Autres villes	Milieu urbain	Milieu rural	Zone littorale	Superficie	Densité primaire (hab/km²)	Densité totale (hab/km²)
2008								
Cotonou	754	0	754	20	774	79	348	9796
Cotonou ouest	439	6	445	87	532	100	971	5324
Cotonou est	72	0	72	52	123	100	539	1232
Abomey-Calavi rural		7	7	43	50	439	77	113
Seme-Kpodji rural		7	7	38	44	118	256	375
Porto-Novo		297	297	8	305	50	379	6098
Aguegues		7	7	24	31	103	205	303
So-Ava		21	21	70	91	209	283	435
Adjarra		24	24	48	72	75	553	957
Kpomasse		13	13	50	63	295	139	215
Ouidah		49	49	38	87	336	110	259
Grand-Popo		10	10	37	46	289	106	161
Lokossa		44	44	53	97	260	180	374
Total Zone littorale	1265	484	1749	567	2316	2453	220	944
Zone littorale en % du Bénin			*43,8%*	*12,3%*	*26,9%*	*2,1%*	35	75
Flux annuel et d'"immigrants" du reste du pays et du monde					12			
Taux de croissance 1990 - 2008	4,2%	3,2%	3,9%	3,2%	3,7%			

Nota : La métropole de Grand Cotonou occupe les trois premières communes du tableau.
Le PLB de Grand Cotonou est aussi réparti entre ces trois communes (tableau ci-dessous).

Zone littorale — Produit Local Brut par commune

Valeurs en millions de USD de 2000 et Valeurs par habitant en USD

Commune	Grand Cotonou	Autres villes	Milieu urbain	Milieu rural	Zone littorale
2008					
Cotonou	696	0	696	8	704
Cotonou ouest	186	1	187	29	216
Cotonou est	25	0	25	16	41
Abomey-Calavi rural		2	2	25	27
Seme-Kpodji rural		1	1	12	13
Porto-Novo		195	195	4	199
Aguegues		3	3	12	15
So-Ava		9	9	22	30
Adjarra		10	10	18	28
Kpomasse		4	4	21	25
Ouidah		28	28	15	43
Grand-Popo		5	5	15	20
Lokossa		16	16	19	34
Total Zone littorale	906	258	1180	216	1396
Répartition du PLB par milieu en %			85%	15%	100%
Valeur ajoutée par habitant dans la Zone littorale	716	533	675	381	603
Zone littorale en % du Bénin			*61,4%*	*17,1%*	*43,8%*
Taux de croissance 1990 - 2008	3,8%	3,7%	3,8%	5,4%	4,0%

Ce tableau montre que la zone littorale ainsi définie concentrait en 2008 44% du PIB total du Bénin et 61 % de son PIB urbain sur 2% de la superficie totale du pays.

Flux annuels et stock de capital résidentiel de Grand Cotonou

Valeurs en millions de USD de 2000

Année	1990 u=42 %	2008 u=46 %	2020 u=52 %	2050 u=60 %
Population en milliers d'habitants	*610*	*1260*	*1830*	*5100*
Produit Local Brut	*460*	*910*	*1810*	*11500*
Investissements résidentiels privés	50	110	340	2300
Investissements publics de fonction régionale et locale	10	30	80	600
Stock de capîtal résidentiel privé	540	1340	3400	25000
Stock de capital public de fonction régionale et locale	110	330	860	6000

Ce tableau relatif là la métropole Grand Cotonou donne une évaluation de la croissance des flux annuels d'investissements résidentiels privés (logements, boutiques, bureaux,..) nécessités par la croissance de la population et des activités résidentes et par la réhabilitation et l'amélioration du patrimoine bâti, informel et moderne, impliquées par l'augmentation des niveaux de vie. Ces flux d'investissements privés doivent être accompagnés et facilités par la réalisation parallèle des investissements publics de fonction locale (voirie, drainage, écoles,..) et régionale (hôpitaux centraux, universités,..). Les stocks de capital résidentiel public et privés ainsi accumulés au fil du temps sont évalués dans ce tableau à 31 milliards de dollars en 2050, soit près de trois fois le PLB de la métropole) contre 1.7 milliard soit une multiplication par près de 20. La quasi-totalité de ces constructions et de ces équipements sera évidemment localisée dans la zone côtière.

Attirons l'attention sur le fait que ces estimations ne résultent pas de l'application de normes standards d'équipement public (tant de litres d'eau potable par habitant et de telle qualité, tant de linéaire de voirie, et de tel revêtement,..), qui sont toujours trop ambitieuses et irréalistes, mais sont déterminées en fonction des besoins et de la capacité à payer des populations de chaque strate (dont la strate populaire) et des opérateurs locaux. Les niveaux d'investissement privé sont cohérents avec le niveau de vie des ménages de chaque strate, avec le Produit Local engendré par la capitale. Quant aux investissements publics et aux dépenses récurrentes, elles impliquent un niveau de mobilisation des ressources locales par les collectivités locales très supérieur au niveau actuel (inférieur à 1% du PLB) mais parfaitement réalisable, avec des niveaux d'endettement pour l'investissement supportables, sous réserve de modalités d'accès au financement adaptées: voir le programme ECOLOC. Le tableau suivant montre par exemple que le cout d'entretien du patrimoine public des collectivités locales peut être intégralement couvert par un prélèvement annuel inférieur à 1 % de la valeur du patrimoine bâti du secteur privé.

Grand Cotonou : Cout d'entretien du capital public de fonction locale et modalités de financement

Valeurs en millions de USD de 2000

Année	1990 u=42 %	2008 u=46 %	2020 u=52 %	2050 u=60 %
Stock de capîtal résidentiel privé	540	1340	3400	25000
Stock de capital public de fonction locale (KFL)	*4*	*13*	*30*	*230*
Cout d'entretien du KFL en % de la valeur du capital résidentiel privé	*0,8%*	*0,9%*	*0,9%*	*0,9%*

De ces maquettes, on tire les cinq tableaux suivants qui seront utilisés pour la construction des ébauches de maquettes des 11 pays littoraux Les trois premiers concernent le Bénin, les deux derniers concernent la zone littorale Dans leur version complète, les tableaux de données démographiques couvrent aussi les années 1950,1960, 1970 et 1980, ainsi que l'année 2008, dernière année renseignée par les WDI.[56]

Bénin	Population totale, urbaine et rurale				
en milliers d'habitants	1990	2008	2020	2050	Tx de cr. 2008 - 2050
Populaton totale	4726	8601	12825	25139	2,6%
Population urbaine	1968	3996	6643	15083	3,2%
Population rurale	2759	4605	6182	10056	1,9%
Ratio U/R	0,71	0,87	1,07	1,50	1,3%
Taux de croissance de U/R	6,3%	1,1%	1,8%	1,1%	
Taux de croissance de P	3,1%	3,4%	3,4%	2,3%	
Taux de croissance de U	7,5%	4,0%	4,3%	2,8%	
Taux de croissance de R	1,1%	2,9%	2,5%	1,6%	

Bénin Population primaire et non primaire					
en milliers d'habitants	1990	*2008*	2020	2050	Tx de cr. 2008 - 2050
Populaton totale	4726	8601	12825	25139	2,6%
Population primaire PP	2639	4046	5517	8237	1,7%
Population non primaire PNP	2087	4555	7308	16902	3,2%
Ratio PNP/PP	0,79	1,13	1,32	2,05	1,4%
Taux de croissance de PNP/PP	4,8%	*2,0%*	1,4%	1,5%	
PPU/U	29%	23%	22%	15%	
PPR/R	75%	68%	65%	60%	
Taux de croissance de PP	1,4%	*2,4%*	2,6%	1,3%	
Population informelle PNP1	1678	*3756*	4814	7683	1,7%
Population "moderne"PNP2	409	798	2494	9219	6,0%
PNP1/PNP	80%	82%	66%	45%	

[56] Dans tous ces tableaux, les taux de croissance annuels inscrits en ligne sont calculés sur la période comprise entre l'année de la colonne et celle de la colonne précédente (par exemple sur la période 1990-2008) ; les taux de croissance figurant dans les dernières colonnes sont des taux moyens sur la période 2008-2050 (42 ans).

Bénin : PIB urbain et rural et productivités

en millions de dollars, en dollars par habitant et en milliers de dollars par km², base 2000	1990	2008	2020	2050	Tx de cr. 2008 - 2050
PIB Y	1442	3185	6624	33929	5,8%
PIB rural Y (R)	562	1264	2131	7848	4,4%
PIB urbain Y (U)	880	1920	4493	26081	6,4%
PIB primaire A	460	*1083*	1764	5860	4,1%
PIB informel B1	608	*1438*	2494	8950	4,4%
PIB non primaire moderne B2	375	663	2366	19120	8,3%
PIB non primaire B	983	2102	4860	28069	6,4%
Taux de croissance de Y		*4,5%*	6,3%	5,6%	
PIB par hab (USD) y	305	370	516	1350	3,1%
PIB rural par habitant rural	204	275	345	780	2,5%
PIB urbain par habitant urbain	447	481	676	1729	3,1%
Productivité primaire a = A/PP	174	268	320	711	2,4%
Productivité informelle b1 =B1/PN	362	383	518	1165	2,7%
Productivité moderne b2 =B2/PN	918	831	949	2074	2,2%
Productivité non primaire b=B/PN	471	461	665	1661	3,1%
ratio b1/a	2,1	1,4	1,6	1,6	
ratio b2/b1	2,5	2,2	1,8	1,8	
ratio b/a	2,7	1,7	2,1	2,3	

Bénin — Population de la zone littorale

Superficie : 2 453 Km², soit : 2,1% de la superficie totale du Bénin

en milliers d'habitants	1990	2008	2020	2050	Tx de cr. 2008 - 2050
Population des villes littorales	884	1749	2952	7344	3,5%
dont métropole Cotonou	*608*	*1265*	*2076*	*5109*	3,4%
Villes littorales en % de la pop urbaine	45%	44%	44,4%	49%	
Taux de croissance de la pop urbaine littorale	5,1%	3,9%	4,5%	3,1%	
Population rurale littorale	321	567	688	1192	1,8%
Population totale littorale	1204	2316	3640	8536	3,2%
Niveau d'urbanisation du littoral	73%	76%	81%	86%	
Population littorale en % de la pop. du Bénin	25%	27%	28%	34%	
Densité de population du littoral (hab/km²)	491	944	1484	3480	3,5%

Noter que la densité **moyenne** de la population de la zone côtière devrait presque quadrupler d'ici 2050, de 940 à 3500 habitants par km². Les communes constituant la métropole de Cotonou et celle de Porto Novo devraient avoir des densités de population de l'ordre de 30 000 habitants/km², soit 300 habitants par hectare, ou encore 330 m² par habitant. Ces quatre communes seront donc alors à peu près entièrement urbanisées. On a en effet estimé dans la première partie la consommation d'espace par habitant urbain à 250 m² construits et à 350 m² y compris les plans d'eau, les espaces verts et les zones inconstructibles.

