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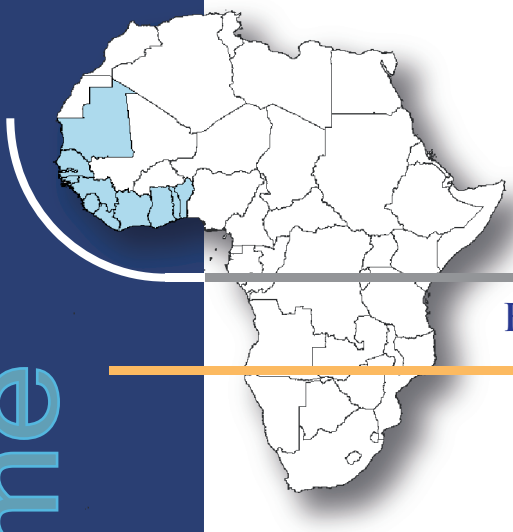
Management scheme



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

COASTAL MANAGEMENT SCHEME

UEMOA

IUCN

2010

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 Regional Programme to combat Coastal Erosion.

Overall coordination: Mathieu Ducrocq, IUCN, marine and coastal Programme Regional Coordinator for Central and West Africa:

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

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

"(…) several countries in the subregion who have coastal zones have already raised the alarm about the adverse effects saltwater intrusion and storm surges could have on infrastructure and coastal ecosystems if there is a rise in sea level. The loss of land at an elevation of 0.5 to 1 m above sea level would mainly affect the most useful areas, agricultural and/or the most populated areas. Generally, the largest cities, or those expanding the most rapidly, are located in low elevation lagoonal settings that are particularly exposed to the effects of a rise in sea level. Note that in certain cases the rise in sea level would in the long term flood rice fields, land and infrastructure causing the displacement of coastal populations; small streams, rivers and irrigation channels would be submerged; mangroves would be destroyed or displaced and there would be adverse effects on oyster farming…"

International Conference for the reduction of the vulnerability of natural social and economic systems in West Africa faced with climate change. August 2006.

Preface by the UEMOA Commission

Preface by the Regional Director of IUCN for Western and Central Africa.

NOMENCLATURE OF DOCUMENTS RELATIVE TO THE MANAGEMENT SCHEME

DOCUMENTS

	SUMMARY FOR DECISION-MAKERS
Document 1	**COASTAL AREA MANAGEMENT SCHEME**
Document 2	**COASTAL AREA MANAGEMENT SCHEME: REQUIREMENTS BY SECTOR**
Document 3	**NOTICES AND TYPOLOGIES RELATIVES TO THE CARTOGRAPHY**
Document 4	**REGIONAL DIAGNOSTIC AND ANNEXES**
Documents 5	**NATIONAL DIAGNOSTICS (5 A to 5 K)**
Documents 6	**CASE STUDIES**

CARTOGRAPHY DOCUMENTS

The mapping of the management scheme: 9 sheets at 1:500,000

Cartography for geodynamic analysis - sensitivity of the coastal area to coastal erosion: 9 sheets at 1:500,000

Cartography of the stakes and human land use on the West African coastal area: 9 sheets at 1:500,000

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
FGEF	French Global Environment Facility
FIBA	International Banc d'Arguin Foundation
GCCA	Global Climate Change Alliance (European Union)
GCLME	Guinea Current Large Marine Ecosystem
GEF	Global Environment Facility
GFDRR	Global Fund for Disaster Reconstruction and Risk Reduction
GHG	Greenhouse gas
IUCN	International Union for the Conservation of Nature
MEA	Multilateral Environmental Agreements
MPA	Marine Protected Area
OMVG	Gambia River Basin Development Organization
OMVS	Senegal River Basin Development Organization
PDALM	Mauritania Coastal Development Plan
PRCLEC	Regional Coastal Erosion Control Programme (UEMOA)
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
WA	West Africa
WALTPS	West Africa Long-Term Perspective Study
WCPA	World Commission on Protected Areas

TABLE OF CONTENTS

This management scheme is a response to the observations made through an extended diagnostic study of the situation of the coastal areas of West Africa and a detailed analysis of the stakes for the human population along this coast. The diagnostic study includes a prospective dimension, based on careful thought about the demo-economic changes expected between now and 2050, combined with a review of the available climate forecasts. The results are presented in the summary diagnostic studies attached to the management scheme (document 4) and through the mapping information presented in document 3.

The general body of the management scheme is completed by a systematic review of the 179 coastal sectors identified, which is presented in document 2.

The shoreline monitoring programme is an integral part of the proposed management scheme, of which it is the second section or direction/programme.

All of the strategic directions and recommendations originating from the study constitute a platform for **West African coastal societies' "no regret adaptation"[2] to the effects of climate change,** and most of the recommended programmes and actions should be eligible for specialist funding that is already operational or currently being set up (the World Bank's GFDRR, Adjustment Fund, ClimDev Africa, GEF, the European Commission's GCCA, etc.).

Annex 1 of this report provides a short glossary of the terms and concepts related to coastal development.

[2] *No regret adaptation:* Actions that make sense in development terms, whether or not a specific climate threat actually materializes in the future.

1. STRATEGIC DIRECTIONS

Acting on all scales

All the elements of diagnostics emerging from the study show the full importance of seeking the **relevant scales** for approaching the management and reduction of coastal risks. These scales are obviously local and national, but also and especially **regional** and in any case inter-state, given that:

⇒ The transport and distribution of sediment is largely controlled by a coastal drift current that ignores national boundaries. Manmade infrastructure influences (i) this coastal drift; (ii) the sediment loads transported.

⇒ The supply of mobilisable sediment to the coast is closely dependent on deepwater structures on the scale of the catchment areas, typically controlled and undertaken at national level, which warrant regional level coordination if their impact extends beyond national borders.

Management of coastal risks should therefore be approached at different scales:

⇒ **Individual:** Behaviours and individual responsibility with respect to risks.

⇒ **Collective:** organisation of coastal players on a given sector of coast.

⇒ **Territorial:** the responsibility and the role of territorial entities will evolve and develop within the framework of decentralisation. Solidarity and reciprocity between adjacent and/or neighbouring territories must be taken into account, as well as the way State powers and prerogatives relate to those of the local authorities.

⇒ **National:** In relation to the sovereign functions of States and their capacity to (i) rally the requisite technical and scientific resources for the monitoring and development of the coastal areas (ii) schedule operations that have a structural impact on land-use planning.

⇒ **Regional:** on the basis of the recognition of solidarity and reciprocal actions among States in the management of a common, shared sediment legacy.

Arbitration of priorities for action should comply with the principle of subsidiarity, conferring the responsibility to act on the smallest competent scale, but the actions conducted at different scales must be complementary and consistent as a necessary condition for their success. Individual coastal protection initiatives must be coordinated. When justified, the protection of the coast should be considered on a scale consistent with the sediment cells[3].

From anticipation to action

An analysis of the risk situations currently experienced in West Africa shows that **they are largely due to the fact that in the past, coastal risks have not been taken into account** for the location and configuration of human developments and settlements. The natural dynamics of geomorphological formations that are normally mobile has not really been taken into consideration, leading to a situation where most of the problems identified have been aggravated, or even caused, by the negligent exposure of the establishments under threat today. The same is unfortunately often true when trying to remedy the observed problems.

[3] **Coastal sediment cell:** EUROSION defines a coastal sediment cell as "a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks". The cell boundaries delineate the geographical area within which the budget of sediment is determined, providing the framework for the quantitative analysis of coastal erosion and accretion. In this respect, coastal sediment cells constitute the most appropriate units for achieving the objective of favourable sediment status and hence coastal resilience. In practical and management terms, the coastal sediment cell sits within a sedimentary framework composed of three geographical zones: the catchment, the shoreline and the nearshore marine environment".

At every scale, development decisions are often made "back to the wall", in urgency and under the pressure of events. They do not typically aim to treat the causes that led to the observed situation, but rather their consequences.

The inertia characteristic of all coastal development and/or protection decisions means that these are typically made and implemented too late to be really effective. The way the developments are designed may also be inadequate due to (i) acquired experience not being taken into consideration; (ii) coastal dynamics beyond the local scale not being taken into consideration; (iii) under-estimation of growing impacts due to intensification of the force of morphogenic agent (wind, swell, waves, currents, etc.).

The expected densification of the population of the West African coastal area (see demo-economic forecast included in the diagnostic study), and the multiplication of human settlements and stakes along the coast, which provides fragile support for the development of the sub-region, **should lead to the systematic adoption of an anticipatory reflex based on a prospective, dynamic reading of the present day situations**.

Adjust governance to the specific features of coastal territories

The littoral zone is a specific geographic entity, which requires suitable improvement and development policies. This special area is characterised by:

⇒ A diversity of uses, often competing for land use, which must be either subject to arbitration or at least coordination and harmonisation.

⇒ The diversity of players and interest groups concerned.

⇒ The dynamic, changing nature of natural milieus (physical and biological), which host and support human livelihoods and land use.

Balanced, effective governance of littoral zones cannot be conceived on a sector-wide basis only, but should draw on a crosswise approach enabling all of the sectors and players concerned to promote and reconcile their often divergent or contradictory or competing interests.

The dynamics that characterise changes in the littoral interface implies the setting up of dialogue and consensus building mechanisms enabling **adaptable management** of the footprint of human land use on the shoreline. Integrated coastal zone management approaches can provide a response to this concern, but to be implemented they require suitable consensus building bodies and clarification of individual roles and responsibilities.

Focus development inland of the coast

The diagnostic study showed that road developments, but also services and facilities (water, electricity, street services, etc.) exert a strong attraction on human settlement. The urban or territorial development schemes **should systematically take into account the specific nature of coastal areas** and direct the development or urban and industrial concentrations as far as possible towards secure areas inland of the coastal systems.

When this option does not meet development objectives, the preservation of green buffer zones which often consist of wetlands that render various ecological services, including the protection of the shoreline, should in any case be taken into consideration.

Reinstate the notion of public maritime domain

Today, given the expected climate changes, the protection of the public maritime domain is of key importance for the coastal countries. It is also a question that concerns democratic governance and anticipation of population needs, particularly the needs of urban population, regarding the satisfaction of the demand for coastal space which will grow in Africa, particularly in urban areas, as in the rest of the world. The public maritime domain is also a land planning notion that is easier to grasp than the vague, extended notion of littoral zone (see annex 1).

The clarification of land ownership rights remains a critical issue in coastal sectors that are subjected to increasing human land use pressure. Like the efforts sometimes deployed in rural and agricultural development, dealing with land ownership questions in relation to coastal development is now firmly on the agenda. The legal pluralism which often prevails in terms of land entitlement in areas near the sea makes land planning difficult. Regaining control of land ownership in these areas should be given priority, which would also help to reinstate the public nature of the maritime domain adjacent to areas that are occupied and have been built on. It will also be important to clarify land entitlement situations relative to certain natural transition areas (mangroves, estuarine and lagoonal areas, wetlands in the coastal hinterland) which are subjected to increasing pressure, in particular in the periphery of the agglomerations.

Enforce a relevant legal and regulatory framework on coastal development.

Not all States have coastal legislation, and for those who do have it, the implementing provisions are often missing. We also note that existing urban development regulations accord little place to the specific nature of land close to the sea. The urgency of the situations observed, and the importance of the coastal legacy to be preserved, should act as an incentive to frame the process of development and human use of this much prized land.

The implementation of the corresponding legislative efforts, relayed and accompanied by a wide consensus-building, informative and explanatory approach targeted at the stakeholders (public, technical services, economic operators and corporations) should be a priority. These efforts should be steered within an inter-sector framework that respects the diversity of the publics concerned by these regulatory provisions.

Legislation on environmental impact studies should also be reviewed to better integrate the specific features of coastal development and take impacts into account, **including impacts at some remove from the developed site in terms of time and space.**

Compliance with these legal and regulatory frameworks is obviously a second challenge that pertains to state sovereignty, but for which an accompaniment, information and consensus building are effective relays.

Natural infrastructure at the service of coastal defence

Natural, functional infrastructure is still largely present on the West African coastal areas, for which they provide natural protection. These may be mangroves, multiple vegetation formations in lagoonal and estuary areas, seabed plants, the natural vegetation of rims and dune systems, etc.

Given the moderate cost of this option, and in the absence of major stakes immediately under threat, the preservation of this green "infrastructure" should be considered systematically as a priority and key issue today, in order to maintain or increase coastal resilience on significant areas. This approach corresponds to the notion of adjustment to climate change based on the ecosystems. The conservation of these sensitive zones also contributes to the sustainability of numerous vital economic activities, such as fishing. In these coastal contexts, the conservation of nature is therefore an integral part of land use planning.

2. GENERAL REQUIREMENTS FOR DEVELOPING COASTAL AREAS.

Independently of specific, local situations, **these general requirements are intended to be internalised and applied by the coastal States at different levels and scales of sector-wide and national governance.**

2.1. PRINCIPLES OF COASTAL DEVELOPMENT

In the field of coastal development, reducing the risks related to coastal erosion is achieved by alternate, complementary or combined approaches. These approaches draw on one or more of the following principles:

⇒ **Reduce exposure to contingencies:** the (re)location of developed areas and of the corresponding human stakes (buildings, infrastructure, services, production zones, etc.) further away from (i) the coastal area; (ii) wetlands behind the littoral zone; (iii) low-lying fluvial valleys subject to seasonal spates of rain is a simple way of reducing the risks associated with coastal contingencies. This recommendation implies regaining control of a certain level of land entitlement.

⇒ **Protect and preserve the natural morphological and plant formations on the littoral zone and their spontaneous dynamics,** in order to safeguard their capacity to adapt to intermittent variations and trends in sea level and their function as part of sediment dynamics (storage, remobilisation).

⇒ **Develop with a view to protecting the segments of coast with critical stakes, which cannot be displaced.** Interventions in terms of improvement/development can take different forms depending on the local situation and the degree of artificialisation caused by these interventions. It is imperative that these interventions be subject to feasibility studies and analyses of impacts from a wider, national perspective, including, at times, a sub-regional scale. The expression coastal defence may be used. A review of the main development provisions is given in annex 3. Coastal defence actions can sometimes be considered temporary solutions that allow time to move the installations further inland.

⇒ **Take into account in an integrated way marine contingencies and contingencies related to continental waters** (rivers, high rainfall), considering that these are closely linked, or even interdependent in determining the risk of flooding/submersion of low-lying areas, and even of coastal erosion in different configurations (estuaries, cliffs of altered and fractured rock, etc.). The different provisions aimed at preventing the risk of submersion from rivers or continental waters (the creation of high water expansion zones for example) also contribute to reducing coastal risks.

⇒ **Make land use planning encompass the different manifestations of coastal dynamics.** Erosion is certainly the most preoccupying manifestation, but the phases of accretion also engender impacts (filling in of lagoon mouths, and increasing organic pollution, deterioration of mangrove stands, siltation of wastewater evacuation, etc.).

In every case, the chosen solutions must be included in **a global, extended approach to the improvement of the coastal area,** based on an understanding of the causes of the phenomena observed and the taking into account of the general requirements listed below.

2.2. OVERALL ORGANISATION OF THE COASTAL AREA

The overall organisation of the coastal area should aim, as far as possible, **to provide for free areas that are not artificialised between the shoreline and human settlements,** and between the "interior littoral zone" (wetlands, lagoons) and human settlements. This "buffer" area should allow coastal formations to evolve naturally, **in particular their migration and progressive adjustment to the rise in sea level.**

⇒ **Activities requiring the proximity of the sea:** move to a good distance from heavy installations. Where necessary, implementation of infrastructure that has the least possible effect on shoreline mobility (wharf, stilts).

⇒ **Assignment of littoral areas:** reserve exclusive occupation zones for a given use, to reduce conflicts over the use of coastal land. In multifunctional areas (the majority of cases), consensual establishment of rules for usage and occupation with a view to avoiding conflicts.

⇒ **Anticipation of the assignment of coastal areas:** plan, whenever possible, the securing of land reserves exclusively for future use (activity zones), depending on foreseeable economic developments, which will probably be considerable in the coastal areas of West Africa.

⇒ **Road infrastructure:** Plan road infrastructure far back from the coast and give preference to secondary branch roads serving the coast to favour circumscribed and localised development of activity centres, rather than an axial development of settlements along the road routes and the coast, a precursor to conurbation. In rugged topographies, give preference to networks on crests.

Developing a strategic retreat: the expected advance of the shoreline, which will vary according to the site, should lead us to envisage, each time this is possible, **redrawing the contours of a future coastline**, arranging a natural "buffer" space between shore and issues at stake. The width of this zone should be calculated depending on different elements:

⇒ The thickness should not only depend on the concern for the safety of people and goods, but also on the dynamics specific to coastal ecosystems. The areas necessary for pushing back wetlands or lagoons will often be at least as important as in the case of dune formations. It is therefore a question of **arranging the space necessary for the spontaneous adapting of natural coastal systems** preserving the way they operate and the ecological services they offer.

⇒ One question that is essential concerns the preservation of wetlands, both for the ecological services they offer, but also for the resources, in particular the fishing resources they provide.

In this respect, **conservation actions are justified anew, by helping to maintain these complex systems in an operational state** and therefore preserve their capacity to adapt to change, which is also related to the diversity and complexity of the mosaic of wetlands. In accordance with this objective, the prevention of the fragmentation of wetland systems is also important and should be taken into account not only in coastal defence actions, but also when developing the use of land.

The justification of arranged retreat should be supported by an analysis of the costs-benefits incorporating the ecological services rendered by wetland areas.

2.2.1. PROTECT GREEN INFRASTRUCTURE (MANGROVES, COASTAL FOREST, DUNE VEGETATION, LAGOONS AND COASTAL SWAMPS, WATER PLANTS)

Green infrastructure (mangroves, plant communities in wetlands and on the banks of lagoons, aquatic plants, stabilising plants on dune systems) must be preserved (i) for the ecological services rendered, essential in a context of densification of human land use; (ii) complementary to the networks of protected areas, as they contribute to their connectivity; (iii) because they make it possible to "freeze" the sensitive areas in which human land use generates risks. These biological communities also fix significant quantities of carbon[4].

[4] IUCN. 2010.-Natural coastal carbon sinks. Briefing Paper. IUCN - WCPA.

This requirement is all the more valid for new developments, where it is possible to decide on the location. In some cases, developments should also strengthen the ecological services rendered by these natural milieus: Hydraulic structures for the purpose of creating floodable spate expansion zones for example, cleaning out of channels and rehabilitation of banks, development of lagoon mouths, etc. The natural formations can also be restored (reforestation of mangroves, refilling of beaches for example). Particular attention will be given to:

⇒ **All the elements that structure the shoreline:** Sediment reserves constituted by the rims and dune systems, submerged groynes constituted by shallows, natural groynes constituted by headlands, hydraulic groynes observed at the mouths of water courses, etc.

⇒ **The biological communities** likely to regulate and influence erosive phenomena**:** influence of the mangroves on the force of the waves, influence on the siltation of underwater sea grass beds, natural vegetation of the lagoons and banks of the lagoons, which provide different ecological services to the population on the banks (purification and filtering of waters, peak limiting of river spates), the other wetlands in the hinterland play a similar role.

In all the situations, the preservation or even defence of the natural coastal formations should therefore be given precedence.

Unused areas should also be planned inland of these formations, in particular in the case of lagoons, to enable migration depending on sea level or other contingencies such as an increase in the flood flows of continental waters in the rainy season.

When the preservation measures, or even restoration of the natural coastal systems concern land that is already used, and in any case where this solution is reasonably feasible in economic and social terms, the planned withdrawal and re-installation of human settlements at a distance from the shore and from the natural formations of the coastal system constitutes a solution to be sought out.

Preserving the integrity and the functioning of natural systems is achieved through various provisions that are organisational, occasionally legal and regulatory, such as the control of material extraction, to be combined with support measures (search for alternative deposits, economic incentives).

In concrete terms, preserving natural infrastructures entails:

⇒ Preserving continuity and connectivity and avoiding the fragmentation of natural areas and green gaps in urban and interurban areas.

⇒ In the urban expansion zones (housing estates, industrial zones, etc.), on the basis of prior inventories (sites of protected species of flora and fauna), define and preserve areas of ecological value and their connection with the adjacent natural and agricultural areas.

⇒ Create defences for the natural vegetation on dune systems with less than 1,000 mm annual rainfall, preserve natural vegetation behind beaches, which plays the role of forerunner to the dunes.

⇒ Generally apply the principles of the ecosystems approach.

2.2.2. PRESERVE THE LANDSCAPE APPEAL OF COASTAL SITES

⇒ Systematically identify remarkable sites to be listed among the protected natural and landscape heritage sites.

⇒ Provide integral protection for points and headlands (in particular in relation to the extraction of rocky materials), but also preservation of urban land and building sprawl on hillsides to conserve the landscape heritage and site aesthetics, an important future resource for the coastal States.

⇒ Urbanisation along crests to be avoided in order to preserve the landscape heritage.

2.2.3. PUBLIC ACCESS TO NATURAL RESOURCES AND LANDSCAPES OF THE COASTAL AREA AND THE SEA

⇒ Preservation of visual cones and clear views from public roads and areas, in particular by avoiding the development of lines of hotels and walled residential homes, which also contribute to the privatisation of beaches and landscapes.

⇒ Preserve free access for the public to beaches and creeks, by banning the privatisation of the coast.

⇒ Improve access and traffic movements in the approaches to busy urban beaches.

⇒ Provide for grant of easement for access to the coast in the seafront development schemes in urban and perirurban areas. Seafront developments and/or improvements on littoral zones with dunes should respect the following sequence: beach/backbeach/dune with passages-bridges built (on stilts)/wide area for pedestrians/roads-tracks/buildings, avoiding all building on the dune rim itself.

2.2.4. INTEGRATION OF MARINE LIVELIHOODS AND RELATION OF RISK PREVENTION TO COASTAL DEVELOPMENT

Various trends contribute to the gradual intensification of human activities in coastal seas. The main trends among these are due to:

⇒ Increasing demand for hydrocarbons, which leads to the implementation of infrastructure for offshore oil prospecting and extraction. This trend will, in the long term, concern all the West African coasts, but at the moment it is mainly developed in Mauritania, Côte d'Ivoire and Ghana.

⇒ Intensification of merchant navy traffic, with the increase in size of ships offset in the long term by trans-shipments and intra-regional links which will lead to an intensification of coastal traffic. .

⇒ Industrial fishing and changes in the strategies of nomadic artisan fishing, with an increase in the radius of action of artisan fishermen.

These trends highlight the necessity of **more effective organisation of coastal sea areas** (maritime spatial planning) with a view to limiting conflicts over the use of maritime areas, which create the risk of accidents and the associated pollutions, the spillage of hydrocarbons in particular. Setting up marine protected areas and controlling access to fishing resources, as well as other regulations (trawling in shallow waters particularly, which is highly destructive for sea grass beds which play a decisive role in fixing sediment) are part of this strategic direction.

The systematic drawing up of preventive POLMAR plans also contributes to identifying sensitive areas of the littoral zone and therefore to planning.

2.2.5. TERRITORIAL INTEGRATION OF CONSERVATION

Few protected areas have really played a structural role in territorial organisation, apart from three cases: (i) when they constitute the main engine for local economic development; (ii) when they have led to agreed approaches that are acted upon to control the pressure on resources; ((iii) when they have enabled the introduction of consensus-building around conflictual transborder issues.

Their management often remains very self-centred and not very open to the development processes and dynamics that typify the territories they lie within. On a political and institutional level, there has long been an evident divorce between conservation actions and development and poverty reduction strategies. Reconciliation approaches are in preparation, as witnessed by the Libreville Consensus which emerged from the Pan African Conference on Biodiversity and Poverty Eradication (12-17 September 2010, Gabon).

While this situation is improving, it is up to the national and local authorities and those in charge of conservation to seek better integration of protected areas in land planning, in particular in coastal land planning; considering that marine and coastal protected areas cannot under any circumstances be isolated from their geographic context.

The sustainability of protected ecosystems remains closely dependent on the maintaining, within more extensive rural and coastal areas, of a mosaic of functional, preserved natural milieus. A concept of strings or bunches of marine protected areas may correspond to the particular distribution of wetland networks in coastal areas. Management of such rich and diverse areas in accordance with the gradual protection statuses, from natural areas simply preserved within coastal lands to real protected areas managed to achieve a conservation goal, should involve all the players: Population groups, territorial authorities, but also economic players, at the service of maintaining a **natural capital** to ensure the sustainability of their activities. The multiple ecological services these mosaics of natural areas provide also contribute to the security of goods and people. Lastly, what is often preserved in this way are strategic sediment reserves.

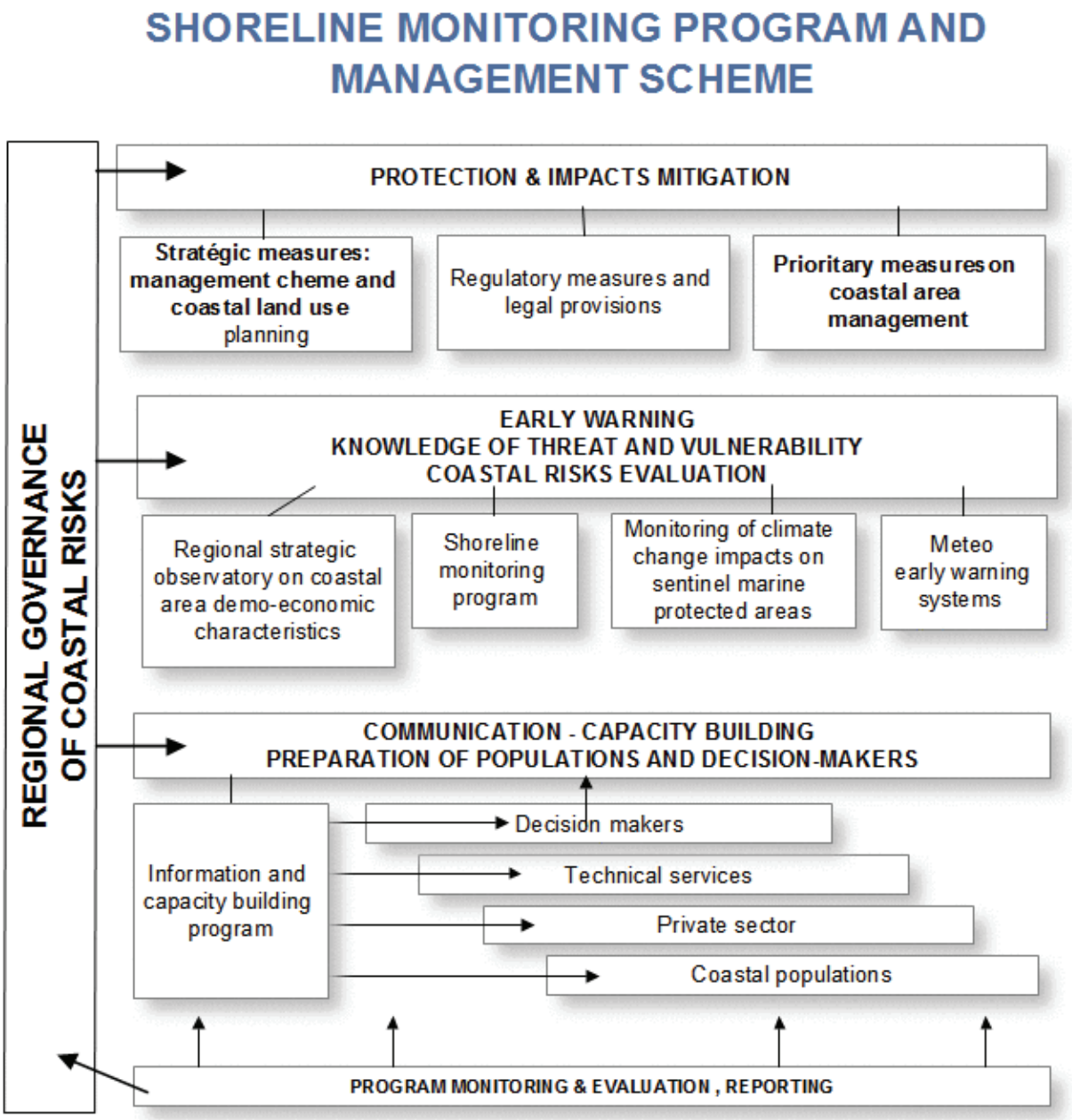
3. THREE PILLARS FOR A REGIONAL RESPONSE IN TERMS OF REDUCING COASTAL RISKS

While the main concerns regarding the effects of coastal erosion fully justify a specific study on the subject, the regional response in terms of combating coastal erosion should be part of a **wider framework of a regional policy aimed at the global security of the coastal population and land areas**.

The very concrete nature of the risks related to coastal erosion, which are already perceptible to the population and the political authorities, should act as an incentive to initiate integrated risk management and risk reduction operations in other domains, while at the same time building the capacities of specialist bodies, including the e national platforms implemented within the framework of the ISDR[5].

An effective regional response for the reduction of coastal risks should be based on the three pillars or operational directions/programmes presented below, which complete and mutually reinforce each other. The consistency between these three pillars should be assured by **regional coastal risk governance mechanisms** connecting the different levels of intervention.

[5] International Strategy for Disaster Reduction.



Organisation of the regional coastal erosion programme

The objectives of the three directions - programmes are presented below:

	Direction/Programme	Goal
1	**PROTECTION AND ATTENUATION OF IMPACTS**	**Increase the resistance and resilience of the littoral areas occupied by people and human facilities, with a view to reducing the vulnerability and exposure of the population groups and human settlements in the littoral zone.**
2	**WATCHKEEPING AND VIGILANCE**	**Identify and detect with anticipation the situations that engender risks.**
3	**PREPARATION AND CAPACITY BUILDING**	**Increase coordinated individual, collective and institutional capacities to respond to coastal risks.**
Crosswise direction: Regional governance of coastal risks		

These three programmes are also consistent with the priorities of the Hyogo Framework for Action for risk reduction, which are re-stated below as a reminder:

	Priority	Programme
1	Make disaster risk reduction a priority	**Regional governance of coastal risks (crosswise direction)**
2	Identify the risks and take action	**Watchkeeping and vigilance programme (direction-programme 2)**
3	Instil comprehension and awareness of risks	**Information and capacity building programme (direction-programme 3)**
4	Make preparations and be ready to act	
5	Reduce risks	**Protection and attenuation of impacts (direction-programme 1)**

These three directions/programmes must be brought together and facilitated through **regional provisions for the governance of coastal risks**, with a roadmap or regional strategy to be built on the basis of the recommendations (i) of the UEMAO – UICN study on shoreline monitoring in West Africa; (ii) existing regional and national strategies,

3.1. REGIONAL GOVERNANCE OF COASTAL RISKS

Consolidate the regional organisation process engaged by UEMOA

The added value of a regional approach to coastal risk management is obvious, given that most of the problem issues and risks facing the coastal States are effectively shared. The circulation of sediment stocks is oblivious to national borders, as are the impacts of coastal developments (ports for example) or inland developments (river dams). Certain works and infrastructure that have an impact on the littoral zone are designed on an inter-State scale. Management of coastal risks is therefore achieved in the first instance by the **recognition of regional solidarities and reciprocities** in terms of coastal planning.