Bénin Zone Littorale : Produit Local Brut et densité d'activité					
en millions de dollars et en dollars par habitant, base 2000	**1990**	***2008***	**2020**	**2050**	**Tx de cr. 2008 - 2050**
Produit Local Brut Littoral Y	**685**	**1396**	**3055**	**17203**	**6,2%**
Produit Local Brut rural PLB (R)	**84**	**216**	**325**	**1360**	**4,5%**
Produit Local Brut urbain PLB (U)	**600**	**1180**	**2730**	**15843**	**6,4%**
dont métropole Cotonou	***460***	***906***	***2065***	***11483***	***6,2%***
dont autres villes littorales	***141***	***274***	***665***	***4360***	***6,8%***
PLB Littoral en % du PIB	**47%**	**44%**	**46%**	**51%**	
PLB rural Littoral en % du PIB rural	**15%**	**17%**	**15%**	**17%**	
PLB urbain Littoral en % du PIB urbain	**68%**	**61%**	**61%**	**61%**	
dont métropole Cotonou	***52%***	***47%***	***46%***	***44%***	
PLB par hab (USD) y	**569**	**603**	**839**	**2015**	**2,9%**
PLB rural par habitant rural	**263**	**381**	**472**	**1141**	**2,6%**
PLB urbain par habitant urbain	**679**	**675**	**925**	**2157**	**2,8%**
dont métropole Cotonou	**756**	**716**	**995**	**2248**	**2,8%**
dont autres villes littorales	**510**	**565**	**759**	**1950**	**3,0%**
Densité d'activité: PLB littoral par km² en 1000 USD	**279**	**569**	**1245**	**7013**	**6,2%**
ratio de productivité métropole / autres villes	**1,5**	**1,3**	**1,3**	**1,2**	
ratio de productivité autres villes côtières / autres villes	**2,0**	**1,7**	**1,6**	**1,5**	
PLB par hab. Littoral /moyenne nationale	**1,9**	**1,6**	**1,6**	**1,5**	
PLB rural par hab. Littoral /moyenne nationale	**1,3**	**1,4**	**1,4**	**1,5**	
PLB urbain par hab. Littoral /moyenne nationale	**1,5**	**1,4**	**1,4**	**1,2**	

Noter la multiplication par 12 de la densité d'activité économique (PLB par km²) d'ici 2050 (moyenne pour l'ensemble de la zone). Noter aussi la très forte croissance de l'activité des villes littorales hors de la métropole Cotonou : le PLB de ces autres villes devrait être multiplié par 16.

L'activité en milieu rural devrait aussi augmenter notablement (multiplication par 6), à la fois du fait du développement de l'agriculture et de l'élevage périurbains, de la pêche et de l'aquaculture, et du développement des activités rurales non agricoles induites par l'intensification de l'agriculture, par les activités aval (transformation et la commercialisation des produits agricoles,..) et par l'augmentation des niveaux de vie en milieu rural.

Depuis les premiers contacts entre ce pays (l'ex Dahomey) et les commerçants et colonisateurs étrangers, la zone côtière s'est peuplée, densifiée et développée beaucoup plus rapidement que l'hinterland, victime du trafic des esclaves et de conditions sanitaires défavorables. Ce tropisme côtier s'est accéléré avec l'accès à l'indépendance, l'installation de la nouvelle administration, le développement de la capitale et l'expansion des échanges extérieurs. Puis le mouvement vers la côte s'est ralenti avec la déconcentration administrative (création de centres secondaires) et grâce aux premières tentatives d'aménagement du territoire, mais aussi comme conséquence de la crise du secteur moderne. L'accélération de la croissance économique attendu dans le futur devrait contribuer à renforcer le mouvement de concentration des activités modernes près de la métropole et des ports secondaires, jusqu'au stade où la rareté de l'espace disponible et l'accroissement des prix fonciers inciteront les agents économiques à la déconcentration vers l'immédiat arrière pays ce que l'étude WALTPS appelait la Zone 2). La marge de manœuvre entre cette évolution tendancielle et une politique volontariste de rééquilibrage du territoire sera très faible à moyen terme et restera modeste à plus long terme.

Extrapolation à l'ensemble des 12 pays côtiers et de la zone littorale d'Afrique de l'Ouest

On peut, en utilisant les enseignements de l'étude de cas du Bénin et selon le même cadre conceptuel, mais sans recourir à un modèle explicite, construire pour chacun des onze autres pays les trois tableaux nationaux et les deux tableaux littoraux mentionnés précédemment :

Pays : Population totale, urbain et rurale 1950-2050 ;
Pays : Population primaire, non primaire informelle et moderne 1950-2050
Pays : PIB urbain, PIB rural et productivités par strate : 1960-2050.
Zone Littorale : Peuplement 1950-2050 ;
Zone Littorale : Produit Local Brut et densité d'activité mêmes années que pour le tableau national.

Les deux tableaux relatifs à la zone littorale comportent, pour 2050, deux scenarios démographiques et économiques. Le premier est qualifié de scenario tendanciel. Le second est baptisé « maîtrise des déséquilibres ». Cette variante 2050 repose sur la même image économique nationale que le scenario tendanciel. Ceci revient à considérer comme du second ordre la variation de l'économie nationale en fonction de la répartition de la population et de l'activité entre la côte et l'intérieur, et en fonction du poids relatif de la capitale dans l'économie urbaine. Cette hypothèse n'est acceptable que pour des scenarios pas trop éloignés du scenario tendanciel, ce qui est le cas. Des scenarios beaucoup plus contrastés seraient sans intérêt parce que hautement improbables.

L'objectif du deuxième scenario est d'évaluer grossièrement les implications d'une politique volontariste de rééquilibrage national au profit de l'hinterland : moindre croissance démographique des villes côtières, densification du peuplement rural un peu plus faible, et implications économiques pour la zone côtière. A l'horizon 2020, il est inutile de distinguer deux scenarios, l'effet de politiques même immédiates serait à peine perceptible à cet horizon. On verra que, à l'horizon 2050, les marges de manœuvre en matière de rééquilibrage de territoire sont notables, mais restent encore modestes.

Dans tous ces tableaux, les taux de croissance annuels inscrits en ligne sont calculés par décennie (par exemple sur la période 1980-1990) ; les taux de croissance figurant dans les dernières colonnes sont des taux moyens sur la période 2008-2050 (42 ans).

Tous ces tableaux figurent, pour chaque pays, dans la maquette Excel[57] jointe à l'étude. On ne présente ici que les tableaux régionaux de même structure obtenus par sommation des tableaux de chaque pays, et quelques tableaux de synthèse par thème donnant, pays par pays, le PLB du littoral et son poids dans l'économie nationale, et la densité d'activité des zones littorales. Les tableaux donnant la population urbaine, la population des métropoles, la distribution de la population urbaine par taille, la densité de population et la consommation d'espace urbain littoral sont dans la première partie de ce document. Les données figurant dans ces tableaux sont arrondies, non seulement pour ne faciliter la lecture, mais aussi pour rappeler qu'il ne s'agit que d'ordres de grandeur, deux chiffres significatifs suffisent amplement.

[57] Fichier Excel intitulé : SDAL Tableaux extraits des douze pays et des zones littorales. Ce fichier comporte une feuille de synthèse pour les douze pays puis une feuille par pays, et une dernière feuille de format comparable à celui du fichier source (non joint) comprenant tous les calculs détaillés.

Tableaux relatifs à la région constituée des douze pays côtiers et de l'ensemble de la zone littorale

12 pays côtiers Population primaire et non primaire

en millions d'habitants	1950	1960	1970	1980	1990	2000	*2008*	2020	2050	Tx de cr. 2008 - 2050
Populaton totale	19	26	33	44	60	79	97	131	231	2,1%
Population primaire PP	18	22	25	29	35	41	47	58	77	1,2%
Population non primaire PN	2	4	8	14	25	38	50	73	155	2,7%
Ratio PNP/PP	0,1	0,2	0,3	0,5	0,7	0,9	1,1	1,3	2,0	1,5%
Taux de croissance de PNP/PP		7,2%	4,6%	4,0%	4,0%	2,6%	*2,0%*	1,4%	1,6%	
Taux de croissance de P		2,9%	2,6%	2,7%	3,2%	2,8%	2,6%	2,6%	1,9%	
Taux de croissance de PP		2,0%	1,6%	1,5%	1,7%	1,7%	1,6%	1,8%	0,9%	
Taux de croissance de PNP		9,3%	6,3%	5,6%	5,8%	4,3%	3,6%	3,3%	2,5%	
Population informelle PNP1	1	2	5	9	18	28	*36*	48	70	1,6%
Population "moderne"PNP2	1	2	3	5	7	10	*14*	26	85	4,3%
PNP1/PNP	40%	51%	61%	66%	71%	73%	*72%*	65%	45%	

12 pays côtiers : PIB urbain et rural et productivités

en milliards de dollars, en dollars par habitant et en milliers de dollars par km², base 2000	1960	1970	1980	1990	2000	*2008*	2020	2050	Tx de cr. 2008 - 2050
PIB Y	9	15	20	23	30	36	74	400	5,9%
PIB rural Y (R)	5	6	7	9	11	13	21	69	4,1%
PIB urbain Y (U)	5	9	13	14	20	23	53	331	6,6%
PIB primaire A	4	5	6	7	8	9	15	47	3,9%
PIB informel B1	1	2	4	6	9	11	20	70	4,4%
PIB non primaire moderne B2	5	8	10	9	13	15	38	282	7,3%
PIB non primaire B	5	10	14	15	22	26	59	352	6,4%
Taux de croissance de Y		4,7%	3,1%	1,2%	2,9%	2,1%	6,0%	5,8%	
PIB par habitant (USD) y	361	445	463	380	383	369	561	1727	3,7%
PIB rural par habitant rural	205	227	243	239	230	233	308	727	2,7%
PIB urbain par habitant urbain	1293	1156	934	630	600	543	825	2416	3,6%
Productivité primaire a = A/PP	186	204	218	211	204	202	261	614	2,7%
Productivité informelle b1 =B1/PNP1	369	401	406	355	320	317	428	1006	2,8%
Productivité moderne b2 =B2/PNP2	2081	2410	2072	1256	1269	1046	1491	3325	2,8%
Productivité non primaire b=B/PNP	1208	1189	972	617	578	525	799	2278	3,6%
ratio b1/a	2,0	2,0	1,9	1,7	1,6	1,6	1,6	1,6	
ratio b2/b1	5,6	6,0	5,1	3,5	4,0	3,3	3,5	3,3	
ratio b/a	6,5	5,8	4,5	2,9	2,8	2,6	3,1	3,7	