A regional approach should also make possible the connection or even formal networking of players who face similar sets of problem issues, irrespective of their location, by encouraging **the sharing of knowledge, experience and solutions and know-how**.

The purpose of this regional effort is to complete, optimise and valorise local and national efforts which remain in the "frontline" in compliance with the principle of subsidiarity.

The Regional Steering Committee of UEMOA's Regional Programme to combat coastal erosion (PRLEC) is a relevant regional entity capable of **federating and networking national efforts and capacities**. This committee should make sure the other existing bodies are kept informed or even try to involve them: Permanent Secretariat of the Gulf of Guinea Large Marine Ecosystem, the Canaries Current Large Marine Ecosystem project, the Abidjan Convention, ECOWAS. Other regional initiatives may also play a key role in capacity building and relaying messages, such as PRCM, which covers 7 countries in West Africa.

In the long term, recently created inter-sector bodies, such as the national disaster prevention platforms, should be consolidated. If they are integrated into a regional network (as part of the risk reduction strategy in West Africa, in the same way as the European platforms) this should relay and consolidate this regional governance.

The **validation of a platform of recommendations on a regional scale**, relative to coastal risk management, could also be subject to the implementation of an **additional protocol to the Abidjan Convention** or a **West African Coastal Areas Charter** using, on a wider geographic scale, principal directions of he coastal improvements drawn up within the framework of UEMOA's PRLEC. The drafting and negotiation of such a Protocol or Charter constitutes a relevant undertaking for the Abidjan Convention, in application of article 10, as part of the framework of its current revitalisation approach.

In the pilot phase of the shoreline monitoring programme, **the UEMOA steering committee would therefore constitute the steering committee of the shoreline monitoring programme**, with the aim of simultaneously ensuring, jointly with the secretariat of the Abidjan Convention, the writing of an additional protocol to the Abidjan Convention that ahs the weight of a regional strategy. This steering committee could be extended to include a representative of NEPAD, ECOWAS, the permanent secretariat of the GCLME and in the near future the CCLME (the opportunity should be examined).

3.2. COASTAL PROTECTION AND RISK REDUCTION DIRECTION/PROGRAMME.

Goal: **Increase the resistance and resilience of the littoral areas occupied by people and human facilities, with a view to reducing the vulnerability and exposure of the population groups and human settlements in the littoral zone.**

In the first instance, it is through the internalisation of the orientations recommended by the study at their level (policies, strategies, practices of the technical services, legislative amendments, improvement directives and sector schemes, etc.), that the partner States will contribute to implementing this programme.

3.2.1. SPATIAL PLANNING AND COASTAL DEVELOPMENT

A central tool for supervising coastal development is **the sector scheme,** containing the planning and land use options in a given portion of the coast. This tool may correspond to different instruments already existing in each of the States, for example, the DAL (coastal development directive) in Mauritania. In any case, rules and/or directions should be established (whether enforceable or not) for coastal development, by setting (i) in a cooperative way, with the intervention of all the sectors concerned, and (ii) on the basis of a detailed study:

⇒ **Zoning of the coastal area** under consideration, based on arbitration that respects the risks, with and indication of the functional or multifunctional vocation (habitat, industry, harbour areas, nature reserve, etc.) and the degree to which the different zones are buildable.

⇒ **Normative prescriptions** (concerning hydraulic, sanitary, wastewater collection and management facilities and any shoreline defence installations, etc.).

⇒ **A traffic flow and improvement plan for public spaces**.

⇒ **A plan for the preservation and defence of natural infrastructure and breaks in urbanisation (preservation of the ecological services mentioned above and of the landscape identity of the sites).**

⇒ **Clarification of the responsibilities and prerogatives** of the different categories of local players, and the and ownership status of the areas concerned.

While this anticipation of spatial planning does not yet seem to be on the agenda of a number of African states, the expected economic growth should, as in countries with intermediate revenue, lead to urban renovation operations. These will be an opportunity to apply the fundamental rules of sustainable coastal development. However, the stakes and the risks observed sometimes advocate for quick decisions, to be taken before this type of process, if they are only expected to be set in motion in the medium term.

3.2.2. ARTIFICIALISATION OF THE SHORE – COASTAL DEFENCE

Whatever the materials and solutions employed (gabions, tetrapods, ballast, concrete armouring, groynes, breakwaters, etc.), this may comprise:

⇒ Establishing a fixed shoreline that is resistant to the energy of the waves and the sea.

⇒ Reducing sediment transport energy in places, in order to increase deposits or simply decreasing the energy of the erosion-generating agents.

⇒ Re-establishing the local sediment budget by supply of sediment.

The high cost of these solutions and **their very generally negative long term impacts** (there are numerous cases throughout West Africa and elsewhere where such developments have been completely counter-productive), the choice of solutions for the artificialisation of the sea front should only concern zones where the stakes are particularly high, and should systematically require at least three dispositions:

⇨ An impact study to be conducted not only on the site and its close surroundings, but taking into account **the remote impacts of the development depending on the coastal drift, preferably within the framework of the operation of the local sediment cell[6], including beyond the borders of the country concerned, where necessary.**

⇨ A cost-advantages or multiple criteria analysis justifying the investment.

⇨ The implementation of a mechanisms for **monitoring the effectiveness of the developments over time** (see watch-keeping and vigilance direction/programme) intended to enhance feedback from the experience.

These solutions should only be implemented in accordance with arbitration concerning the nature and importance of the stakes on the sector of coast to be preserved and the determination of a reference line for the coast to be maintained. This arbitration, and the acceptance of the costs corresponding to the developments imply **a clear definition of the vocation of the area under consideration**. In certain cases, these solutions could be employed temporarily in order to gain the time required for implementing more radical solutions such as planned retreat.

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[6] **Coastal sediment cell:** EUROSION defines a coastal sediment cell as "a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks". The cell boundaries delineate the geographical area within which the budget of sediment is determined, providing the framework for the quantitative analysis of coastal erosion and accretion. In this respect, coastal sediment cells constitute the most appropriate units for achieving the objective of favourable sediment status and hence coastal resilience. In practical and management terms, the coastal sediment cell sits within a sedimentary framework composed of three geographical zones: the catchment, the shoreline and the nearshore marine environment".

On practically all of the coastal area studied, it may be considered that any heavy infrastructure built on the shoreline will create, in the more or less long term (depending on the characteristics of the sites and the design of the structures) new needs in terms of artificialisation and shoreline defence. This remark should obviously lead to specialising the sectors that have heavy installations and concentrating them in order to avoid the multiplication of the developments required in the future.

When the stakes justify this, and the impacts, in particular ecological, are controlled and acceptable, solutions for "counter-attacking" by rock fill sometimes last longer than coastal defence by anti-erosion mechanisms only.

A review of the different solutions for the artificialisation of the shoreline is given in annex 3.

The list of priority coastal sectors where developments could be considered is given in annex 3. This list should not be considered, however, as exhaustive, especially in the long term, with regard to the way the situation may change very quickly on the ground.

3.2.3. ACCOMPANYING MEASURES

Inventory of strategic sediment reserves

For each state, it would be useful to have **an inventory of the strategic sediment reserves** that can be used as an alternative to the extraction of coastal materials and for the possible restoration of coastal systems, including the future refilling of certain beaches. These strategic sediment reserves are frequently inside marine protected areas.

Updating of standards and transfer of risks

A study should be conducted under the aegis of the regional steering committee to draw up concrete proposals in terms of **updating standards** of urbanism, hydraulics, construction, civil engineering and coastal engineering, in order to adapt them to the possible intensification of certain risks (of storm surges, flooding and submersion). This updating of standards should involve the insurance companies, for a discussion should also be engaged on the **systems of risk transfer** related to investments in coastal areas.

The States are encouraged to identify the benchmark events enabling the updating of centennial levels, in particular for river spates in proximity to urban areas.

Impact studies and strategic environmental evaluations

Impact studies should be a systematic requisite for significant developments in the coastal zone, with the remote effects of such developments explicitly taken into consideration, including effects that go beyond national borders. The role of the members of the regional scientific committee set up by UEMOA, assisted, where necessary, by the regional and international resources from a pool of expertise, could include the validation of these impact studies for access to direct and indirect funding from PRLEC.

Any impact study that concerns structural work with potential transborder impacts should include communication and cooperation with the institutions in charge of the coastal development issues in the neighbouring countries who are directly concerned.

The strategic environmental evaluation could be used for major projects, such as the building of a large new harbour, like the one planned in Guinea for the evacuation of mining production. In this particular case, the impact study would only give a partial view of the implications and direct and indirect effects of such large-scale projects.

3.2.4. IMPLEMENTATION OF PROTECTIVE MEASURES.

To be eligible, funding applications for implementing coastal defences should comply with this planning mode, and take into account the different criteria ensuring the effectiveness and sustainability of the developments, including, in particular:

⇒ The consistency of the protective measures on a given segment of coast, and the inclusion of impacts on the surrounding sectors, at least at the scale of the sediment cell the sector is a part of.

⇒ Accompanying measures (land ownership statuses, land use plan, regulation of certain livelihood activities or uses of land that would threaten the balance of the coastal system).

⇒ Measures to monitor the developments carried out and the communication of information relative to the development initiative to the West African Regional Coastal Observatory mentioned below.

3.3. WATCHKEEPING AND VIGILANCE DIRECTION/PROGRAMME

Goal: **Identify and detect with anticipation the situations that engender risks. (Shoreline monitoring programme)**

The aim of this direction/programme is to produce reliable information for all levels of decision-making (from individual to regional). This information should make it possible to anticipate situations that generate risks, and adjust the responses implemented. This is therefore support for decision-making. The anticipation of risk situations is envisaged on several time scales:

Long term	**Strategic forecast monitoring** of population settlement and growth in the coastal areas of West Africa. Monitoring and anticipation of climate change.
Medium term	**Anticipatory monitoring** of changes in the shoreline and of the stakes related to land use and human livelihoods. This monitoring should also be accompanied by the monitoring of coastal developments based on experience feedback. Monitoring of sentinel marine protected areas in order to grasp the progression of the rise in sea level and the impacts on the natural coastal milieus.
Short term	**Weather forecasting and early warning** of extreme weather events and contingencies that generate risks. Feedback operations after extreme events or disasters.

⇒ In any case, the aim of monitoring, **anticipatory monitoring or forecast monitoring** is to **improve the capacity to anticipate and detect risk situations from weak signals**. This implies that the data from monitoring (regular observations) be compared to a forecast image of the situations under consideration, and that this comparison may lead to a review of the scenarios. The information collected and interpreted in this way should be used to continuously update these scenarios and a long term view of the situation of the coastal areas and the ways they are changing on every scale.

⇒ This approach responds to the concern to be able to intervene more strategically and not after the fact under the pressure of events, or once it is too late.

⇒ It is a question of creating the necessary conditions for the early adoption of adjusted, relevant, decisions that will allow the (i) securing of the population groups and environment that supports economic development in the coastal areas; (ii) minimising of the costs of repair, where relevant, of compensation, and of protection; (iii) long term optimisation of the investments devoted to developments.

The methods for communicating the information obtained from the various compartments of the monitoring system to the audiences concerned are broached within the framework of the capacity building direction-programme.

This direction will be implemented under the supervision of the UEMOA-PRLEC Regional Steering Committee and Regional Scientific Committee. Representatives of each stakeholder country sit on these committees. This will be the main aim of the West African Coastal Observatory (WACO).

3.3.1. THE PLAYERS IN THE WATCHKEEPING AND SHORELINE MONITORING PROGRAMME

The continuous observation of changes in the West African coast implies the networking of the various information providers. Three key, complementary players could be mandated to implement this work of monitoring and centralising and processing information:

⇒ **West African coastal Observatory (WACO):** Plans are already underway to set up this body with the support of UEMOA, which is considering entrusting the CSE with this responsibility. The WACO would be in charge of centralising and managing validated information on changes in coastal dynamics.

⇒ **The New Sahel and West Africa Club**, which would be in charge of producing (on a bi-annual basis) a forecast report on population settlement and growth in West Africa.

⇒ **The African Centre of Meteorological Application for Development (ACMAD), which implements the African ViGiRisC Programme,** and constitutes an important network head in West Africa vis-a-vis the national meteorological and hydrological services.

Also noteworthy is the Regional Network of Marine Protected Areas in West Africa (RAMPAO), whose possible contribution would be based on the ecological monitoring of the existing MPA, which have a recognised role as sentries for measuring the effects of changes in sea level.

3.3.2. STRATEGIC MONITORING OF GROWTH AND POPULATION SETTLEMENT IN THE COASTAL AREAS OF WEST AFRICA

The prospective work conducted as part of the diagnostics associated with the study has shown the **significant amplitude of the probable changes to be expected in terms of settlement, urbanisation and economic growth in the coastal areas under consideration**. A first demo-economic model has been drawn up as part of this prospective exercise. The regular updating of this model in the coming years could be used to refine and perhaps re-orient the initial scenarios (2020 and 2050).

The magnitude of the expected transformations in terms of population concentration and economic stakes in this coastal area requires careful attention, for the security of population concentrations and economic investments, on which sustainable development depends, can only be guaranteed by **early structural decisions in terms of land planning**.

This strategic monitoring requires broad access to statistical data on the States concerned, but also the active involvement of the States, of the regional economic communities (ECOWAS and UEMOA), as well as their technical and financial partners.

From the recent think tanks held (task force on the future of the SWAC) with a view to updating the status and activities of the Sahel and West Africa Club (SWAC), a new platform, called “new Club” emerged. The Members of the "new Club", with equal powers, will be those regional West African organisations that wish to join, the countries from the North and South and the international organisations who wish to contribute to its mission, defined as follows:

"The Sahel and West Africa Club is a multilateral group countries, West African regional organisations and other international organisations who share the determination to work together for the development and integration of the West African region. To this end, the Club is an instrument of monitoring, prospective analyses and dialogue that ensures a permanent surveillance and an independent structural analysis of the socio-economic and political evolutions of the region,

as well as the relationship between these evolutions and global issues. The Club contributes to the effectiveness of action taken by its Members and other stakeholders by providing information and prospective analyses to help better anticipate the potential for development and the risk of conflicts in West Africa."