Zone littorale des 12 pays côtiers : PIB urbain et rural et productivités et densité d'activité							**Scenario tendanciel**			**Maîtrise des déséquilibres**	
en millards de dollars et en dollars par habitant, base 2000	**1960**	**1970**	**1980**	**1990**	**2000**	***2008***	**2020**	**2050**	**Tx de cr. 2008 - 2050**	**2050**	**Tx de cr. 2008 - 2050**
Produit Local Brut Littoral Y	**4,6**	**8,1**	**11,5**	**12,5**	**17,3**	**20,1**	**44**	**262**	**6,3%**	**224**	**5,9%**
Produit Local Brut rural PLB (R)	**0,8**	**1,1**	**1,4**	**1,9**	**2,3**	**2,7**	**4**	**15**	**4,2%**	**15**	**4,3%**
Produit Local Brut urbain PLB (U)	**3,8**	**7,0**	**10,1**	**10,6**	**14,9**	**17,4**	**40**	**247**	**6,5%**	**209**	**6,1%**
dont les métropoles des 12 pays côtiers	***2,9***	***5,8***	***8,7***	***9,2***	***13,1***	***15,3***	***35***	***210***	***6,4%***	***174***	***6,0%***
dont autres villes littorales	***0,9***	***1,2***	***1,4***	***1,4***	***1,9***	***2,1***	***5***	***37***	***7,1%***	***35***	***7,0%***
PLB Littoral en % du PIB	**49%**	**54%**	**57%**	**55%**	**57%**	**56%**	**60%**	**66%**		**56%**	
PLB rural Littoral en % du PIB rural	**18%**	**18%**	**20%**	**21%**	**22%**	**21%**	**20%**	**22%**		**22%**	
PLB urbain Littoral en % du PIB urbain	**78%**	**77%**	**78%**	**78%**	**76%**	**76%**	**75%**	**75%**		**63%**	
dont les métropoles des 12 pays côtiers	***60%***	***64%***	***67%***	***68%***	***67%***	***67%***	***67%***	***63%***		***53%***	
PLB par hab (USD) y	**1010**	**1100**	**990**	**730**	**710**	**680**	**1040**	**2700**	**3,3%**	**2600**	**3,2%**
PLB rural par habitant rural	**330**	**350**	**370**	**350**	**330**	**340**	**440**	**1100**	**2,8%**	**1100**	**2,8%**
PLB urbain par habitant urbain	**1780**	**1620**	**1300**	**900**	**870**	**810**	**1210**	**3000**	**3,2%**	**2900**	**3,1%**
dont les métropoles des 12 pays côtiers	***1910***	***1710***	***1400***	***960***	***940***	***880***	***1340***	***3200***	***3,1%***	***3000***	***3,0%***
dont autres villes littorales	***1440***	***1290***	***920***	***630***	***580***	***500***	***690***	***2340***	***3,7%***	***2470***	***3,9%***
Densité d'activité: PLB littoral par km² en 1000 USD	**40**	**70**	**100**	**110**	**150**	**170**	**380**	**2300**	**6,4%**	**2000**	**6,0%**
ratio de productivité métropole / autres villes	**2,2**	**2,3**	**2,5**	**2,6**	**2,7**	**2,8**	**2,9**	**1,9**		**1,5**	
PLB par hab. Littoral /moyenne nationale	**2,8**	**2,5**	**2,1**	**1,9**	**1,9**	**1,8**	**1,9**	**1,6**		**1,5**	
PLB rural par hab. Littoral /moyenne nationale	**1,6**	**1,5**	**1,5**	**1,5**	**1,4**	**1,5**	**1,4**	**1,5**		**1,5**	
PLB urbain par hab. Littoral /moyenne nationa	**1,4**	**1,4**	**1,4**	**1,4**	**1,4**	**1,5**	**1,5**	**1,2**		**1,2**	

Tableaux de synthèse par thème et par pays

Produit Local Brut Littoral des zones littorales des 12 pays côtiers							Scenario tendanciel			Maîtrise des déséquilibres	
en millards de dollars, base 2000	1960	1970	1980	1990	2000	2008	2020	2050	Tx de cr. 2008 - 2050	2050	Tx de cr. 2008 - 2050
Bénin	0,3	0,4	0,5	0,7	1,0	1,4	3,1	17	6,2%	15	5,8%
Côte d'Ivoire	0,8	2,3	4,3	4,3	6,0	6,2	15,2	87	6,5%	72	6,0%
Cap Vert	0,1	0,1	0,2	0,3	0,5	0,8	1,5	8	5,5%	8	5,5%
Ghana	0,9	1,1	1,0	1,3	2,3	3,6	7,1	41	6,0%	34	5,5%
Guinée	0,2	0,5	0,9	1,3	1,9	2,5	5,3	32	6,3%	27	5,9%
Gambie	0,1	0,1	0,2	0,2	0,3	0,5	0,9	6	6,4%	6	6,3%
Guinée Bissau	0,1	0,1	0,1	0,1	0,1	0,1	0,3	3	7,8%	3	7,7%
Liberia	0,6	0,9	1,0	0,2	0,3	0,3	1,1	7	7,8%	7	7,6%
Mauritanie	0,1	0,3	0,4	0,5	0,7	1,1	2,1	14	6,2%	13	6,0%
Sénégal	1,2	1,5	1,9	2,5	3,2	2,1	3,9	23	5,9%	20	5,5%
Sierra Leone	0,2	0,4	0,5	0,5	0,2	0,7	1,4	10	6,6%	9	6,3%
Togo	0,1	0,3	0,5	0,6	0,7	0,8	2,0	13	7,0%	11	6,6%
12 pays côtiers	4,6	8,1	11,5	12,5	17,3	20,1	44,1	262	6,3%	224	5,9%

Densité d'activité: PLB littoral par km² de surface littorale							Scenario tendanciel			Maîtrise des déséquilibres	
en milliers de dollars /km²	1960	1970	1980	1990	2000	2008	2020	2050	Tx de cr. 2008 - 2050	2050	Tx de cr. 2008 - 2050
Bénin	140	170	220	280	400	570	1250	7000	6,2%	6200	5,8%
Côte d'Ivoire	50	160	300	300	420	430	1070	6100	6,5%	5000	6,0%
Cap Vert	10	20	40	80	130	210	380	2000	5,5%	2000	5,5%
Ghana	70	90	80	110	190	290	580	3300	6,0%	2700	5,5%
Guinée	20	50	80	120	180	230	490	3000	6,3%	2500	5,9%
Gambie	50	60	90	130	170	270	530	3600	6,4%	3600	6,3%
Guinée Bissau	4	5	6	8	10	9	30	200	7,8%	200	7,7%
Liberia	40	70	70	20	20	20	80	500	7,8%	500	7,6%
Mauritanie	5	20	30	30	50	80	140	1000	6,2%	900	6,0%
Sénégal	80	100	130	160	210	140	260	1500	5,9%	1300	5,5%
Sierra Leone	20	40	50	40	20	60	130	900	6,6%	800	6,3%
Togo	50	170	290	300	380	410	1090	7000	7,0%	5900	6,6%
12 pays côtiers	40	70	100	110	150	170	380	2300	6,4%	2000	6,0%

PLB littoral en % du PIB des pays							Scenario tendanciel		Maîtrise des déséquilibres
	1960	1970	1980	1990	2000	2008	2020	2050	2050
Bénin	54%	50%	50%	47%	43%	44%	46%	51%	45%
Côte d'Ivoire	39%	50%	56%	52%	57%	57%	61%	67%	55%
Cap Vert	100%	100%	100%	100%	100%	103%	104%	100%	100%
Ghana	45%	44%	38%	40%	47%	48%	50%	56%	46%
Guinée	25%	45%	58%	60%	61%	60%	62%	66%	56%
Gambie	71%	73%	74%	74%	71%	75%	79%	87%	86%
Guinée Bissau	59%	61%	65%	55%	58%	57%	68%	77%	75%
Liberia	78%	82%	69%	57%	52%	54%	69%	76%	70%
Mauritanie	21%	58%	60%	61%	61%	73%	76%	87%	80%
Sénégal	66%	64%	72%	72%	69%	68%	70%	75%	66%
Sierra Leone	46%	56%	56%	46%	37%	46%	51%	61%	55%
Togo	33%	49%	55%	51%	54%	48%	55%	64%	54%
12 pays côtiers	49%	54%	57%	55%	57%	56%	60%	66%	56%

11.4. CONCLUSION

On retiendra notamment le tableau dans fournissant, pays par pays, une estimation de la consommation d'espace par le milieu urbain du littoral. Les résultats de ces calculs, si sommaires soient ils, sont à méditer :

Même dans le scenario de « maîtrise des disparités », l'espace (bâti et non bâti) occupé par les villes occuperait la quasi-totalité de la zone littorale dans le cas du Bénin et du Togo, qui ne disposent que d'un étroite bande côtière et sont entourés de pays très denses comme le Nigeria et le Ghana. En Gambie, au Ghana et en Côte d'Ivoire, la zone littorale serait urbanisée sur 40 à 60 % de sa surface totale ce qui est aussi considérable.

Ces évaluations doivent d'abord inciter à revoir le concept et la délimitation de la « zone littorale » : selon les pays et les conditions physiques et humaines, il faut évidemment adopter des critères différents. Les « zones littorales » du Bénin et du Togo doivent sans doute être revues plus largement, comme aussi peut-être au Ghana et en Côte d'Ivoire. Au Bénin, par exemple, le Livre Blanc du Littoral (2001) adopte la définition suivante : *« La zone du littoral couvre 30 circonscriptions administratives et s'étend sur 8 692 km2 environ soit 7,7 % du territoire national. Elle est caractérisée par trois zones agro-écologique dont : la zone humide = 3 461 km2 ; la zone de dépression = 1 852 km2 ; et la zone de terre de barre = 3 379 km2 ».* La zone littorale ainsi définie a une profondeur moyenne de 70 km contre 25 dans la présente étude du SDLAO (profondeur fixée arbitrairement).

Malgré ses faiblesses, ce rapport tend à prouver – ou confirme- que, du Bénin – et même du pays Ibo à l'est du Nigeria- à Abidjan en Côte d'Ivoire, la zone côtière risque de constituer à long terme une conurbation quasi continue, ponctuée tous les 100 km de métropoles multimillionnaires, avec plusieurs centaines de villes satellites et d'agrovilles desservant des zones de mise en valeur agricole intensive et de production animale de type industriel, laissant peu de place au développement touristique et à la protection de la nature.

La multiplication par un facteur 11 à 13 entre 2008 et 2050 de la densité d'activité économique mesurée par le Produit Local Brut par km² de zone littorale est l'un des paramètres à prendre en compte dans la conception de certaines composantes du SDLAO : définition des vocations et règles d'occupation des sols, zones consacrées à l'industrie lourde, aujourd'hui quasi inexistante, environnement urbain (parcs industriels, gestion des déchets, approvisionnement en eau, traitement des eaux usées, lagunage,..) et péri-urbain (ceintures maraîchères, agrovilles, zones à vocation touristique, espaces protégés,..) politiques d'aménagement et d'équipement, politiques foncières. Les pays dans lesquels la pression industrielle sur la zone littorale sera la plus forte seront, comme pour la population, le Bénin (dont le voisinage immédiat avec Lagos fait de la zone portuaire de Cotonou une quasi annexe du Nigeria), le Togo, la Côte d'Ivoire, le Ghana et plus localement le Sénégal avec la presqu'ile du Cap Vert et le Grand Dakar.

Enfin, le besoin d'accumulation de capital résidentiel privé et public urbain et les couts récurrents pour l'entretien du capital public de fonction locale par les collectivités locales que l'on a évalués précédemment dans le cas de Cotonou attirent l'attention sur deux points essentiels :

Assurer la compatibilité entre les ambitions du SDLAO et les objectifs en matière de normes d'équipement et de qualité de service d'une part, et les préoccupations et priorités des gouvernements et des collectivités locales, et la capacité des opérateurs locaux (entreprises, ménages) à changer de comportement et à supporter les surcouts éventuels, ce qui implique un important effort de pédagogie.
Mettre en place des mécanismes de mobilisation des ressources locales pour faire face aux dépenses récurrentes et les modalités d'accès au financement par emprunt à l'échelle des besoins et tenant compte des capacités contributives des ménages et des opérateurs. On a vu que le coût de l'entretien du patrimoine public des collectivités locales peut et doit donc être intégralement financé par un prélèvement supportable sur la valeur du patrimoine privé, donc sans aucune financement extérieur. Il est clair que la première condition de succès du SDLAO et du développement durable de la zone littorale est et sera de faire en sorte que toutes les institutions locales soient effectivement en mesure d'assurer l'entretien de leur capital, ce qui n'est nulle part en Afrique de l'ouest le cas aujourd'hui.