The functions of this body have been defined as follows:

Watchkeeping	Analyses of the socio-economic, political and environmental trends of the region in its international context promotes an understanding the region's challenges in the short- and mid-term..
Prospective analysis	Focused on the agendas of the regional organisations, t**wo-year cycles of prospective analyses address development perspectives and risks of conflict in the mid- and long-term.**. While drawing lessons from retrospective evaluations, new policy options are proposed.
Dialogue	All the Club's activities are based on dialogue and information sharing. Its annual Forum brings together the Club's Members and key stakeholders to address one specific development issue. The Club's mission is also to deepen the participation of regional organisations in global debates, in order to ensure that West African perspectives are taken into account, in particular within the OECD's forums.

In this new configuration, the regional integration organisations (UEMOA and ECOWAS in particular) become full Members; UEMOA could therefore confer on the New Club the mandate to coordinate and facilitate prospective analyses of trends in human settlement and growth in the West African coastal area.

The production of a biennial summary updating the scenarios drawn up by the study and establishing adjusted projections is a necessary contribution for anticipatory and adaptive coastal management.

3.3.3. THE MONITORING OF COASTAL SYSTEMS: WEST AFRICAN COASTAL OBSERVATORY (WACO)

WACO (provisional name) is a vital mainstay for:

⇒ Collecting and analysing the data originating from the regional shoreline monitoring system.

⇒ Ensuring watchkeeping over trends in shoreline monitoring techniques and in shoreline protection techniques.

⇒ Creating contacts between and networking (i) West African specialists with skills in the field of coastal erosion; (ii) specialists and laboratories outside the region that could enable the transfer of technology and skills useful to the coastal States. This networking function could, however, be delegated and/or relayed by a Resource Centre integrated into the Observatory.

The setting up of the Observatory therefore constitutes an essential task which will require:

- The definition of a mode of operation and an organisation conferring on it **recognised regional legitimacy**, without which its information collection and centralisation role would not be feasible.

- The structuring of the observation and information production network (players, procedures, contractualisation and mutual obligation frameworks). A regional coastal information charter could be binding on the observatory and its partners.

- The establishing of information products and the modes of redistribution of this information (communication strategy) to the different levels of decision-making in the region, as well as the form these information products could take. Different levels of distribution should be considered in this respect; on different time scales and geographic scales, depending on the recipients and the types of decisions expected (inter-State mechanisms, governments, local authorities, local players and other distribution networks) as well as an annual, biennial or triennial summary of changes in the shoreline

and the human issues at stake on the whole coastal front which already appears to be an indispensable product.

Players and networks the observatory could draw on

Network of coastal observers-correspondents: an essential function to be organised

The coastal management scheme is organised around the segmentation into 179 sectors of the whole of the coastal area of the eleven countries involved, including their prioritisation based on the evaluation of coastal risks. **This segmentation determines the basic geographic reference for managing the information on the West African coastal area**. Priorities have been set in the general management scheme to guide the monitoring of these sectors. A distinction is made between:

⇒ **The "at risk" or priority sectors** (*intensive and regular monitoring, and regular monitoring*) that require close monitoring: for these sectors, the setting up of local committees (watchkeeping/vigilance), bringing together the main interest groups concerned, with the coordination of the appropriate national technical services, is highly recommended.

⇒ **The "potential risk" sectors** (*watchkeeping for anticipation*), where the consolidation and development of previously identified emerging dynamics may lead, immediately or in the long term, to risk situations. These sectors should be subject to watchkeeping, conducted either by the technical services or any other competent operator authorised through delegations of prerogatives, preferably contracted and subject to regular evaluation (strong notion of responsibility to be established).

⇒ **The sectors with no particular stakes,** for which monitoring can be conducted less frequently and reporting can be part of the periodic regional summaries.

For the first two categories of sectors, the monitoring to be done could be based on a battery of indicators to be determined (possibly inspired by those of the European DEDUCE programme) and adapted to the specific features of the West African coastal area or even more precisely, to the concrete situations experienced in the segments under consideration. The methods for measuring and quantifying these indicators should be defined and standardised through a regional workshop to be run under the aegis of the Regional Scientific Committee of UEMOA. It is understood that the level of priority of the different sectors can change and will be updated in line with changes in the situations on the ground as documented by the monitoring.

Indicator
Estimated area of urbanisation (ratio of built up/unbuilt areas)
Estimated ratio of first homes to second or leisure homes
Evidence of organic pollution
Evidence of hydrocarbon pollution
Significant change in natural coastal habitats
Agricultural land use
Estimated proportion of natural habitats preserved
Proportion of semi-natural habitats
Estimated area of urbanisation
Protected areas
Building heritage under threat
Percentage of the coastline served by road
Intensity of tourism
Number of days of storms
Dynamic coastline undergoing erosion
Dynamic coastline undergoing accretion
Anti-erosion improvements made
Trends in land value
Rise in sea level observable from plant formations on the shore
Coastline subject to protection systems
% of coastline built on at less than 500 m from the shore

Examples of indicators taken from the European DEDUCE project

The observers-correspondents would be in charge of annually updating the information relative to their respective sectors. For sectors, in particular urban sectors, where the current risks are substantial and identified, the setting up of a sector committee would be considered appropriate. Regular meetings of these local committees (annual or biannual or at a frequency to be determined) would also play an information and awareness-raising role.

Network of West African researchers in the field of coastal erosion

The situation of the shoreline in different sites has been characterised in case studies. These do not cover all of the most sensitive sectors, and an extension with some complementary studies should be carried out, on a model refined from the methodology followed during the regional UEMOA-UICN study. However, some of these sectors have already been subject to regular monitoring for several years by academic teams, which should be pursued by these researchers networked through the Observatory.

We also note that these current monitoring approaches work with no regional coordination, which would allow, where relevant, the harmonisation of measurement methods, highlight the interrelations between the sectors subject to monitoring, the isolation of trends to be differentiated from periodic oscillations due to natural shoreline dynamics (sediment waves on sandy coastlines, seasonal or exceptional event related changes in beach profiles).

Monitoring often only concerns very localised sites, and the observations are not compared to the overall operation of the morpho-sedimentary cells. An applied research work undertaking should lead to the systematic close monitoring of the most sensitive sites.

The measurement methods depend on the practices of the teams involved, but changes to methods that mobilise the most recent techniques on the most critical sites could be considered[7] as a test, if the means can be accessed through a partnership with research teams from the North with a similar interest.

[7] Aerial photogrammetry, Webcam, marine and land LIDAR, GPS and DGPS, Multibeam echoprobes, seismic, granulometric analysis, conventional topography, etc. See for example OPTIMAL - BEACHMED-e. 2007. - **Optimisation of integrated monitoring techniques applied to coastlines**. Interreg III-C. 196p or MESSINA. 2006.- **Monitoring and modelling the shoreline**. Isle of Wight Council - Interreg IIIb. 215p .

Network of West African marine protected areas[8]

To the extent that this network could be expanded to include the Gulf of Guinea countries, in relation to the Abidjan Convention for example, the ecological monitoring work conducted on certain sites (for example by the BIOCOS FFEM/FIBA project in progress, but also through the Banc d'Arguin Observatory, originating from the PACOBA project) will produce important data for highlighting the trends that characterise the changes in coastal milieus. This remark is particularly pertinent for the rise in sea level, for which the monitoring of the distribution of coastal vegetation in the relatively undisturbed milieus of the protected areas provides useful indications which complement the information provided by the ride gauge[9].

Spatial reference base and databases

It is proposed that the spatial reference base for the monitoring of the shoreline be constituted by the 179 sectors distinguished within the framework of UEMOA-UICN regional study. The critical databases to be implemented are defined as follows:

⇒ **Sectors database** including the different indicators to be defined.

⇒ **Database on coastal developments**: This can be built by the Observatory from the results of the (i) national diagnostic studies; (ii) case studies. It could be completed by (i) the research teams working on the geomorphological monitoring of the shoreline: (ii) the observers-correspondents and sector committees, the implementation of which is broached above. The constitution of a complementary database of photographs taken at regular intervals is recommended. The long-term analysis of results, impacts and the sustainability of developments and protective systems will feed the capacity building of developers on the basis of feedback from concrete, documented experiences.

⇒ **Database on the dynamic sites subject to geomorphological shoreline monitoring**: the situations already subject to regular monitoring work have been partially listed by means of the study and has been the subject of case studies. These case studies must be integrated into a geographic database that the CSE is implementing as part of the study. This database will compile the older series and will archive reference situations that are sometimes old (the case of the Barbarie Spit in Senegal, for example).

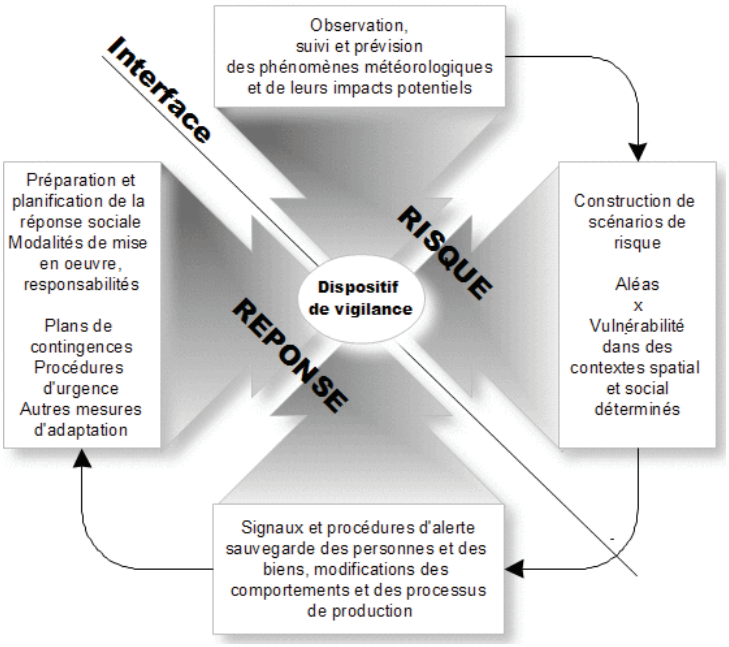
3.3.4. CLIMATE AND WEATHER MONITORING

The foundations of this monitoring are still to be organised, which could be done as part of a second phase. The legitimate operator to be approached would be ACMAD (African Centre of Meteorological Applications for Development), a centre certified by the World Meteorological Organisation, which is the head of an important network for African meteorological services as a whole. ACMAD is already the operator of the ViGiRisC project, co-funded by the FGEF, whose mission is to implement early warning systems for different contingencies, including storm surges. The aim of climate and weather monitoring will be to:

⇒ Update the climate forecast for the coastal areas of West Africa.

⇒ Establish vigilance and an early warning service in relation with the national meteorological services, regarding the risks of flooding and storm surges.

[8] The network of protected areas in West Africa (RAMPAO): RAMPAO was officially created by fifteen MPAs in four countries (Mauritania, Guinea-Bissau, Senegal and the Gambia) in April 2007. It draws on the regional management strategy for marine protected areas.
[9] European project BRANCH



Stages and components of the vigilance services (in french)

3.4. INFORMATION AND CAPACITY BUILDING DIRECTION/PROGRAMME

Goal: **Build the capacities of coastal players in terms of shoreline management by making effective, high quality information available on the anticipation and treatment of coastal risk situations**

Preparation of populations and decision-makers: the fight against coastal erosion and the reduction of the impacts of coastal dynamics should be organised at all levels and will require considerable efforts in terms of informing and raising the awareness of all the categories of people confronted with it.

Different levels, approaches and products will be considered in terms of capacity building depending on the different categories of players, including partnership with other international programmes, such as the European ANCORIM project. The sharing of experience and "bringing it to the attention" are considered here as an integral part of the capacity building function.

The Resource Centre, set up within WACO, could coordinate the implementation of this important capacity building programme, which will perform the following functions:

⇒ Regularly deliver to coastal players up to date, relevant and accessible information on changes in the coastal systems.

⇒ Contribute to preparing the population and decision-makers to reduce risks through awareness-raising, information and experience feedback.

⇒ Relate the needs in terms of expertise with the technical resources and specialist skills available on a regional and international level.

⇒ Increase the intervention capacities of national players through training and the re-skilling of technical players.

⇒ Accompany academic research and training operations by providing appropriate scientific supervision and by running a network for sharing experience and documentary supply.

3.4.1. IMPLEMENTATION OF INFORMATION AND CAPACITY BUILDING PROGRAMME

This programme will be entrusted to the Resource Centre of the West African Coastal Observatory. Within WACO, the main functions of the resource centre are oriented towards the mediation of regional and international knowledge and skills relative to coastal monitoring and development. A connection with the IUCN's global skills network certainly constitutes part of the added value of the involvement of this institution in the implementation of the jobs mentioned below. The activity of the Observatory Resource Centre will be materialised through different products intended for wide distribution:

⇒ **Production of a biannual "communicative" summary report on the status and changes of the West African coastal areas, which will include all the information originating from the prospective of the SWAC, WACO and the network of observers, the marine protected areas network and the climate and meteorological monitoring section**

⇒ **Online publication and maintenance of a regional** web **portal** on the coastal area (for example, based on the model of the European portal ENCORA).

⇒ **Production of communication tools and materials, including a periodical e-letter** about current events on the West African coast (work in progress, legislative decisions, international events, **experience** feedback on the extreme events observed). The editorial line of this letter will be defined under the aegis of the UEMOA Steering Committee and Regional Scientific Committee.

⇒ **Production of didactic information tools** intended for the categories of audiences the most concerned by local shoreline management (local authorities, tourism operators, hotel and restaurant owners, urban services, etc.).

⇒ **Networking (and database – map of capacities) of a pool of national and international experts** specialised in the domain and highly qualified to be able to intervene to support (i) the coastal States; (ii) the UEMOA Steering Committee; (iii) the West African Coastal Observatory. Already, at this stage, this database could include, through the system to be put online by the CSE within the framework of the study, the directory of researchers and laboratories working on coastal erosion, to which can be added the directory of experts who contributed to the drafting of the national diagnostic studies. The different resources from the EOS.D2C network can also be added. Putting the database online should allow the technicians, consultants and laboratories interested to sign up, on condition that a procedure to validate the registration is drawn up within the framework of the guidelines of the observatory and the resource centre.

⇒ **Facilitation of the scientific supervision** of research students working for a diploma on the topics related to the study of ecosystems, coastal planning and the attenuation of coastal risks

⇒ **Organisation of training and re-skilling sessions for the technical services, professionals and engineers** in relation with coastal planning, and probably in liaison with the post-graduate diploma studies on coastal risks already in place at the universities of Nouakchott and Saint Louis.

Priority topics in terms of capacity building

- Risk evaluation engineering
- Coastal engineering
- Land planning applied to the coast
- Conducting of impact studies and drafting of specifications for the impact studies in coastal areas.

Through the different media produced at regular intervals, the WACO Resource Centre will handle all the communication tasks of the Regional Steering Committee. Also drawing on the existing networks, such as the PRCM's RESOCOTAO, the Resource Centre will act as a Hub and relay among the partners working on coastal issues in West Africa.

4. FIRST PHASE OF PROGRAMME OPERATIONAL OVER 2 YEARS

In the absence of an initial framework and precise programming, this proposal is designed for a period of one year, on the assumption that the regional mechanisms should be operational when it is completed. This first phase of the operational programme will include the following stages (non-exhaustive list).

4.1.1. DETAILED IDENTIFICATION AND FEASIBILITY OF THE SYSTEM

This work aims to identify and draw up a detailed budget for the shoreline monitoring programme to be conducted with all of the stakeholders concerned. This includes specifying the technical and administrative provisions and the work schedules of the various components, in the form of a detailed roadmap including a system for assessing progress. Identification should, in particular, include:

The framing and consolidation of the institutional system:

⇒ **Updating of the terms of reference and procedural guidelines for the Regional Steering Committee**, which will serve as the procedural guidelines for the programme, including, for the States, the procedures for applying for planning funding from PRLEC, but also the operating procedures of Steering Committee and the Regional Scientific Committee, mobilisation of the members (technical skills, supervision of the network of observers in each country, **experience feedback operations after exceptional events**, etc.), and the framing of the relations to be developed with all the existing regional actors.

⇒ **Updating of the draft project concerning the organisation and setting up of the West African Coastal Observatory**, the sizing of its resources, the definition of its relations with the information providers and other partners, and the technical contents of its services (drafting of specifications and designation of the deliverables, based in particular on a series of indicators appropriate to the different levels of watchkeeping).

⇒ **Examination of a detailed project concerning the WACO Resource Centre component**, the setting up of its relations with all the partners, the technical contents of the services, in particular the specifications and identification of the different deliverables, including the integration of the adaptation and distribution in the region of products originating from other initiatives, such as the didactic tools from the European ANCORIM and ARCOPOLE projects addressed to local elected representatives local coastal land authorities

⇒ **Negotiation with the SWAC** on methods for producing prospective monitoring of the population settlement and growth in West Africa (write a proposal for a project to be included in the budget of the programme in year II)

⇒ **Negotiation with ACMAD** on the methods of climate and meteorological monitoring of the coastal areas of West Africa (write a proposal for a project to be included in the budget of the programme in year II). A contribution of the programme in the co-funding of the ViGiRisC project for the implementation of a prototype product for early warning of storm surges should be considered.

4.1.2. ACTIONS IDENTIFIED AS NECESSARY DURING THIS PERIOD

PRLEC-UEMOA Regional Steering Committee and Regional Scientific Committee

⇒ Regular meetings to support the identification process mentioned above.
⇒ **Regional workshop** to present the initiatives of the shoreline monitoring programme within PRCLEC
⇒ Information and awareness-raising of the national authorities (national information seminars).

West African Coastal Observatory

- ⇒ Installation and consolidation of logistics.
- ⇒ Stock-taking of existing information.
- ⇒ Organisation of the system of geographic databases, standardisation of methods and reference bases, transfer and appropriation of the achievements of the SDLAO UEMOA-UICN study
- ⇒ Recruitment and skills upgrading for the dedicated personnel.
- ⇒ In liaison with the PRLEC Regional Steering Committee and Regional Scientific Committee**, regional workshop to prefigure the network of observers and identify the battery of appropriate indicators for monitoring the sectors**. Drafting of an observer's guide.

Waco Resource Centre

- ⇒ Installation and consolidation of logistics.
- ⇒ Creation and online publication of a web portal on the coastal areas and archiving of the reference documents, particularly cartography documents, on the West African coastal area.
- ⇒ Building of the database on existing national and international capacities and resources (continuous task).
- ⇒ Drawing up of a programme of formal training courses to be launched in year II.
- ⇒ Support for facilitation of the scientific networks associated with WACO.
- ⇒ Production of an educational guide on coastal erosion for the local authorities and tourism operators.
- ⇒ In conjunction with the observatory and the different users of the information, drawing up of a communication strategy for delivering the information tools and appropriate decision support tools
- ⇒ Creation of a mobile exhibition providing information on the results of the regional study, expressed in a communicative form and making accessible to the general public the established reference situation, as well as the outlook and agreed recommendations. Identification of national relays and of the exhibition programme. This exhibition could be accompanied by an events-based dimension, the expectations, terms of reference, partnerships and co-funding of which should be defined.

4.1.3. ANCILLARY PROGRAMMES

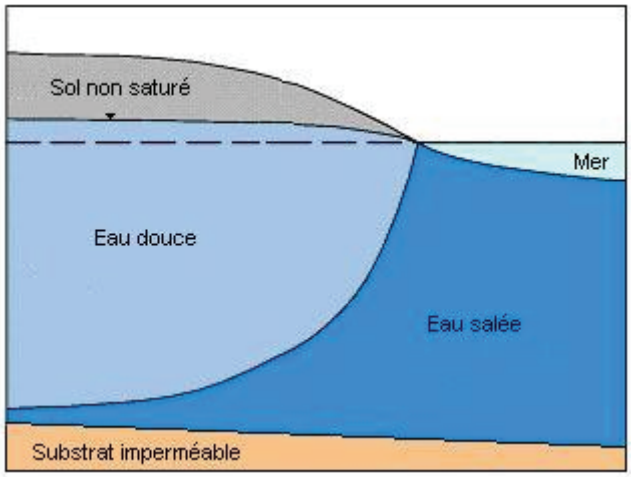
The work conducted as part of the shoreline monitoring study highlighted various potentially interesting sites for the conservation of biodiversity on a regional scale that are not currently subject to any conservation measures. These sites feature in the detailed management scheme, and include, for example, the area from Sherbro Island to Robertsport in Liberia. Complementary investigations should be conducted on these sites, with a view to confirming their value, and possibly initiating a conservation approach if this is justified and approved by the national authorities.

From the same point of view, a number of small estuaries, particularly in Liberia, were identified as sites (mentioned as remarkable small estuaries in the 1:500,000 cartography), that are of relatively small dimensions, but that present mosaics of exceptionally rich and diverse natural milieus, the preservation of which is also vital for the local, often isolated populations. A feasibility study for a dynamic conservation programme for small estuaries would be a pertinent initiative ancillary to the programme and resulting from, among other things, the findings of the regional study.

ANNEXES

ANNEX 1: SOME TERMS AND CONCEPTS RELATED TO COASTAL DYNAMICS AND PLANNING

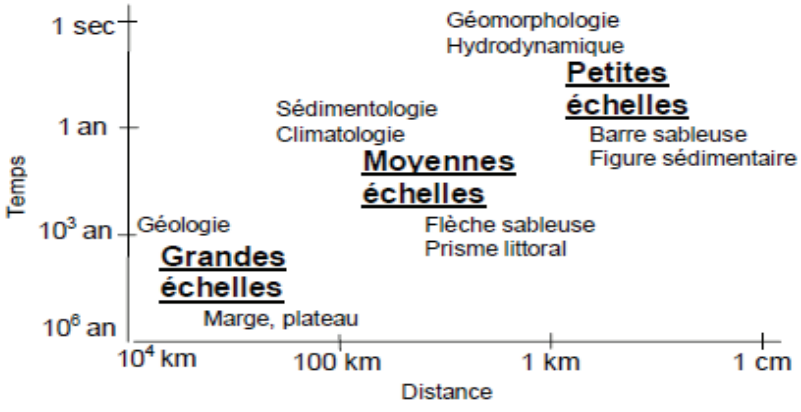
SALT WATER WEDGE: Saltwater (typically ocean) intrusion in a coastal aquifer contained between the base of the aquifer and an interface that separates fresh water and saltwater: The leading edge (toe) of the saltwater is underneath the fresh water. The intrusion of a salt water wedge beyond a natural position of low penetration is almost systematically the consequence of over-exploitation of the aquifer. An adequate reduction in pumping, as part of coordinated management for example, can restore the situation to normal in the medium term.



Cross-section of saltwater intrusion
with a deep impermeable substratum

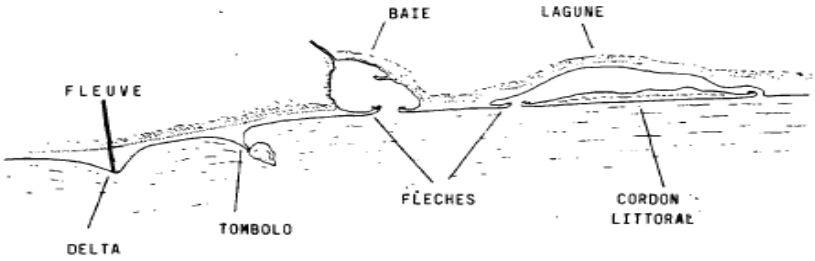
MPD OR MARITIME PUBLIC DOMAIN: this typically corresponds to a distance ("not geometric") calculated from the high water mark, which is considered as the mean level reached by the sea during tides with a coefficient of 120 (for France). Permits to use the maritime public domain can be issued in the form of concessions (breakwaters, moorings, beaches, ports) or "AOT" – temporary use permit. The MPD has legal status and is generally inalienable.

COASTAL DYNAMICS: coastal dynamics are expressed and perceived at different scales of time and space:



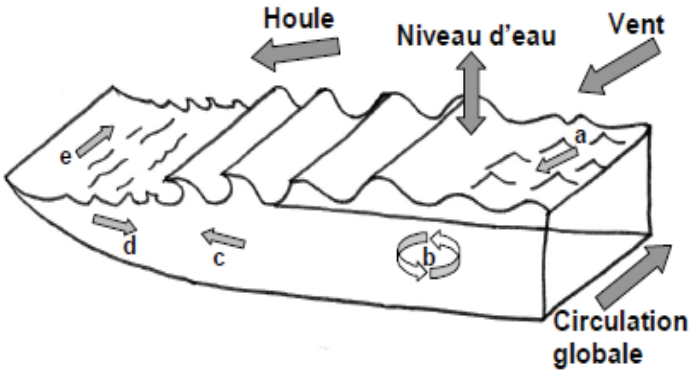
Coastal system observation scales.
(according to Desmazes. F. 2005.- **Characterisation of sand bars on a beach on the Aquitaine Coast.** French Thesis - University of Bordeaux).

On soft coasts, the coastal dynamics are expressed in particular by the **forms of coastal accumulation**: coastal rims, spits, deltas or mudflats.



Different forms of accumulation
(BRGM. 1984.- Elements of coastal sedimentary dynamics. UNESCO - WACAF III)

These forms of accumulation are the result of different phenomena induced by the **forcing** of the coastal system. The energy responsible for the forcing is supplied by the wind, ocean waves, current and water level, the continental waters – these are **morphogenic agents**. The dissipation of this energy is reflected in the transport of particles, including sediment of varying gradation.

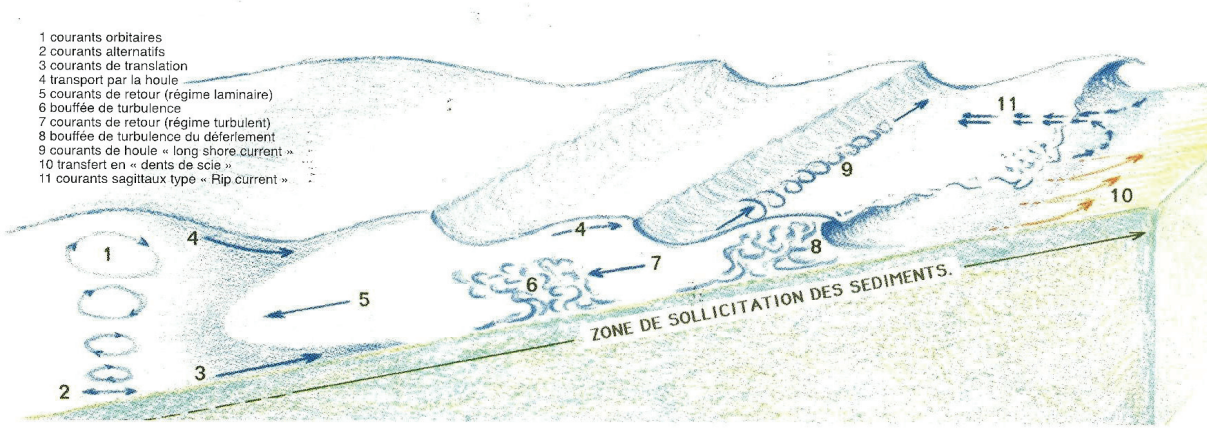


Forcing in the coastal milieu. The sediment is transported by the different currents: (a) induced by the wind; (b) rotating currents generated by the tide. Some of these currents are induced by the transformation of wave energy: (c) mass transport; (d) return current; (e) coastal drift. according to DEZMAZES. F. 2005.- **Characterisation of sand bars on a beach on the Aquitaine Coast.** French Thesis - University of Bordeaux).

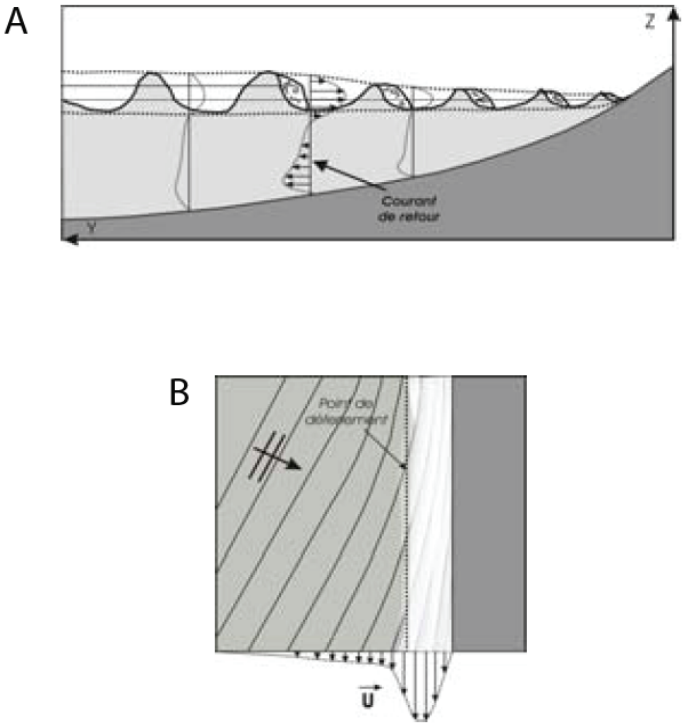
The direction of the ocean waves is evidently a determining factor which scientists have long investigated[10] differentiating the effect of waves perpendicular to the shore (oscillation waves) that generate **cross-shore** transport, but with high energy, and oblique waves (translation waves) that generate **longshore** transport, essential to understanding coastal dynamics.

[10] Johnson. D.W. 1919. - **Shoreprocess and shoreline development**. New York. Chapman and Hall. 584p.

On sandy beaches, these dynamics are exacerbated during storm surges which may generate spectacular and brutal reconfigurations of the beach profile.