Plus généralement, ce volet de l'étude du SDLAO permet d'identifier quelques points chauds de l'aménagement du littoral, et les pays où il est le plus urgent de mettre en œuvre des politiques urbaines

spécifiques. Certaines de ces politiques pourront par exemple viser à ouvrir à l'urbanisation et au développement industriel des espaces aujourd'hui en déshérence parce que non équipés ou peu propices en raison de leurs caractéristiques topographiques, ou du fait de leur enclavement et de la présence d'obstacles comme les lagunes, les embouchures de rivières et les ouvrages comme le canal de Vridi en Côte d'Ivoire.

La complexité des questions à aborder dans cette partie hyper dense et très sensible de l'Afrique de l'Ouest pourrait aussi inciter à étudier, avec les principales institutions de la région et avec leurs partenaires l'opportunité de mettre sur pied des instruments sous régionaux à même de suivre de très près le développement de la zone littorale. Il existe en la matière plusieurs précédents dont il convient de tirer les leçons. Le plus intéressant est celui formé par le couple CILSS-CSAO (Comité Inter états pour la Lutte contre la Sécheresse au Sahel, au sud, et Club du Sahel et de l'Afrique de l'Ouest composé des principaux partenaires du nord. Ces deux institutions gèrent de nombreux programmes comme le FEWS (Food Early Warning System), qui permet de suivre de très près et en temps réel la situation alimentaire des pays du Sahel et de prévenir les crises.

Le littoral où les problèmes à aborder et les risques à maîtriser sont de nature très différente pourrait lui aussi bénéficier d'un montage institutionnel de même nature. Au Sud, il faudrait instituer une sorte de Comité Inter états pour la Protection et l'Aménagement du Littoral, dont le secrétariat serait constitué des responsables de la planification de chaque pays membre. Au Nord, il suffirait de s'appuyer sur la structure existante, à savoir le CSAO et son secrétariat rattaché à l'OCDE. Ce Secrétariat, dûment mandaté, trouverait là une excellente occasion de valoriser le patrimoine de connaissance accumulé depuis plus de deux décennies sur toute la région et sur la gestion des rapports institutions de la région et leurs partenaires extérieurs.

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12. ANNEX 5: TRANSPORT INFRASTRUCTURE

Colonisation in West Africa and the emergence of Nation States through independence led to the creation of borders, the fragmentation and partitioning of a region that was originally roughly continuous, even though the natural barriers, religious or linguistic contrasts and ecoclimatic gradients conferred great diversity on it.

Mobility has always been an essential and adaptive response for African societies to the extent that it is a part of the subsistence and production strategy of many populations. The matrix of the territory of West Africa, once structured by the rivers, landform, the edges of the major ecoclimatic zones and the distribution of societies, from empires to forest and coastal micro societies, was brutally transformed with the development of towns and the communication routes that are closely associated with them. **The corridorisation of urban development and the resulting connectedness of the urban areas** (conurbations) are today a major fact in most of the countries in West Africa, and this is particularly true in the coastal area.

Road and rail networks

The road network, which is of varying serviceability, and for which we do not always have a reliable picture on a regional scale (updated database[58]) is organised roughly into two types of routes:

- **Routes from the coast to the interior** historically connecting West African port capitals with the interior of the countries**.** Some of these old routes are paired with a more or less functional railway line (Dakar-Tambacounda-Bamako; Conakry-Kankan; Abidjan – Bouaké –Ouagadougou) some of which are essentially for the transport of ore (Conakry, Nouadhibou). In the 1960s, these "penetration routes" were not connected to each other, except by the coastal route between Accra and Lagos, linking Ghana, Togo, Benin and Nigeria. Another coastal road served a part of Côte d'Ivoire from Abidjan to San Pedro. In Senegal, the internal road system was already relatively organised.

- **East-West interstate connections of regional importance:** Between 1960 and 1975 the East-West interstate connections were developed with the connection of the whole area from Côte d'Ivoire to Nigeria. The network in Senegal was also improved, as was the interconnection of the network of major cities in the non-coastal Sudanian-Sahelian countries.

The current situation shows 3 major regional routes:

⇒ **The coastal route from Port Harcourt to Nouadhibou,** with two functional interconnecting segments: Port Harcourt-Liberian border (Gulf of Guinea) and Kaolak-Nouadhibou in Mauritania. Between Liberia and Guinea Bissau, in many segments of the route serviceability is uncertain, and the route is not coastal, since it bypasses Liberia and Sierra Leone and does not connect with the coast. The same can be said of the Boké (Guinea) – Bissau liaison. NEPAD is planning to build a trans-coastal motorway link from Nouadhibou to Nigeria (6 lanes over a distance of 4,560 km at an estimated cost of US $10 billion).

⇒ **The Sudanian-Sahelian route** is more or less serviceable from Bamako to Kano in Nigeria. The link from Nouakchott or Dakar to Bamako is also more or less practicable, although conditions are sometimes difficult. A project for a Trans-Sahelian route is under study by NEPAD, the Dakar-Bamako segment is already scheduled.

⇒ **The Sudanian route,** which links Kankan-Korhogo-Tamale-Kara-Parakou-Abuja**.** This route should be consolidated and reinforced in the light of the force of attraction these zones represent for agricultural and agro-food production.

A last route, still relatively undeveloped, could be described as post coastal. This route would

[58] Staff communication. AFRICAPOLIS.

connect Nzérékoré, Yamussukro – Kumasi – Bohicon and could play an important role in the integration of the area inland of the coast. It would constitute a pertinent, driving measure in the reconfiguration of a future coastal area by relieving population pressure in the immediate coastal fringe.

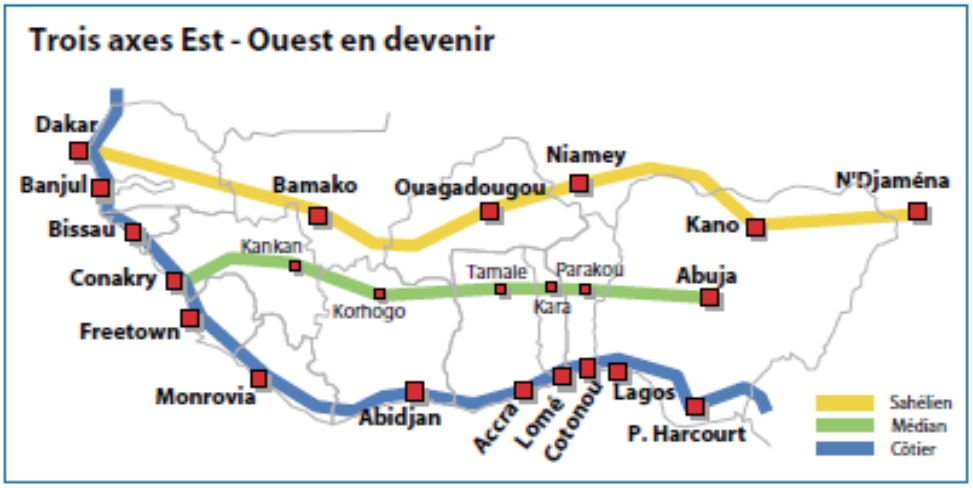

Figure 1. Position of the future three main regional road routes in West Africa.
(according to CEDAO/SWAC. Regional Atlas of transport and telecommunications in ECOWAS). **For the moment, with the exception of the Côte d'Ivoire - Nigeria coastal route, it is mainly North - South routes leading from the major sea capitals to the capitals in the landlocked Sudanian-Sahelian countries which play a major role in regional exchanges.**

The coastal region is reached in a variety of ways: either from a "comb tooth" system linking the coastal access points to a road route parallel to the coast and situated further inland, or in some cases on the coast of Senegal and countries in the Gulf of Guinea, directly by the coastal route.

On the straight stretches of sandy coast, traffic often uses the beach at low tide, with considerable impacts at entry and exit points when the coastal rim dune system is crossed.

Coastal shipping is not widespread, except, subject to verification, in countries where the coast is largely hemmed in (Liberia and Guinea Bissau).

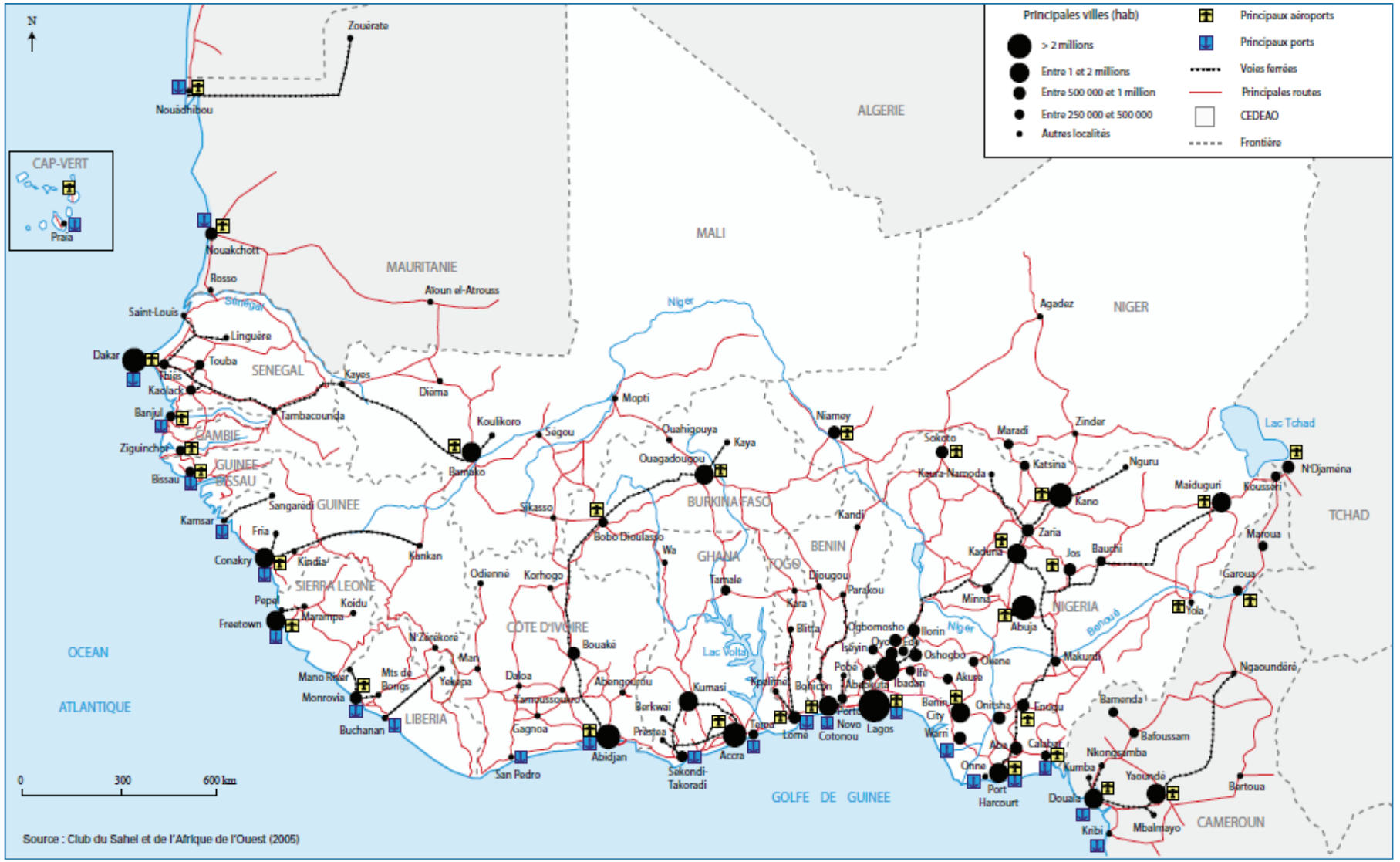
N
Principales villes (hab)
> 2 millions
Entre 1 et 2 millions
Entre 500 000 et 1 million
Entre 250 000 et 500 000
Autres localités
Principaux aéroports
Principaux ports
Voies ferrées
Principales routes
CEDEAO
Frontière
CAP-VERT
Praia
Nouâdhibou
Zouérate
Nouakchott
Rosso
Saint-Louis
Linguère
Dakar
Thiès
Touba
Kaolack
Kayes
Diéma
Tambacounda
Banjul
GAMBIE
Ziguinchor
Bissau
GUINEE BISSAU
Sangaredi
Kamsar
Fria
Conakry
Kindia
Kankan
SIERRA LEONE
Pepel
Koidu
Freetown
Magnampa
OCEAN ATLANTIQUE
N'Zérékoré
Mano River
Monrovia
Mts de Bongs
Buchanan
LIBERIA
Man
Yekepa
Odienné
Korhogo
Daloa
Bouaké
Abengourou
Gagnoa
San Pedro
Abidjan
COTE D'IVOIRE
Sikasso
Bobo Dioulasso
Ouahigouya
Ouagadougou
Kaya
BURKINA FASO
Wa
Tamale
GHANA
Bamako
Koulikoro
Ségou
Mopti
MALI
Aioun el-Atrouss
MAURITANIE
ALGERIE
Niger
Sénégal
Niamey
Agadez
NIGER
Kandi
Parakou
Djougou
BENIN
TOGO
Kara
Atakpamé
Sokoto
Maradi
Zinder
Katsina
Kano
Kaura-Namoda
Nguru
Zaria
Kaduna
Jos
Bauchi
Minna
Abuja
NIGERIA
Ilorin
Ogbomosho
Oyo
Ede
Oshogbo
Ife
Ibadan
Abeokuta
Ijebu-Ode
Akure
Ondo
Benin City
Warri
Onitsha
Enugu
Aba
Calabar
Onne
Port Harcourt
Makurdi
Benoué
Lac Tchad
N'Djamena
Maiduguri
Mubi
Garoua
Maroua
Yola
TCHAD
Barmenda
Bafoussam
Nkongsamba
Kumba
Douala
Yaoundé
Bertoua
Ngaoundéré
Mbalmayo
Kribi
CAMEROUN
Kumasi
Berkwai
Prestea
Takoradi
Sekondi-
Accra
Tema
Lomé
Kpalimé
Atakpamé
Porto Novo
Cotonou
Lagos
Lac Volta
GOLFE DE GUINEE
0
300
600 km
Source : Club du Sahel et de l'Afrique de l'Ouest (2005)