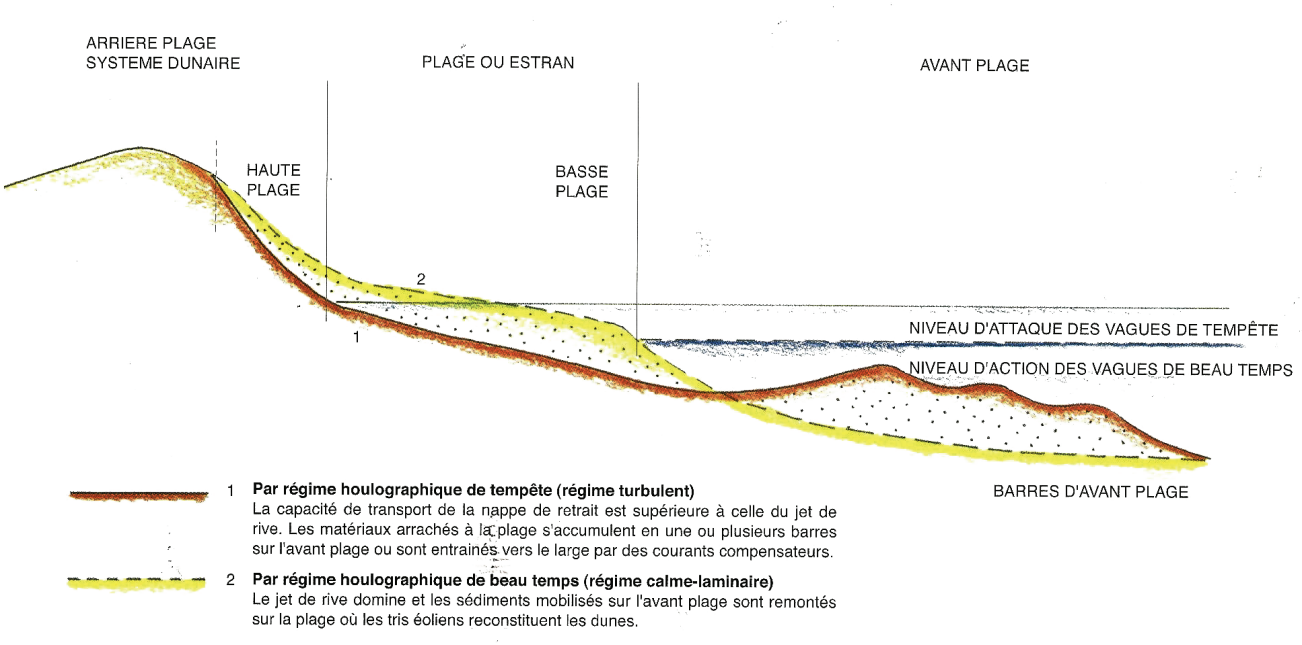
Schematisation of the principal currents generated by the ocean waves (according to Cazes-Duvat. V., Delmas-Ferré. M. and R. Troadec. 2002.**- Manual for monitoring and treating coastal erosion – Indian Ocean Countries.** Regional Environment Programme – Indian Ocean Commission. 45p.).



Schematization of the crosshore current – return current (A) and longshore current (B) (from CASTELLE. B. 2004.**- Modelling of sedimentary hydrodynamics above the sand bars subjected to the action of the ocean waves: application to Aquitaine coast.** French Thesis – University of Bordeaux).

MORPHOLOGICAL AND SEDIMENTARY DYNAMICS OF BEACHES: the visible (emerged) part of a beach is only one element of a sediment system the immerged part of which is subject to the agitation of the sea (see figure ….).

The behaviour of sandy beaches (formation of bars, migration of bars in the profile, shape and typology of bars) is still poorly understood and is the subject of large numbers of doctoral theses. The influence of the morphology of the seabed with the related refractive phenomena partially explain this great complexity and the diversity of observable forms, which largely exceed the current possibilities of modelling at a cost compatible with the investigation of considerable expanses.



Changes in the transverse profile of a beach (from Cazes-Duvat. V., Delmas-Ferré. M. and R. Troadec. 2002.- **Manual for monitoring and treating coastal erosion –** Indian Ocean Countries**.** Regional Environment Programme – Indian Ocean Commission. 45p.).

The dynamics of sandy beaches is dominated by different systems of bars:

⇒ **The ridge and runnel system** (1- formation of a bar roughly parallel to the beach; 2- accretion behind this bar; 3- formation of a tidal pool downstream of the bar; 4- migration of the system in the direction of coastal drift). The speed of migration (propagation) of these undulations observed on a 35 km section of sandy coast showed an average displacement of 2.4 m/day, with 16% of the formations migrating in the opposite direction from the prevailing coastal drift[11].

⇒ **The crescent bars** observed in the subtidal part of many sandy beaches**.** These are systems with a marked rhythmicity with a wavelength varying from 10 to 1,000 metres, with an average of 100 metres.

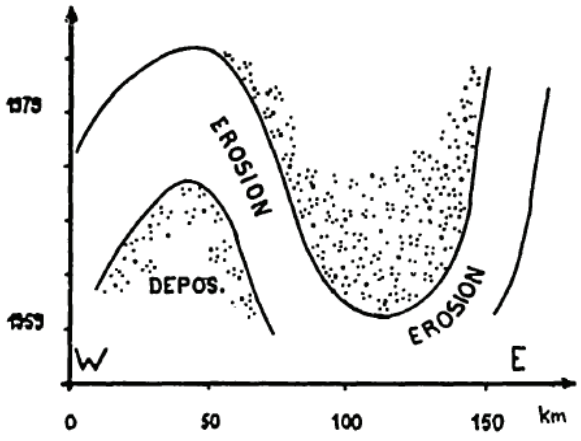
⇒ **The channel systems** observed in particular during storm episodes associating longitudinal bars interrupted by channels not parallel to the beach that originate in the upper beach.

Bars may constitute serious obstacles to boats, in particular when embarking from the beach, with frequent accidents affecting artisanal fishermen.

[11] Lafon, V., Dupuis, H., Howa, H., Froidefond, J.-M., 2002. Determining ridge and runnel longshore migration rate using spot imagery. **Oceanologica Acta** 25, 149-158.

Bar system (ebbing tide - West of the port of Abidjan COTE d'IVOIRE, source: Google Earth)

Changes in sandy coastlines should be observed on a variety of temporal and spatial scales. The accretion and erosion episodes in a given point can be associated with the passing of "sediment trains" which may correspond to a stabilisation of erosion. In Benin, the siltation wave advances at an estimated speed of 2.8 km a year and its return period is approximately 25 years.



Siltation wave on the coast of Benin in time and space
(UNESCO). 1986.- **Quaternary coastal geology of West Africa and South America.** 179p.)

The capacity of sediment to be mobilised by morphogenic agents largely depends on its cohesion (soft, cohesive or consolidated sediment), and gradation.

OUTLET STREAMS: coastal release points (waste water, rainwater)

FORESHORE: the area of a shore that lies between the average high tide mark and the average low tide mark.

COASTAL AREA: In practice, **how coastal area is defined often depends on why it is being defined**, from the "state" coastal area limited to the MPD[12], to the developer's coastal area (population basin affected by the marine economy), or again that of the environmentalists, which includes the different natural elements contributing to the dynamics of the marine and coastal ecosystems. Often more than territorial, this definition of coast originates from **a reflection on function**, and in fact leads to a collective representation that is quite generally shared, but the territorial limits of which remain globally ill-defined on the land side, including in the most sophisticated legislation.

The recognition of the role of the coast as a development area that contributes to the national economy in multiple ways; like the recognition of the different resources linked to it, leads us to take this coastal strip into account in an extended, more social than territorial way, which, on the level of legal systems, remains shared between the public law that applies on the MPD, and the private law that applies outside the MPD[13]. In West Africa, common land ownership law is still often recognised locally.

The emergence of a specific notion, called "proximity to the sea" makes it possible to add rules and procedures common to the two areas - land and sea. The purpose of these rules and procedures is to guarantee **the compatibility of usages** in the whole of the coastal strip, and harmonise the modes of development according to the imperatives of preserving natural milieus that are both fragile and vital for national economies.

According to this functional representation of the coastal area, any zoning arrangements should incorporate usages and players, with a view to proposing a system of spatial units compatible with the **recognition of management responsibilities**, which may possibly be subject to contractual policies.

The notion of coastal area therefore spreads through the terrestrial milieus located outside the PMD according to a **principle of the general equilibrium** of the territory, the public management of which incorporates proximity to the sea, and in particular the constraints and natural risks susceptible to affect the security and continuity of terrestrial activities.
The coastal area therefore remains above all a complex territory that groups together all the milieus directly marked and influenced by proximity to *coastal waters*. It is easily conceivable that in such a definition, based primarily on functional considerations, the territorial limit on the land side **should be defined in each local situation**. The interlinking of the following components of the terrestrial part of the coast should be successively distinguished:

- The maritime public domain.
- The territories of communities with a sea front.
- The population basins where products from the sea are processed and commercialised.
- Natural coastal areas and conservation sites.

Note that the geomorphologic definition consisting in considering the sediment formations originating from deposits and fashioned by marine currents, and linked to the interaction of the two systems of sedimentation, terrestrial and marine (intertidal zone, dune belts, lagoon systems, delta formations, brackish waters and wetlands) whose regime is in particular linked to tides, is often applicable.

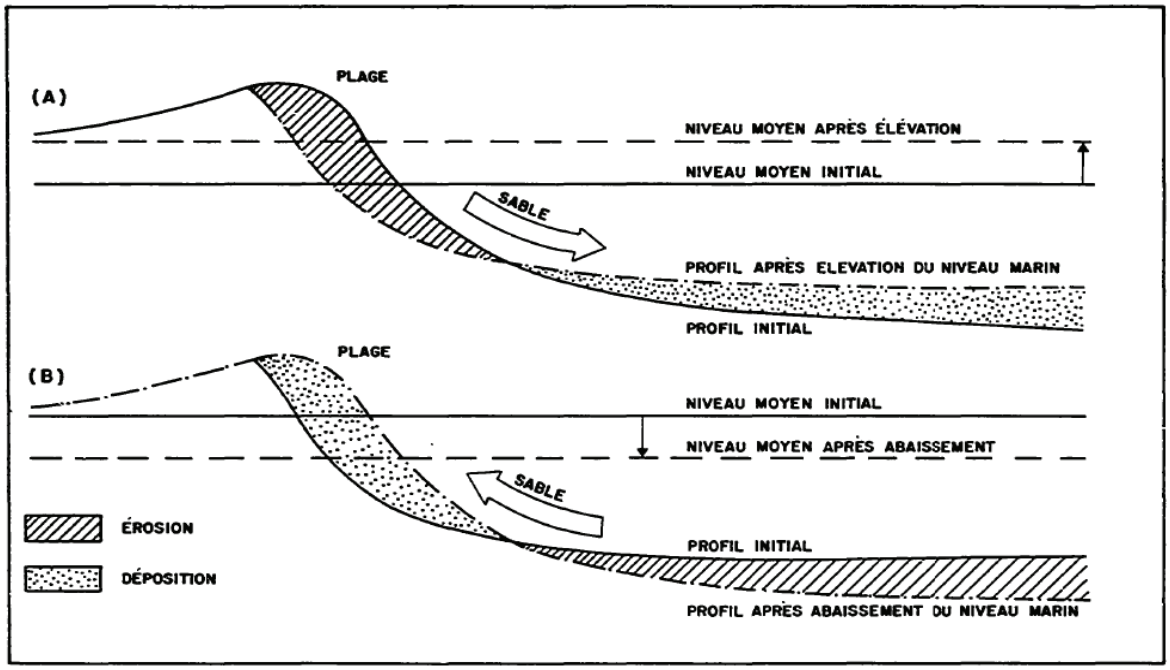
The same problem of boundary may also be posed on the maritime side of the coastal interface. An extension of coastal maritime space to the entire EEZ seems exaggerated if it is a question of qualifying **coastal waters**. However, the morphology of the continental shelf and the bathymetry of nearshore coastal waters can play a significant role in the organisation and dynamics of coastal currents, as in the storage and redistribution of sediment reserves.

The ambiguities evoked above concerning the very notion of coast are also perceptible in other domains, where the diversity of the players and stakeholders has for corollary a diversity of points of view. Certain notions such as zoning or the vocation of areas can give rise to interpretations that are a simplification with respect to the functional aim of the development. For, in fact, there are potentially multiple ways of zoning the coast depending on the point of view we begin from. The identification of the vocations of areas with a view to

[12] Maritime Public Domain

identifying the stakeholders in the development should above all preserve their **multifunctional** nature. Even if the accent can be placed pertinently in a given sector on such and such a type of activity, use or occupation, this should respect the principle of territorial equilibrium, in particular by respecting the principles of compatibility between usages.

BRUUN'S RULE: Bruun's rule postulates that maintaining the equilibrium profile of a beach, faced with a rise in sea level, implies that sediment is eroded from the beachface and deposited on the foreshore, to increase the height. This increase is directly proportional to the height of sea level.



Behaviour of the equilibrium profile of sandy beach
Resulting from variations in sea level (Bruun's rule, 1962)

RISK: There are various definitions of the risk, since that of Bernoulli (1738). Risk arises from a combination **of a contingency, vulnerability and the coping capacity** of the exposed systems, and of **the exposure** of people and property:

Risk = contingency * vulnerability * exposure

Contingency: **event (meteorological, seismic, geomorphologic, epidemic, technological, etc.) that has potential impact.**
Vulnerability: **Susceptibility to be affected by a contingency.**
Exposure: **Physical component of vulnerability.**

On the basis of this definition of risk, it can be understood that the rupture that characterises a disaster is not caused by the contingency alone, **but by the interaction of the contingency with more or less vulnerable social and economic systems,** provoking an impact likely to take on a disastrous dimension, in particular depending on the stakes.

The increase in vulnerability resulting from a disaster situation can favour the appearance of secondary events of a disastrous nature, which would then be caused by contingencies which, under normal circumstances, would only have marked impacts ("domino effect").

The distinction should also be made with "major risk", defined as a very serious accident with exceptional consequences, but the probability of which is very low. This is a collective risk.

RISK PREVENTION AND/OR ATTENUATION: without going into the differences in the conception covered by these terms, this is a recent, or even emerging concept. It is by nature **transverse** and also related to the precautionary principle. Risk prevention is explicitly mentioned within the framework of the Johannesburg Plan of Implementation for sustainable development. The boundaries of risk prevention/attenuation are summaries in the figure below (specific approaches category).