Figure 3. Practicability of road routes in West Africa in 2005 (according to SWAC)

Harbour infrastructure

The countries in the region count 36 main identified ports (World Port Index), around fifteen of which have volumes of traffic in excess of 500,000 tonnes. It is nonetheless difficult to envisage the West African harbour network without including Nigeria, which is by far the largest.

Most of these ports handle international or even intercontinental traffic, as the regional traffic is not highly developed. These ports have a variety of different origins: built on the historical site of a colonial harbour (Cotonou), established in a peri-urban zone (Lomé), genesis of a satellite harbour town (Tema in the case of Ghana). In all cases, whether the ports were developed or extended in a particular context (at least in the Gulf of Guinea), marked by a narrow shelf, low sediment stocks and a strong longshore drift, these infrastructures have strongly disrupted coastal dynamics downdrift of and in the immediate proximity of the developments.

The picture of the ports of West Africa produced in figure 25 only partially illustrates this coastal system, which should be completed with the multiple secondary and/or specialised harbour infrastructures: ore wharfs, fishing ports that are roughly equipped and quays for landing catches, coastal shipping points in particular in mangrove areas or border areas typified by informal trading such as between Benin and Nigeria. Information on these secondary, but no less integral centres is not directly available, and should be obtained from the national diagnostic studies that are in progress.

List of the main harbours on the coast of West Africa (source: World Port Index - WPI)

Wpi code	Name	North Latitude	Longitude	Lat Type	Lon Type	Size	Comments	Average tide (amplitude)
MAURITANIA								
45812	NOUADHIBOU	20.916	17.05	North	West	Average	Natural coastal harbour	0.66
45814	NOUAKCHOTT	18.033	16.0333333	North	West	Restricted	Open port	0.33
SENEGAL								
45818	ST LOUIS	16.0166	16.5166667	North	West	Restricted	Natural river port	0.33
45819	M BAO OIL TERMINAL	14.7166	17.4	North	West	Very restricted	Open port	0.33
45820	DAKAR	14.6833333	17.4333333	North	West	Average	Sheltered by jetty/ breakwater	0.66
45821	RUFISQUE	14.7	17.2833333	North	West	Very restricted	Open port	NA
45822	KARABANE	12.5666667	16.6666667	North	West	Very restricted	Natural river port	0.33
45823	LYNDIANE	14.1666667	16.1666667	North	West	Very restricted	Natural river port	0.66
THE GAMBIA								
45825	BANJUL	13.45	16.5666667	North	West	Very restricted	Natural river port	0.66
GUINEA BISSAU								
45835	RIO CACHEU	12.2833333	16.2333333	North	West	Very restricted	Natural river port	0.66
45838	BISSAU	11.8666667	15.6333333	North	West	Very restricted	Natural river port	1.98
GUINEA								
45850	KAMSAR	10.6333333	14.6166667	North	West	Very restricted	Natural river port	0.99
45855	CONAKRY	9.51666667	13.7166667	North	West	Average	Sheltered by jetty/ breakwater	1.32
45857	BENTI	9.16666667	13.2	North	West	Very restricted	Natural river port	0.99
SIERRA LEONE								
45862	FREETOWN	8.5	13.2333333	North	West	Restricted	Natural coastal harbour	0.99
45865	PEPEL	8.58333333	13.05	North	West	Very restricted	Natural river port	0.99
45867	BONTHE	7.53333333	12.5	North	West	Very restricted	Natural river port	0.99
LIBERIA								

Wpi code	Name	North Latitude	Longitude	Lat Type	Lon Type	Size	Comments	Average tide (amplitude)
45940	MONROVIA	6.31666667	10.8166667	North	West	Restricted	Sheltered by jetty/ breakwater	0.33
45950	BUCHANAN	5.86666667	10.0666667	North	West	Very restricted	Sheltered by jetty/ breakwater	0.33
45952	GREENVILLE	4.98333333	9.05	North	West	Very restricted	Natural coastal harbour	0.33
45955	CAPE PALMAS	4.36666667	7.71666667	North	West	Very restricted	Open port	0.66
COTE D'IVOIRE								
45963	SAN PEDRO	4.66666667	6.61666667	North	West	Very restricted	Open port	0.66
45965	SASSANDRA	4.95	6.08333333	North	West	Very restricted	Open port	1.32
45970	BAOBAB MARINE TERMINAL	4.95	4.53333333	North	West	Very restricted	Open port	NA
45990	PORT BOUET	5.23333333	3.96666667	North	West	Very restricted	Open port	NA
46000	ABIDJAN	5.25	4.01666667	North	West	Average	Port in lagoon	NA
46007	LION TERMINAL	5.03333333	4.8	North	West	Very restricted	Open port	0.66
46008	ESPOIR MARINE TERMINAL	5.03333333	4.45	North	West	Very restricted	Open port	NA
GHANA								
46040	TAKORADI	4.88333333	1.73333333	North	West	Average	Sheltered by jetty/ breakwater	0.33
46045	SEKONDI	4.95	1.7	North	West	Very restricted	Sheltered by jetty/ breakwater	0.33
46063	SALTPOND	5.2	1.05	North	West	Very restricted	Open port	NA
46070	TEMA	5.61666667	0.01666667	North	East	Restricted	Sheltered by jetty/ breakwater	0.99
TOGO								
46090	PORT OF LOME	6.13333333	1.28333333	North	East	Very restricted	Sheltered by jetty/ breakwater	0.33
46095	KPEME	6.2	1.51666667	North	East	Very restricted	Open port	0.66
BENIN								
46110	COTONOU	6.35	2.43333333	North	East	Restricted	Sheltered by jetty/ breakwater	0.66
46115	SEME TERMINAL	6.3	2.65	North	East	Very restricted	Open port	0.66

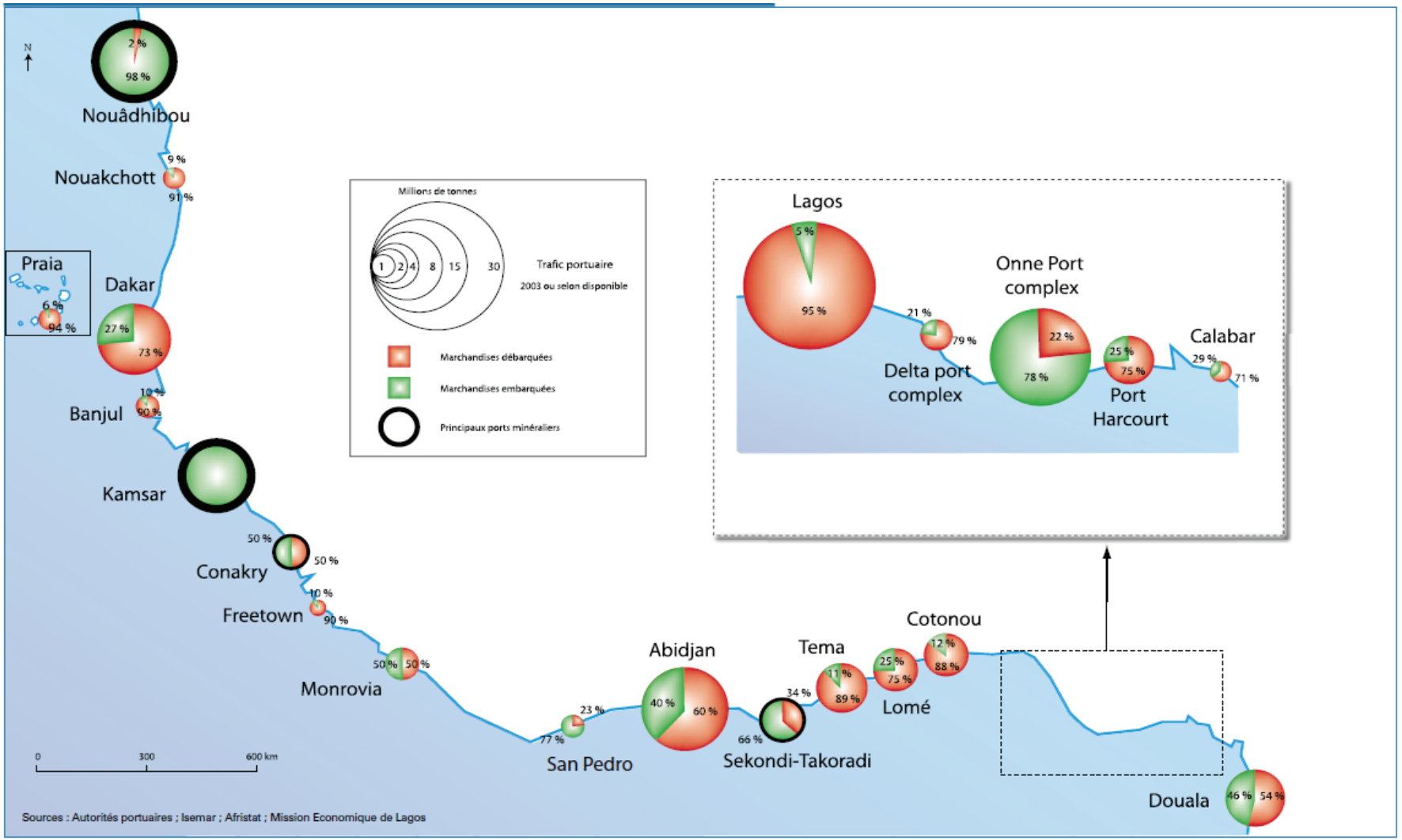

Figure 4 - Freight handling in the main ports of West Africa (2003). According to ECOWAS Transport Atlas (ECOWAS/SWAC-OECD)

These ports perform a variety of functions, some being almost exclusively for the handling of ore (Nouadhibou and Kamsar), while other, hub ports are largely connected to the inland areas (Dakar, Abidjan, Cotonou and Lagos). In the light of the recurring costs of these infrastructures and their impact on the dynamics of the shoreline, we may wonder about the pertinence, from a regional perspective, of such a legacy system in which some of the component elements even compete with each other. The implementation of regional road (and/or railway) infrastructure planned by NEPAD should help to rationalise the regional system with an increase in the hub role of certain major ports to the detriment of ports whose existence is currently justified by the relative lack of a functional regional road system.

It should also be noted that the growth in demand for raw materials (particularly the products of mining) today leads to the possibility of the development of several more ore ports (Saint Louis for phosphates, for instance, with the improved navigability of the Senegal river) or in Guinea Conakry for the export of iron and bauxite. The essential role played by the private sector in implementing and developing infrastructure should have as a corollary a building up of technical services in terms of the strategic evaluation and tracking of impacts.

13. ANNEX 6: ELEMENTS OF CLIMATE FORECAST

What kind of climate changes would have a direct effect on the state of the coastal sea and significant impacts on erosion phenomena? Here is a summary of the different change scenarios to 2050 for the different West African coastal climate profiles described previously.

13.1. UNCERTAINTY OF CLIMATE MODELS FOR WEST AFRICA

Global climate models (general circulation models) are solidly based on physical principles and are capable of reproducing certain characteristics of past and present climates. Increasing confidence is being accorded to the capacity of Ocean-Atmosphere general circulation models (AOGCM) to estimate future large scale climate changes (Randall et al., 2007)[59]. The confidence in the forecasts of certain variables such as temperature is better than for precipitations, for example. Thus the models reproduce unambiguously the significant warming of the earth over the past few decades due to the increased concentration of greenhouse gases (Randall et al., 2007). To assess the relative credibility of the climate forecasts produced by the different models, it is assumed that the models capable of reproducing past observations will also give the most plausible projections.

However, there are systematic biases in the simulation of the African climate by most of the climate models that contributed to the 4th report of the IPCC (Intergovernmental Panel on Climate Change). 90% of these models overestimate the precipitations on a large part of the continent (Christensen et al., 2007)[60].. The temperatures simulated also show bias, but this is not significant enough to call into question the credibility of the projections.

The intertropical convergence zone simulated is moved towards the equator in most of these models. The surface sea temperatures are overestimated by 1 to 2 degrees on the Gulf of Guinea. A large part of these models have no monsoon, as they cannot properly reproduce the Northward movement of precipitations on the continent. Only 4 of the 18 global ocean-atmosphere models in the 4th IPCC report examined by Cook and Vizy (2006)[61] are able to produce quite realistically the interannual variability of surfacewater temperatures in the Gulf of Guinea and the dipolar structure of precipitations between the Sahel region and the Guinean coast.

Climate change scenarios

Future changes in climate depend on a number of natural and anthropic parameters. The most important anthropic factor is the increase in greenhouse gases related to industrial activity. These emissions depend in turn on a number of socio-economic factors, for which it is impossible to predict future changes. This is why the IPCC produced a special report on emissions scenarios (SRES) to enable the evaluation of climate change. Four families of scenarios were drawn up (figure 1). These scenarios take into account various factors that could influence climate, such as population increase, socioeconomic development or technological choices.

[59] Randall, D.A. et al., 2007. **Climate Models and Their Evaluation**, Cambridge, United Kingdom and New York, NY, USA.
[60] Christensen, J.H. et al., 2007. **Regional Climate Projections.**
[61] Cook, K.H. and Vizy, E.K., 2006. Coupled Model Simulations of the West African Monsoon System: Twentieth- and Twenty-First-Century Simulations. **Journal of Climate, 19:** 3681-3703.

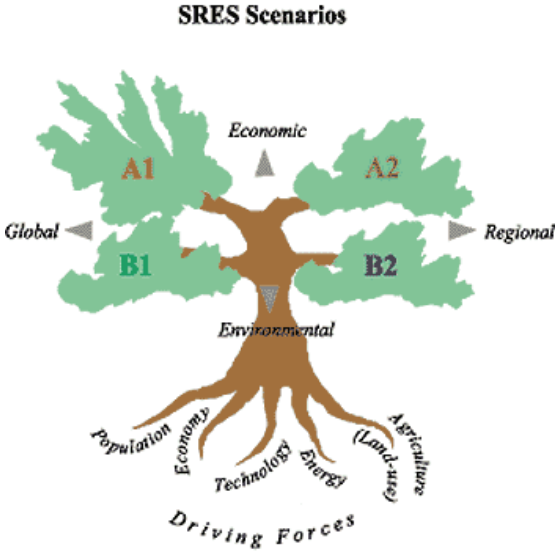

Figure 1. Schematic of the SRES scenarios.

13.2. FUTURE PROJECTIONS TO 2050

Temperatures

The Intergovernmental Panel on Climate Change (IPCC) submitted its fourth report in 2007 and the conclusions leave no room for doubt that the global climate is warming up, sea levels are rising and the ice cap is melting.

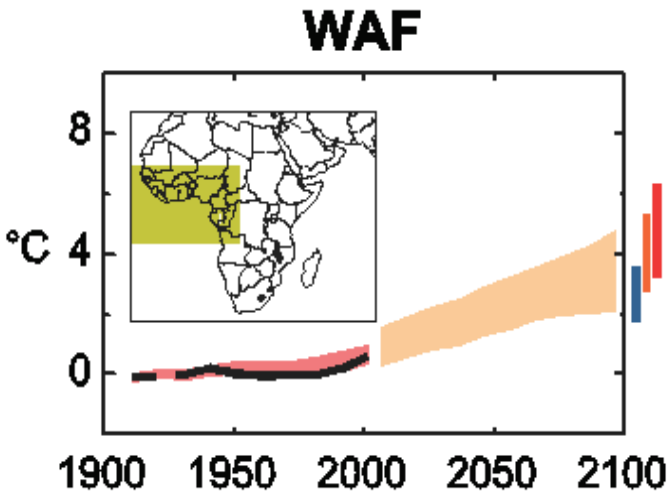

Figure 2: Anomaly of temperatures observed and projected till 2100 compared to the 1900-1950 period for West Africa (IPCC, 2007).

According to this report, the decades to come will see warming of approximately 0.2°C per decade and even of all concentrations of greenhouse gases were stabilised at their 2000 values, warming of around 0.1°C per decade would still be expected.

Maintaining the current pace of emissions would cause additional warming and would lead to "numerous alterations to the global climate system in the course of the 21st century which would very likely be greater than those observed in the course of the 20th century".

The projections for Africa show temperature rises that will very probably be superior to the average global rise, with an accentuation on the arid zones. The average temperature rise for West Africa to 2050 will be between 1.5 and 3°C.

Precipitations

The global ocean-atmosphere model has more difficulty simulating precipitations than temperatures. In several regions of the world, these models agree on the rise or fall in precipitations, but they diverge greatly in their projection of precipitations in West Africa and the signal for variations in precipitations on the Sahel and Guinean coast remain uncertain.

The models therefore generate clear but contradictory answers. The extreme cases are the GFDL/CM2.1 models, which predict a considerable reduction in the precipitations over the Sahel and the Sahara, and MIROC3.2 which predicts strong increases. The overall average presents a downward trend in JJA (June July August) precipitations on the West African coast to the North of the 10th degree of latitude, which is approximately the domain of the maritime trade wind and the North of the Liberian-Guinean domain.

This decrease will be accompanied by an increase in the intensity of precipitations and a reduction in the number of rain events (Tebaldi et al., 2006)[62].. In the South, on the domain of the permanent Atlantic monsoon, the models do not agree on the signal of change, even though the average presents a slight upward trend.

The increase in the intensity of precipitations and the reduction in the return periods of certain extreme events could cause the flooding of coastal zones and aggravate erosion phenomena (which could in certain specific cases lead to increased siltation).

The global reduction of rainfall in the course of the 21st century would cause a decrease in the flow rates of the major rivers such as the Senegal and the Volta, which would be accompanied by a sediment deficit and an aggravation of coastal erosion. To this should be added the influence of works such as dams on these watercourses, which only aggravate the phenomenon.

[62] Tebaldi, C., Hayhoe, K., Arblaster, J. and Meehl, G., 2006. Going to the extremes. **Climatic Change, 79(3):** 185-211.

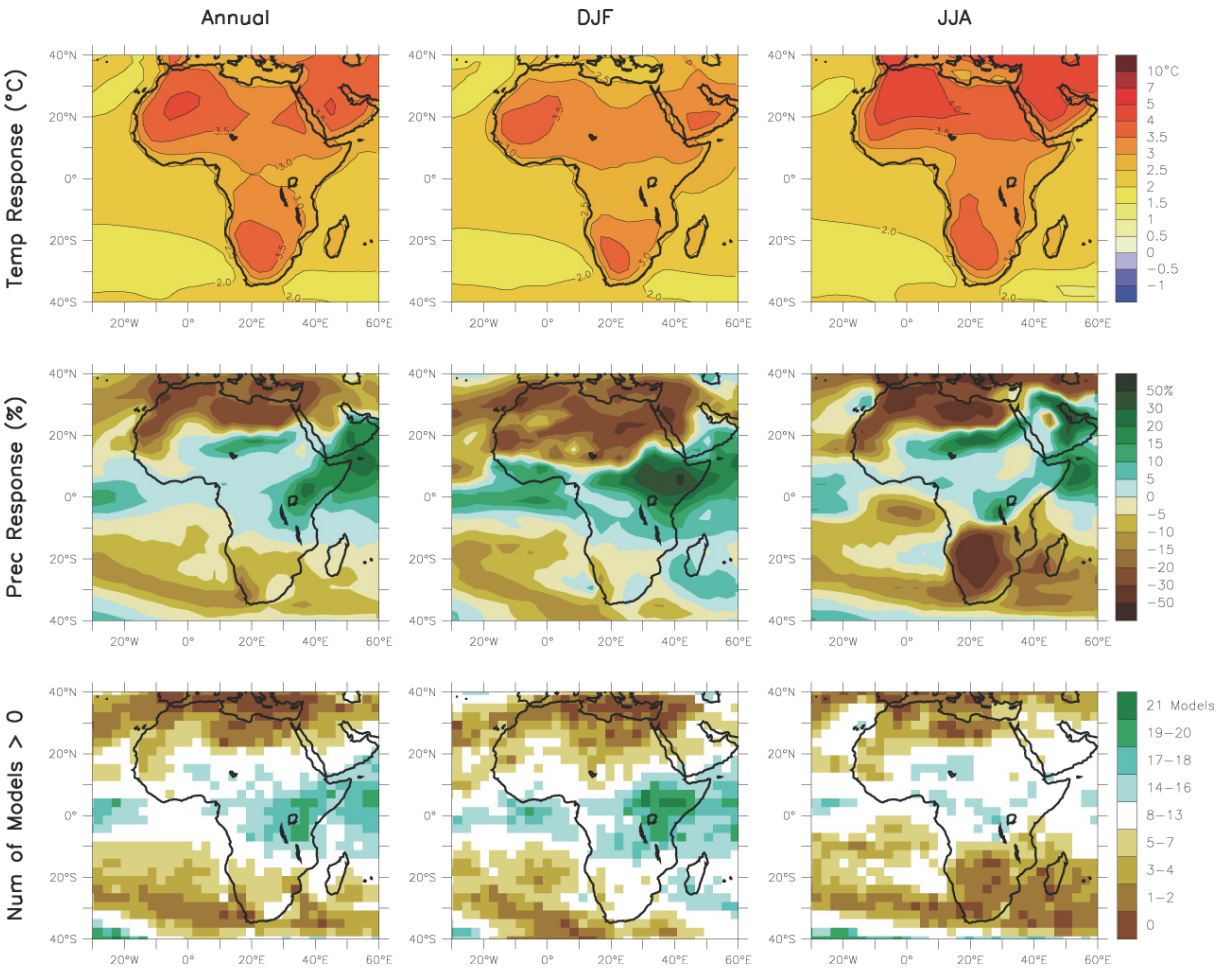

Figure 3: Projected changes in temperature and precipitations in Africa from multi-model simulations of A1B scenarios. First line: change in annual average temperatures, DJF and JJA. Middle line: ditto for fractional changes in precipitations. Third line: number of models projecting increases in precipitations of the 21 (Christensen et al., 2007).