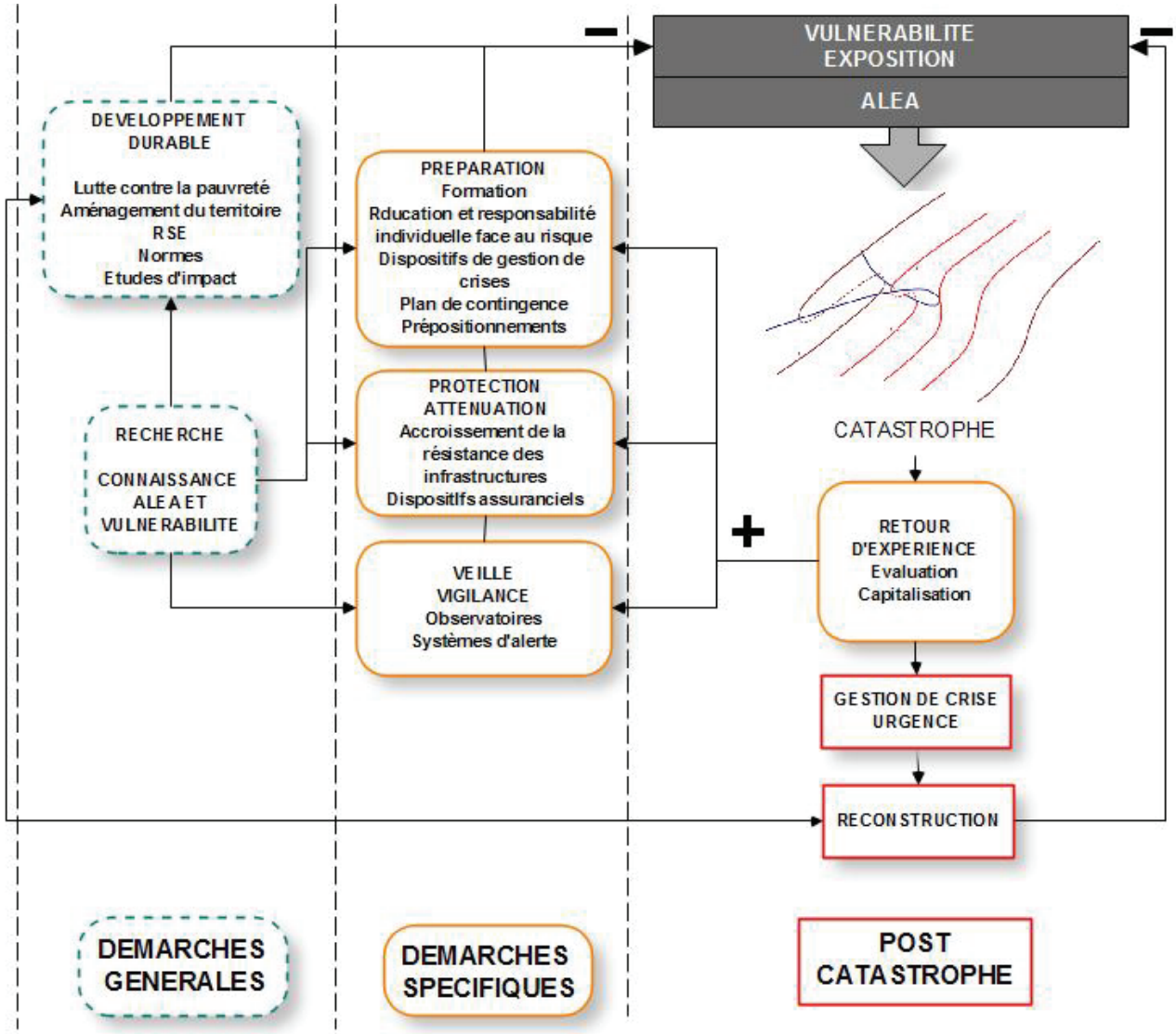


Figure 1. Conceptual elements relative to risk prevention (source: French Foreign Ministry 2008.-Evaluation of the actions of France in terms of disaster risk prevention in international cooperation. JJ Goussard - EOS.D2C).

At political level, the prevention of risks can be characterised through **objectives and priorities of the Hyogo framework for action** (United Nations Global Conference in Kobé – 2005).

Risk prevention/attenuation is an integral part of measures to adapt to climate change and in this domain is particularly aimed at controlling the impacts related to increasing climate variability. One fundamental difference relates to the time perspective: present and near future for risk attenuation, long term perspectives for adaptation. The two approaches can be considered in synergy.

The English expression *disaster risk reduction* distinguishes, according to ISDR, between three complementary modes of action aimed at minimising the negative impacts on society and the way it operates:

⇒ **Prevention:** Measures aimed purely and simply at avoiding the negative impact of natural contingencies and the environmental and technological disasters that result. Wise planning, for example the decision to not build houses on land subject to flooding, is part of risk prevention.

⇒ **Attenuation:** Measures aimed at limiting the negative impacts caused by natural contingencies and the environmental and technological disasters. The upgrading of buildings or the building of construction of flood walls, training and the voting of relevant laws are examples of attenuation.

⇒ **Coping capacity or preparation:** Preventive measures to be taken to cope effectively with the impact of disasters. The implementation of efficient evacuation infrastructure and the regular verification of alarm systems are among such measures.

The European Union has also selected these three modes of intervention[14].

From this conception, the term prevention **therefore designates only one of the compartments of action to be implemented** to reduce the risks of disaster. **The notion of risk prevention, on the other hand, encompasses all these modes of intervention**, according to a typology of the domains of risk prevention proposed for this evaluation, and which can be organised as follows:

1. Knowledge of the contingencies and of the social and economic vulnerability: Completed fundamental research.

2. Structural or even strategic measures to reduce the vulnerability in the medium and long term: sustainable development approach, fight against poverty, normative activity, etc.

3. Watchkeeping and alarm system: monitoring of dangerous phenomena, early warning and observation systems. These must be varied in accordance with the (i) the contingencies taken into account; (ii) spatial scales considered.

4. Protection, attenuation and reduction of exposure measures aimed at reducing the exposure to risk and restricting the negative impacts of the contingency. These measures aim to increase the **resistance** of the systems affected. The term attenuation used here should not be confused with attenuation as conceived in relation to climate change (reduction in GHG emissions).

5. Preparation, emergency systems, contingency plans and insurance provisions: development of individual responsibility in the face of risk and the risk culture, education, training, impact studies and the corresponding attenuation measures (mitigation), organisational measures, drawing up of emergency and contingency plans, insurance (risk transfer policies) to improve resilience. It is a question of consolidating the response of the society to high-impact events.

6. Evaluation, capitalisation and feedback from experience: study of the memory of risk, anthropology of risk, institutional training, evaluation, capitalisation and experience feedback systems.

STORM SURGES: The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (generally low atmospheric pressure). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place. Strong winds combine frequently with atmospheric pressure to amplify the value and effects of ebbs and surges. Concerning the surges, the greatest threat is the risk of flooding to coastal areas, and this risk occurs only too often when extreme weather raises a storm surge which is superimposed on the tidal wave and propagates the surge landward. (Source: Météo France)

SIGNIFICANT WAVE: the surface of the sea appears very disordered, even chaotic. Statistical methods are therefore required to express the height, period and energy of waves. Significant wave height is defined, and measured during a given time (often 10 minutes) as the average heights of one third of the highest waves in the series observed. In the same way, the significant wave period is the average of one third of the highest periods

[14] European Union 2008.- **EU strategy for disaster risk reduction in developing countries (working title).** Issues Paper – 17/4/2008.

in the series observed. The average energy of the wave per unit of marine surface is proportional to the square of its height.

PLANNED STRATEGIC RETREAT: given the mobility of the shoreline, against a background of climate change likely to intensify it, there are few alternatives and the choice essentially depends on each local situation[15].. Among these alternatives, one solution that is viable in the long term is a planned strategic retreat.

The expected advance of the shoreline, which will vary depending on the site, should lead us to consider, whenever possible, **redrawing the contours of a future coastline**, arranging a natural "buffer" space between shore and the stakes. The width of this zone should be calculated depending on different elements:

- ⇒ The thickness should not only depend on the concern for the safety of people and goods, but also on the dynamics specific to coastal ecosystems. The areas necessary for pushing back wetlands or lagoons will often be at least as important as in the case of dune formations. It is therefore a question of arranging the space necessary for the spontaneous adjustment of natural coastal systems preserving the way they operate and the ecological services they offer.

- ⇒ One essential question concerns the preservation of wetlands both for the ecological services they provide, but also for the resources, fishery resources, in particular, that they procure. In this respect, conservation actions are justified anew, by helping to maintain these complex systems in an operational state and therefore preserving their capacity to adapt to change, which is also related to the diversity and complexity of the mosaic of wetlands. In accordance with this objective, preventing the fragmentation of wetland systems is also important and should be taken into account not only in coastal defence actions, but also when planning land use.

The justification of planned retreat should be supported by a cost-benefits analysis incorporating the ecological services rendered by wetland areas.

Determining a setback line: This is a question of anticipating the retreat of the shore to allow it to conserve its natural and functional characteristics. The methods that can be used (see inset) are interesting despite the following constraints:

- ⇒ They apply especially when the retreat is more or less gradual and measurable (sandy coasts) and are not suitable for taking into account other, special situations (the connecting of lagoons or low areas with the sea, breach or fragmentation of lidos or dune ridges).
- ⇒ They require historical data to assess the speed of shoreline retreat independently of any structural works installed there.
- ⇒ They require observation to be able to assess the retreat due to surges.

The setback line can be measured[16] by extrapolating the historical shoreline displacement trends measured towards a future date to be set, adding the accidental retreat due to storm surges:

$Lr = (\Delta rLT \times A) + \Delta rCT$ where

A = the number of years chosen
ΔrLT = the displacements of the shore in the Long Term expressed in m/yr
ΔrCT = the retreat of the shore in the Short Term (exceptional storm) expressed in m/yr

[15] Klein R.J.T., Nicholls R.J., Ragoonadeu S., Capobianco M., Aston J. Buckley E.N., 2001. Technological options for adaptation to climate in coastal zones**. Journal of Coastal Research**, 17, 3, p. 531-543.

[16] Sabatier. F. & al. 2008. **Determination of a retreat line on the coastal areas undergoing erosion: example of beaches in the Golfe du Lion**. Acts of the international pluridisciplinary colloquium "le littoral : subir, dire, agir". Lille France - 16-18 January 2008.
Ferreira O., Garcia T., Matias A., Taborda R., Dias J.A., 2006. An integrated method for the determination of set-back lines for coastal erosion hazards on sandy shores. **Coastal Engineering**, 26, p. 1 030-1 044.

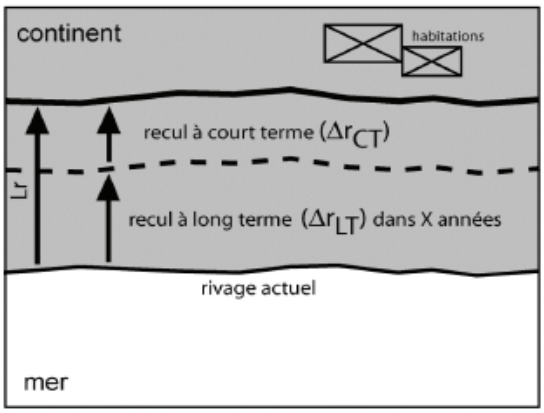


Figure: Determination of the setback line (according to Sabatier & al. 2008).

To this strip an additional width should be added to enable the sedimentary equilibrium of the dune-beach system to be maintained.

MARITIME SIGNALING: localised characteristics of lighthouses, buoys and lights.

STORM SURGE (OR STORM TIDE): exceptional rise in sea level due to the conjugation of different factors: (i) high sea coefficient - spring tide; (ii) low atmospheric pressure; (iii) strong ocean swell. Certain storm surges can reach a height of 3 metres. On sandy beaches, a storm surge can cause a brutal reconfiguration of the shoreline.

SHORELINE: the shoreline is the limit of the highest level of the sea in spring tides and exceptional tides. It separates land from sea. It is not clearly distinct from the natural upper MPD limit, which is more easily characterised by the limit of the vegetation characteristic of salt water milieus. Conventionally (in Europe) the coefficient 120 is used to define the highest spring tide without a surge nor wind set down. Numerous factors (wind, swells, atmospheric pressure) can however, and with a same tide coefficient, alter this line, **which is therefore primarily a convention**.

At first sight, the notion of shoreline seems intuitively easy to understand: *the line that separates the ocean from the continent.* In reality, the boundary of the shoreline implies the fixing of a "static" limit within a milieu, the shore, that is primarily characterised by its dynamic nature and dual inclusion in the land and the coastal waters. It should therefore be accepted a priori that the shoreline is generally mobile[17]. The instability of the shoreline also hinges on different time scales: short (waves, tides), longer (deposits or extraction of sediments (re)mobilised during exceptional or seasonal events); geological time (eustatism, marine transgressions and regressions).

In every case, the line chosen is therefore only a **compromise** between different positions of the shore. Except in the case of unaltered rock formations, the position of the shoreline therefore remains difficult to define and should theoretically be the result of the **average of repeated measurements**. As part of the work conducted for the Aquitaine Coast Observatory, the French oceanographic institution IFREMER and Geological and mining research Bureau (BRGM) define *an average dynamic shoreline* ("a line of equilibrium marked by the berm crest in good weather or springtime") and *a maximum dynamic shoreline*, equivalent to the "line of dynamic action marked by the peak of the winter surges, the erosion beach scarps and the highest watermarks of tides". This definition is certainly the most commonly encountered on an international level. Note that for France the difference between these two measurements concerns an average height of approximately 1.20 m.

On another level, the length of the shoreline itself depends on the scale of its cartographic expression and **generalisations** (simplifications of the line) which are made when the scale is reduced, for in fact the shoreline is a fractal object.

[17] Especially on soft coasts, but rocky coasts also evolve on other time scales.

Lastly, in the case of estuaries, the limit to be placed can only be arbitrary, given the highly seasonal nature of the distribution of the salinity gradient of the waters.

While the definition of the shoreline today appears somewhat obsolete for geomorphological studies and tends to be replaced by morphodynamic monitoring of the shoreline making it possible to apprehend and characterise the processes governing its evolution, **it is still necessary for placing the legal and fiscal ownership boundary of the public maritime domain**, currently often based on the analysis of the distribution limit of adjacent terrestrial plant formations characteristic of saltwater milieus.

HYDROGRAPHIC ZERO: level of the lowest spring tides (lowest astronomical tide), lower limit of the foreshore

ANNEX 2 – COASTAL SECTORS IN WHICH COASTAL DEFENCE SYSTEMS COULD BE CONSIDERED

Nota: Some of the sectors mentioned here are not directly threatened by coastal erosion, but control the erosive phenomena that occur in the(s) sector(s) downstream of the coastal drift and may therefore be concerned by the developments. The management scheme mentions the precautions to be taken before undertaking coastal defence mechanisms, and clearly stipulates that effective long-term results are rarely obtained. For the location of the sectors, please refer to the maps accompanying the management scheme.