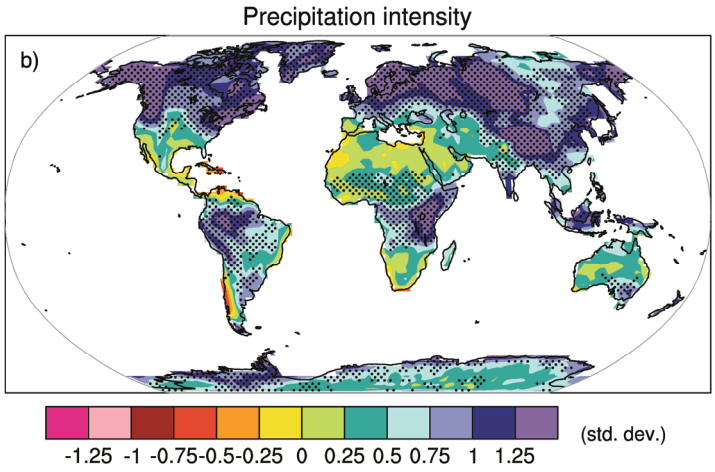

Figure 4: Average of all nine models (Tebaldi et al., 2006) of change in intensity of precipitations for the 2080-2099 period compared to 1980-1999 (A1B scenario). The black dots show places where more than half the models project a significant change.

The Southern Oscillation (ENSO)

The El Niño phenomenon affects climate in places all over the world including Africa, where it is accompanied by extreme events such as drought in West Africa. Van Oldenborgh et al. (2005)[63] estimated the changes in the variability of ENSO in a future climate. The projected changes differ from one model to another, however. Based on the 6 models out of 19 the most apt to reproduce the current variability of El Nino, they found no statistically significant change. The uncertainties are too high to permit an estimation of the future intensity of the El Nino La Nina phenomena. The models nonetheless project a future weakening in the coupling of El-Nino and the monsoon (Philip and Van Oldenborgh, 2006)[64].

Frequencies of extreme events

Among the most important extreme events affecting the coasts of West Africa, the episodes of intense precipitations, depressions and tropical storms can cause considerable damage. There is disagreement between the different studies on the projected the frequency of extreme events (including cyclones) as a result of global warming. There seems to be more of an agreement on their increase in intensity because of a perceptible increase in the temperature of marine surfacewaters.

The theory indicates, and the observations and results of models confirm, that a consequence of global warming will be more violent cyclones. A quite recent study (Webster et al., 2005)[65], based on satellite data, has shown that the number of category 4 cyclones has almost doubled since the 1970s, although there is no significant trend for the total number of these events over the same period.

In any case, it is difficult to establish series of data that lend themselves to statistical analysis for events the extreme nature of which has for corollary their low frequency.

Storm surges depend greatly on local conditions, in particular bathymetric and related to tidal regimes. This means studies of storm surge statistics are specific to each region and can not be generalised.

Significant wave height

There are a limited number of studies on wave climatology projections (Weisse and von Storch, 2010)[66]. Most of the studies use statistical disaggregation to project the significant height of waves in a future climate (Caires et al., 2006[67]; Wang et al., 2004[68]).

These studies allow for a considerable increase in the significant height of waves in the North Atlantic, consistent with the deviation of storm paths towards the poles. These studies do not predict an upward trend in low latitudes. For West Africa, the change will therefore come especially from the increase in the frequency and duration of tidal wave events, in particular related to extreme events.

13.3. TREND: RISING SEA LEVEL AND STORM SURGES

The fact that sea level is rising seems to have been largely confirmed. The historical tide gauges show a rise in the average level of the sea of 20 cm over the past 100 years. Current estimates for the end

[63] Van Oldenborgh, G., Philip, S. and Collins, M., 2005. El Nino in a changing climate: a multi-model study. **Ocean Science Discussions, 2(3):** 267-298.
[64] Philip, S. and Van Oldenborgh, G., 2006. Shifts in ENSO coupling processes under global warming. **Geophys. Res. Lett, 33.**
[65] Webster, P., Holland, G., Curry, J. and Chang, H., 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. **Science**, 309(5742): 1844.
[66] Weisse, R. and von Storch, H., 2010. **Marine Climate Change**: **Ocean Waves, Storms and Surges in the Perspective of Climate Change.** Springer Verlag.
[67] Caires, S., Swail, V. and Wang, X., 2006. Projection and analysis of extreme wave climate. **Journal of Climate, 19(21):** 5581-5605.
[68] Wang, X., Zwiers, F. and Swail, V., 2004. North Atlantic ocean wave climate change scenarios for the twenty-first century. **Journal of Climate, 17:** 12.

of this century are between 20 and 50 cm. Much more dramatic estimates evoke (on a conservative hypothesis) a rise of 3.3 metres should the West Antarctic plaque disintegrate completely[69].

Non uniform spatial distribution of the signal

The spatial distribution of the sea rise signal is far from uniform. First of all, the surface of the oceans is not regular and for example in the subtropical Atlantic we note a convex area of approximately 1 metre in elevation. This spatial distribution also depends on climate variability and the hazards of marine circulation. These spatial disparities were already observed in the data for the decade 1993-2003.

At regional level, this rise can significantly deviate from the global average due to little know local factors such as land subsidence, the change in atmospheric circulation and wind regime, the redistribution of atmospheric pressure or the unequal distribution of thermal expansion. Our current state of knowledge does not allow more accurate estimations.

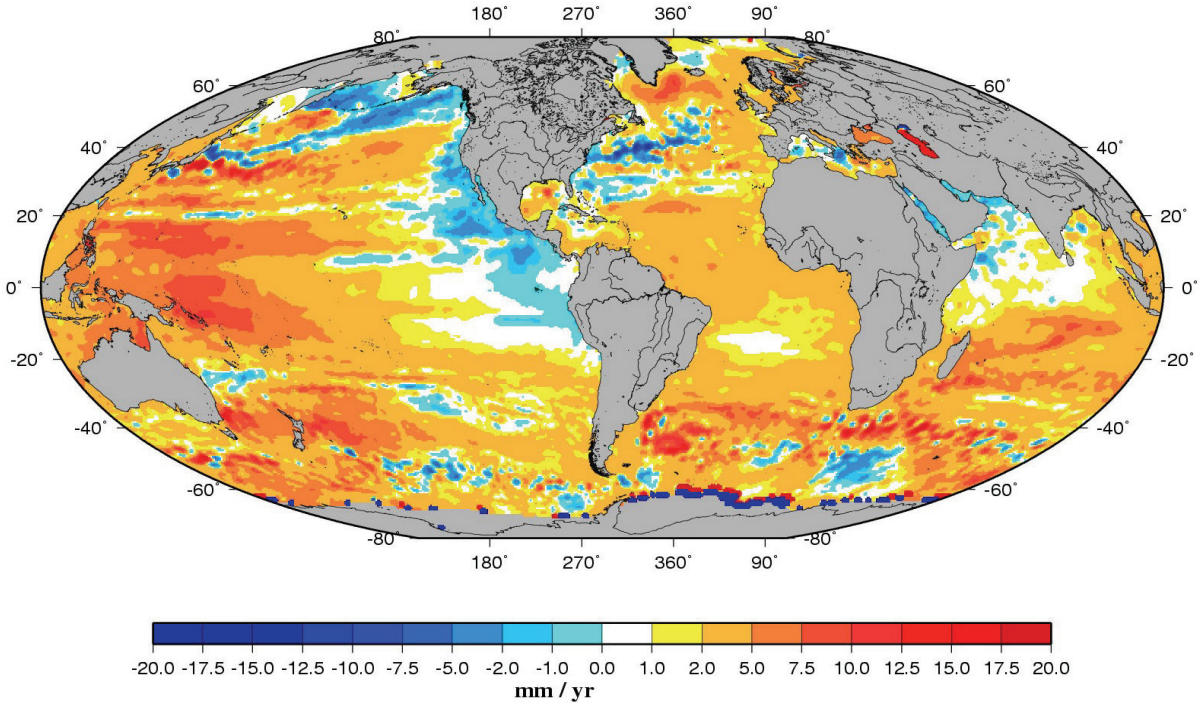

Figure 5: Map of the geographic distribution of the speed of variation of sea level 1993-2007) according to Topex/Poseidon and Jason-1. We observe that the speed of elevation can vary by a factor of 5 from one region to another. This distribution appears to be quite stable between 1993 and 2007. LEGOS/CNES/IRD/CNRS - http://www.legos.obs-mip.fr/fr/.

The causes

The causes of the rise in sea level are multiple and can be summarised as follows:

⇒ Thermal expansion of ocean waters (variations in volume)
⇒ Exchange of masses of water with the continental zones (variations in mass).

[69] Bamber. J.L. 2009.- Reassessment of the Potential Sea-Level Rise from a Collapse of the West Antarctic Ice Sheet. **Science.** 324: 901-903.

A few facts: the tidal gauges provide relative data but the Topex Poséidon and Jason-1 satellite programmes provide absolute data. Between 1993 and 2006, Topex evaluated the rise in sea level at 3.3 mm +- 0.4 mm per annum. The contribution of thermal expansion is estimated at 50% between 1993 and 2003 compared to 25% between 1950 and 2000. The contribution of water exchanges is estimated at 40%. The literature also mentions the moderating impact of major dam projects that have been built in the course of the 20th century.

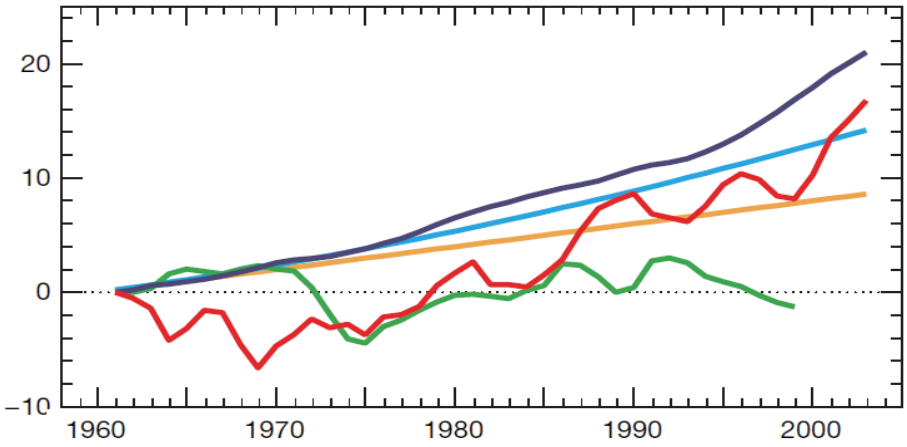

Figure 6 - Different components of the rise in sea level between 1960 and 2000: thermal expansion in the first 700 m (red), thermal expansion in deep waters (orange), Antarctic and Greenland ice sheets (light blue), glaciers and ice caps (dark blue), land retention (green). According to Domingues. C.A. 2008.- Improved estimates of upper-ocean warming and multi-decadal sea-level rise. **Nature.** 453: 1090-1094p.

The rise in sea level is therefore the consequence of several concurrent phenomena. The greatest contribution comes from thermal expansion due to global warming, then, in second position comes ice melt. Some causes, like thermal expansion, due to inertia, will be active for several centuries whatever the perspectives for the reduction of greenhouse gas emissions.

According to the IPCC's 2007 report, in 2009- 10 average sea level will have risen by around 18 to 59 cm compared to 1890-1999. By 2050 the rise will be in the order of 10 to 20 cm. This rise does not take into account the probable acceleration of ice melt, which could add a further 10 to 20 cm. There is a lot of uncertainty surrounding these values, which could be exceeded (Meehl et al., 2007)[70].

[70] Meehl, G.A. et al., 2007. Global Climate Projections.

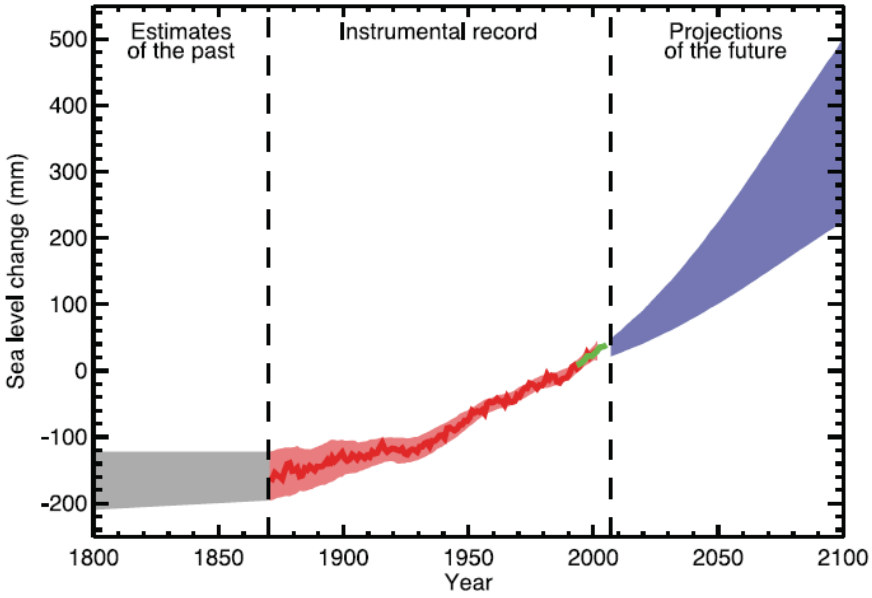

Figure 7: Past, present and future changes in average sea level compared to 2000 (IPCC, 2007

13.4. ALARMING CONCLUSIONS

The erosion and flooding (submersion) of coastal areas which largely contributes to the receding shoreline will be aggravated in the course of the 21st century following an increase in average sea level.

Africa is one of the regions in the world whose coastal zones and deltas are the most exposed to risks of flooding due to the rise in mean sea level (Nicholls and Tol, 2006[71]). This rise in sea level, combined with increased intensity or frequency of extreme events, will have serious consequences for the development of the coastal zone. Many coastal or island areas will be submerged or subject to increasingly frequent flooding causing considerable damage.

In West Africa, although this rise cannot be estimated accurately, a rise greater than the global average is expected. There could be dramatic consequences for several regions, such as around Nouakchott which is already below sea level. Major conurbations are greatly at risk. **The destructive effect of this rise in water level will lead to an increase in the frequency of storm surges and their destructive potential, in particular in river deltas.**

There will be more frequent intrusions of saline waters which will gradually make aquifers unfit for consumption and agriculture (the advancement of the salt-water wedge and alteration of freshwater lenses).

[71] Nicholls, R. and Tol, R., 2006. Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. **Philosophical Transactions A, 364(1841):** 1073.

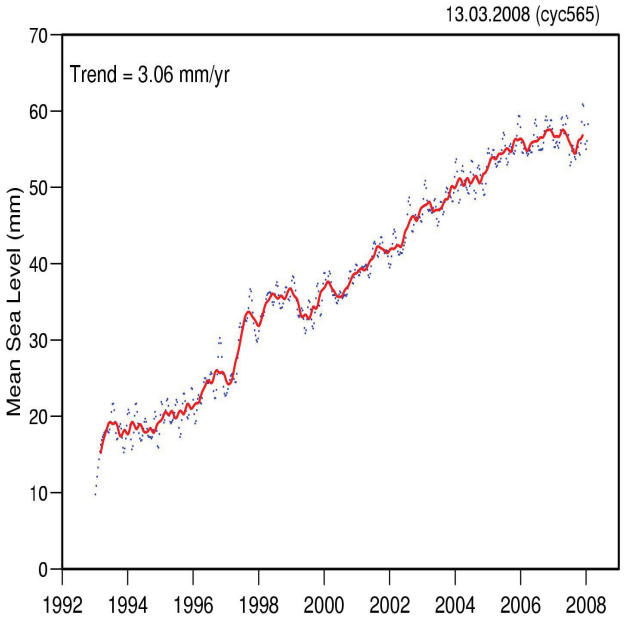

Figure 8. This graph shows the changes in mean sea level since 1993 according to Topex/Poseidon and Jason-1. The mean increase observed between January 2003 and end 2007 was 3.06 +/- 0.4 mm/yr. From this value should be subtracted post glacial rebound, estimated at -0.3 mm/yr), which leads to a rise in seal level of ~3.3 mm/yr for the last 15 years (Cazenave and Nerem, 2004, Ablain et al. in progress, 2008). Source: LEGOS/CNES/IRD/CNRS - http://www.legos.obs-mip.fr/fr/

Foreseeable consequences of the rise in sea level combined with storm surges

The consequences are extremely difficult to evaluate and should only be envisaged through a **detailed study of local situations**. There remains the hypothesis of a 1 metre rise in sea level would significantly aggravate coastal hazards. The most sensitive coasts are clearly low sandy coasts and mangroves, as well as coastal zones composed of sandstone or marno-limestone cliffs. The major lagoon systems will obviously also be affected. The lowest-lying sectors will be subject to increased erosion or temporary or permanent submersion.

Coastal systems are not in fact passive with regard to the rise in sea level, and there are numerous threshold effects (coasts adapt and react). For example in the case of submersion hazard, coastal plant formations can trap sediment, river flow rates can be modified by the variability of continental precipitations, lagoon or estuary outlet streams can be partially closed by the advance of sand spits, etc.

Any evaluation of the impacts of the rise in sea level should therefore remain cautious and avoid swinging into simplistic, reductionist or "mechanical" calculations or representations, in particular in the field of economics. The submersion hazard, when the stakes justify this, can only be properly considered through a local hydraulic approach.

Sandy coastline: Increasing erosion of sand systems is expected, aggravating the risks of submersion, in particular in type 3 units of the cartography given in document 3, causing the shoreline to recede as has already been observed. It would appear that the very special conditions for the application of Bruun's rule make it impossible to quantify the retreat in a realistic way[72]. A possible increase in storms and exceptional weather events should also have an impact on the plant systems of dunes, reducing their fixing action. This vegetation will also be disturbed by increased salination of the freshwater lenses and aquifers behind the dunes. Halophytic plants will be favoured. Over the long

[72] Bruun's equation does not take into account longshore transfers. Slott. J. 2003.- **Shoreline Response to Sea-Level Rise: Examining the Bruun Rule.** Nicholas School of the Environment and Earth Sciences Department of Earth and Ocean Sciences.

term, for sandy beaches, the erosion rate is considered to be double that of the rise in sea level[73]; 70% of sandy beaches in the world are being eroded.

Dune ridges and lidos: lidos and dune ridges will migrate inland, at least for the narrowest lidos. Certain lidos will become fragmented. A tracking programme should enable local identification of the lidos able to migrate and those likely to fragment.

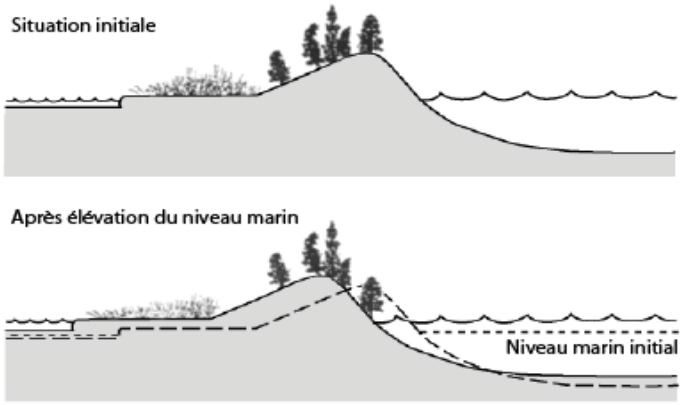

Figure 9. Manner of lido migration subsequent to a rise in sea level (according to Titus. J.G. 1990.- Greenhouse Effect, Sea Level Rise, and Barrier Islands: Case Study of Long Beach Island, New Jersey. **Coastal Management.** 18: 65-90.

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Lagoon systems: the hydrology of lagoons comprises exchanges with continental waters, but also with the sea. In addition, these are located at a height close to sea level. The ecology of lagoons is based on two main parameters: depth and salinity.

If the former is slightly modified (the migration of the lagoons, if this is possible, should conserve the initial depth gradient in most cases even if the depth of the lagoons increases slightly), salinity would be altered (i) following the rise in sea level; (ii) by the salinisation of aquifers; (iii) by a possible decrease in the freshwater supply consecutive to a reduction in rainfall and therefore in flood peaks. On the other hand, the tendencies for lagoons to fill in by terrigenous supply could be partially counteracted.

Closing of lagoon outlets: the closure or strangling of lagoon outlets due to the development of spits and local accretions lead to the eutrophication of the aquatic milieus concerned. The filling in of these outlets also implies flooding in periods of spate.

Other wetlands: different behaviour patterns are possible depending on each local situation:

- ⇒ The spontaneous receding of wetlands inland, made possible in certain cases by the topography and lack of obstacles. Tracking is possible, in particular on the basis of the analysis of the distribution of halophile plant communities.
- ⇒ The elevation due to high sediment supply (vertical accretion), in particular in delta systems, which can largely compensate for the rise in sea level.
- ⇒ Wetlands can gradually disappear by submersion.

[73] Zangh K. 2004.- Global warming and coastal erosion. **Climatic change. 64:** 41-58, 2004.

In every case, considerable changes should be anticipated in the composition of the flora and fauna of these ecosystems, which will depend on each local situation.

Conservation: the destruction of wetlands by submersion during exceptional events can cause irreparable damage to natural infrastructure systems[74] as was shown by the consequences of cyclone Katrina.

[74] Marris. E. 2005. The vanishing coast. **Nature.** 438. 908- 909p.