MAURITANIA

No.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	**MR3**	**NOUAKCHOTT**							
7	**Sector**	**MR3-a**	**North Nouakchott**	**High**	**Regular**	**Yes**	**Yes**	**URBAN & TOURISM**		Yes
8	**Sector**	**MR3-b**	**South Nouakchott**	**Very high**	**Intensive and regular**	**Yes**	**Yes**	**URBAN & HARBOUR**		Yes

SENEGAL

No.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	**SN1**	**SAINT-LOUIS – GANDIOLAIS – GRANDE COTE**							
13	**Sector**	**SN1-a**	**Urban, periurban and heritage sector of Saint-Louis**	**Very high**	**Intensive and regular**	**Yes**	**Yes**	**URBAN & PERIURBAN**		**Yes**
14	**Sector**	**SN1-b**	**South Saint Louis and insularised Barbarie Split.**	**High**	**Intensive and regular**		**Yes**	**ENVIRONMENT & TOURISM**		
15	Sector	SN1-c	Grande Côte – Nyayes	Low	Watchkeeping and anticipation		Yes	ANTICIPATION	Yes	
16	**Sector**	**SN1-d**	**Kayar - Guedjewaie**	**High**	**Watchkeeping and**			**ENVIRONMENT**	**Yes**	

No.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
					anticipation					
	ZONE	SN2	DAKAR							
17	Sector	SN2-a	Dakar dune coast North Camberene – Yoff	High	Intensive and regular	Yes	Yes	PERIURBAN & URBAN		
18	Sector	SN2-b	Dakar rocky coast West Yoff - Cap Manuel	High	Intensive and regular	Yes	Yes	URBAN		Yes
19	Sector	SN2-c	Bay de Hann - Rufisque	Very high	Intensive and regular	Yes	Yes	ENVIRONMENT & URBAN		Yes
	ZONE	SN3	PETITE COTE							
20	Sector	SN3-a	Bargny - Kene - Ndiogom	Average	Regular	Yes		PERIURBAN	Yes	
21	Sector	SN3-b	Popenguine	Average	Regular	Yes	Yes	PERIURBAN		Yes
22	Sector	SN3-c	Saly - Portudal - Somone	Very high	Intensive and regular	Yes	Yes	TOURISM		Yes
23	Sector	SN3-d	Urban sector of Mbour	Very high	Intensive and regular	Yes	Yes	URBAN & TOURISM		Yes
24	Sector	SN3-e	Mbour - Pointe Sarène	High	Intensive and regular	Yes	Yes	TOURISM		Yes
	ZONE	SN4	SINE SALOUM							
27	Sector	SN4-a	Fadiouth peninsula and island	High	Intensive and regular	Yes	Yes	PERIURBAN & URBAN	Yes	

THE GAMBIA

NO.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	GM1	THE GAMBIA							
33	Sector	GM1-b	Banjul Centre	Very high	Intensive and regular	Yes		URBAN		
34	Sector	GM1-c	Banjul - Kololi Point	High	Regular	Yes		TOURISM		Yes
35	Sector	GM1-d	Kololi Point - Bald Cape	High	Intensive and regular	Yes		TOURISM		Yes

GUINEA BISSAU

No.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	GW1	GUINEA BISSAU							
43	Sector	GW1-a	Sector maritime North - Cap Varela	High	Regular	Yes	Yes	TOURISM		

GUINEA

SIERRA LEONE

NO.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	SL3	SOUTH CENTRAL SIERRA LEONE							
73	Sector	SL3-b	Shenge	High	Intensive and regular	Yes?		MANGROVES		Yes

LIBERIA

No.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	LR2	ZONE UNDER THE INFLUENCE OF MONROVIA							
83	Sector	LR2-a	North Saint-Paul river – Right bank	High	Regular	Yes	Yes	URBAN	Yes	
85	Sector	LR2-c	West Point - Mesurado mouth and harbour area	Very high	Intensive and regular	Yes	Yes	URBAN		
	ZONE	LR3	DOLOTA - BUCHANAN							

No.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
92	Sector	LR3-b	Buchanan	High	Intensive and regular	Yes	Yes	URBAN		

COTE D'IVOIRE

No.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	CI3	FRESCO - ASSAGNY							
115	Sector	CI3-c	Grand Lahou, right bank and Bandama estuary	Very high	Intensive and regular	Yes	Yes	URBAN & TOURISM		
	ZONE	CI4	RURAL SECTOR ASSAGNY - JACQUEVILLE - ABIDJAN WEST							
119	Sector	CI4-c	Jacqueville - West Abidjan	Average	Watchkeeping for the purpose of anticipation	Yes	Yes	ANTICIPATION	Yes	
	ZONE	CI5	ABIDJAN - PORT BOUET							
120	Sector	CI5-a	Port Bouet	Very high	Intensive and regular	Yes	Yes	URBAN & HARBOUR		
121	Sector	CI5-b	Port Bouet East	Very high	Intensive and regular	Yes	Yes	URBAN		
	ZONE	CI6	PERIURBAN AREA EAST ABIDJAN - GRAND BASSAM							
122	Sector	CI6-a	Abidjan East periurban area	High	Regular	Yes	Yes	URBAN		
123	Sector	CI6-b	Grand Bassam West coast	Very high	Regular	Yes	Yes	URBAN & TOURISM		
124	Sector	CI6-c	Grand Bassam	High	Regular	Yes	Yes	URBAN		
125	Sector	CI6-d	Bassam Estuary right bank	High	Intensive and regular	Yes	Yes	TOURISM		

GHANA

NO.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study

NO.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	**GH3**	**URBAN SECTOR AND PERIURBAN EXTENSION OF SEKONDI - TAKORADI**							
136	Sector	GH3-b	Takoradi	Average	Regular	Yes		URBAN & HARBOUR	Yes	
137	Sector	GH3-c	Sekondi	Average	Regular	Yes		URBAN & HARBOUR		
	ZONE	**GH8**	**ACCRA URBAN AREA AND EASTERN PERIPHERY**							
150	**Sector**	**GH8-b**	**Accra centre West**	**Very high**	**Intensive and regular**	**Yes**		**URBAN**		
151	**Sector**	**GH8-c**	**Accra centre**	**Very high**	**Intensive and regular**	**Yes**		**URBAN & HARBOUR**		
152	**Sector**	**GH8-d**	**Cut-off, wetland Tema West - Sakumo**	**High**	**Regular**			**PERIURBAN & ENVIRONMENT**		
153	**Sector**	**GH8-e**	**Tema**	**Very high**	**Intensive and regular**	**Yes**		**URBAN & HARBOUR**		
	ZONE	**GH10**	**VOLTA DELTA LEFT BANK**							
160	**Sector**	**GH10-b**	**Keta**	**Very high**	**Intensive and regular**	**Yes**		**RURAL AT RISK**		
161	**Sector**	**GH10-c**	**Keta - dyke**	**Very high**	**Intensive and regular**	**Yes**		**RURAL AT RISK**		
162	**Sector**	**GH10-d**	**Adina**	**High**	**Intensive and regular**	**Yes**		**RURAL AT RISK**		

TOGO

NO.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	**TG1**	**TOGO**							
166	**Sector**	**TG1-c**	**Lomé urban - East port**	**Very high**	**Intensive and regular**	**Yes**	**Yes**	**URBAN & HARBOUR**		**Yes**
167	**Sector**	**TG1-c**	**Lomé East**	**High**	**Regular**	**Yes**	**Yes**	**PERIURBAN**	**Yes**	**Yes**
168	**Sector**	**TG1-d**	**Togoville - Agbodrafo - Aného**	**Very high**	**Intensive and regular**	**Yes**		**RURAL AT RISK**		**Yes**

BENIN

NO.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study

NO.	Type	Ref	Description	Priority	Monitoring-Observation	Improvement	Sector scheme	Key set of problem issues	Potential developments to be anticipated	Case study
	ZONE	BJ1	GRAND POPO - WEST COTONOU							
169	Sector	BJ1-a	Border of Togo - Grand Popo	Very high	Intensive and regular	Yes		TOURISM		
	ZONE	BJ2	COTONOU							
173	Sector	BJ2-b	Cotonou airport to Port	High	Regular	Yes	Yes	URBAN	Yes	
174	Sector	BJ2-c	Harbour sector and Cotonou channel	High	Regular	Yes	Yes	URBAN & HARBOUR		Yes
175	Sector	BJ2-d	Ambassadeurs sector	Very high	Intensive and regular	Yes		URBAN		Yes

ANNEX 3 – REVIEW OF THE MOST COMMON COASTAL PROTECTION SOLUTIONS

DEFENCE OF COASTS AND DEVELOPMENTS: if the issues at stake are important, or even critical and cannot be moved, coastal defence solutions will be chosen, knowing that, as was largely shown by the European EUROSION programme (2004), heavy defences ("hardening" of the coast) generally lead to an aggravation of the initial situation in the long term. The costs must also be in phase with the stakes to be protected and funding must be available.

Reducing these impacts requires the **in-depth taking into account of the articulation between the developed and the undeveloped areas**. It should be noted that the implementation of heavy developments is particularly problematic, **when the direction of the coastal drift current is not constant throughout the year**, which is the case in many sectors of the West African coast (in particular the Petite Côte in Senegal).

PROTECTION WORKS: These are interventions based on the provision of materials form outside (tetrapods, blocks of rock, masonry) aimed at fixing the shoreline. The idea is to physically oppose the retreat of the shoreline.

Blocking exchanges with the sea: this blocking, which has sometimes become necessary (breakwater) leads to a rapid acceleration of the rates at which lagoons are filled in. It directly threatens the ecosystems in the intertidal zone situated opposite the breakwater. Whatever the materials used (gabions, ballast, concrete walls, etc.), **the purpose is to establish a shoreline that can resist the energy of the waves and of the sea.** The slope and/or the materials employed should dissipate some of the wave energy, to prevent a reflective phenomenon, that is too intense, which would inevitably lead to the undercutting of the foundations of the system, which in the long term would destroy it.

There are different formulas for blocking exchanges with the sea

- ⇒ **A gabion** is a metal cage filled with rock. Gabions are piled on top of each other to form a wall. They are used to protect a cliff or a sector in the short term only, for they are easily damaged by storm waves and because the cages tend to rust quickly. On the other hand, the fact that they are (relatively) permeable prevents the wave backlash from being too strong, which can lead to undercutting and destabilising of the structures.

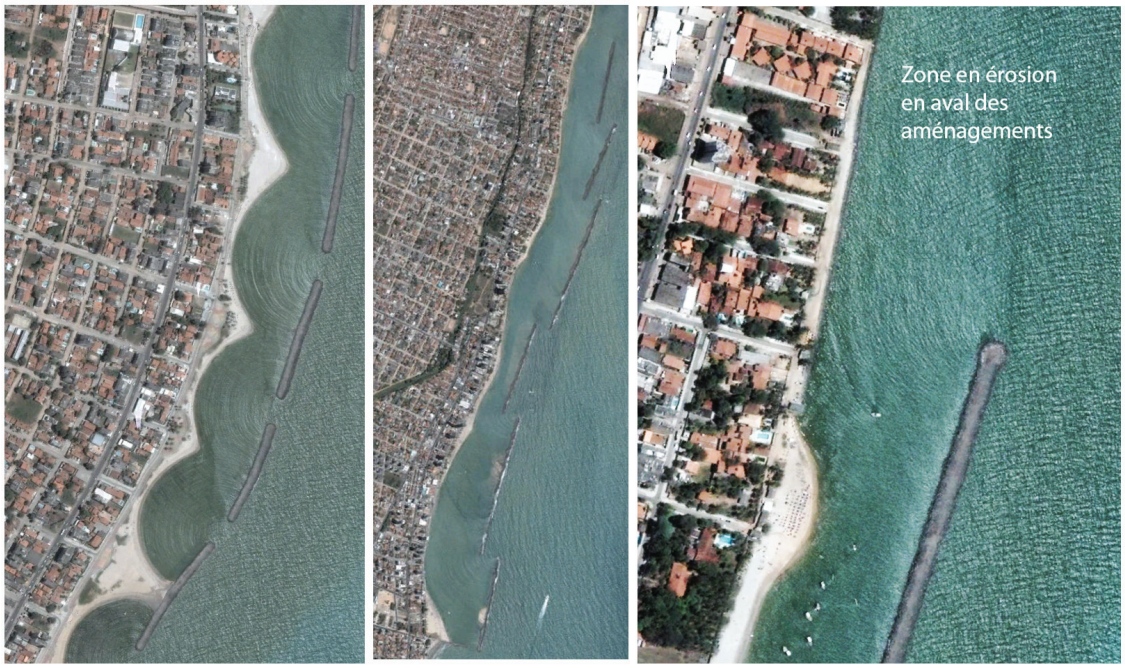
- ⇒ **A revetment** is a sloping feature which breaks up or absorbs the energy of the waves but may let water and sediment pass through. Rock armour or riprap consists of layers of rocks. It has the advantage of good permeability plus it looks more natural. Revetments have the same negative effects as walls and dykes, but to a lesser extent. They distort the seafront, which can cause changes in the foreshore ecosystem.

- ⇒ **Dykes separate the land from the sea**. They can also be used as supporting structure. They are mainly used to counter the erosion of the waves. Dykes may accelerate the erosion of beaches because a large part of the energy of the waves breaking on the structure is redirected to their foot. They do not protect beaches situated in front of them.

Works that alter longshore sediment transport (parallel to the shore): these are solutions perpendicular to the shore: groynes, rock fill. These works logically lead to accretion upstream of the structure and **increased downstream erosion** largely observed and today well known among coastal planners and developers.

Groynes are structures running perpendicular to the shore. Normally built in groups, their purpose is to trap and hold the sediment brought by the coastal drift. They interrupt longshore sediment movement. The sediment trapped and accumulated between the groynes creates downdrift sediment starvation. The problem of erosion is merely displaced. Groynes have a tendency to become unearthed when they are too far apart, and to send sediment seaward when placed too close together.

Solutions parallel to the shore altering wave energy: there are, in particular, breakwaters. These installations are placed on the shore face not far from the coastline. They have the effect of setting up a connecting bar between the structure and the shore. The effects on coastal transport can be relatively significant, as sediment deposited in the developed zones is no longer available in the undeveloped zones. They are therefore protective structures placed out to sea to absorb the energy of the waves before they reach the shore. Breakwaters reflect or diffract the energy of the waves, but they can also concentrate it on sensitive points. In this case, the erosion that affects the coast can lead to the destruction of buildings the breakwaters were supposed to protect.



Development of breakwaters in the North East of the Brazil (in the Recife region). From left to right: 1 - former developments, and placing of tombolos; 2 - more recent developments, the effects are not yet very visible; 3 - the beach located downdrift of the developments is being depleted.

The building of breakwaters gradually results in a cellular beach (see illustration above) with difficulties related to the renewal of water in the cells, which contributes to the development of organic pollution.

Tetrapods: These are artificial blocks made of concrete, used for coastal protection in several countries and in different climate conditions. They constitute a complementary protection system, reinforcing protective structures such as seawalls, dykes, etc. Their shape and size confer the double advantage of reducing the volume of materials and absorbing a large part of the energy released by the breaking ocean waves. The weight varies according to need, and is determined by sizing calculated on the basis of input parameters related to the characteristics of the ocean waves, among other things.

Tetrapods

SOFT SOLUTIONS: Soft solutions are rapidly developing. These solutions create a lesser impact on the sediment system of the beach, which does not always mean their cost is lower. In some cases, local or recycled materials are used (wooden fascines, posts, used tyres, etc..) or recent high-tech materials such as geotextiles. There is a wide diversity of solutions, especially since they are often the result of local initiatives.

Geotextiles: geotextiles are permeable fabrics which retain materials while allowing water to pass through. Geosynthetic tubes are of large tubes composed of woven geotextile fabric, filled with a sand mixture. Geotextiles have come into use relatively recently, but they have given good results in limiting the erosion of beaches, in particular for restoring the convexity of the of beach profile and raising the foot of the dune. They are also very flexible and can be rearranged if the way they are configured does not give good results.

Geotubes: Geotubes (Tencate Geotube ®) are tubular structures specially designed for use in erosion protection. Geotubes are put in place by hydraulic pumping with sandy materials (thanks to their rigidity). The geotube then becomes a flexible, monolithic, continuous structure that resists the force of the water. Geotubes are used for protecting banks, water courses and coastal areas as part of the combating of erosion, and for the construction of hydraulic and maritime structures. They offer numerous advantages, among the permeable fabrics which retain materials while allowing water to pass through. They can also be used as breakwaters.

Tencate Geotube ®)

By-pass this solution restores the movement of sediment retained updrift of a structure by pumping and evacuation downdrift. A variation consists in using harbour dredging materials to restore the sediment to the coastal drift current. When sediments is trapped by a series of groynes, the technique may no longer be profitable. In the case of harbours, the sediment accumulated is likely to be polluted and should not therefore be reinjected into the coastal system.

Stabiplage: STABIPLAGE® technology, used to combat marine erosion, was developed by Espace Pur in 1997. It differs from the traditional heavy techniques (concrete structures, rock fill, etc.). This technique is based on the use of structures that are “tailor made” for a project and installed depending on the physical characteristics of the site. The fundamental principle of the technology is therefore based on the trapping, accumulation and holding of sediment, while at the same time favouring the integration of the structures into the landscape. Stabiplage® is a multilayered structure designed from geocomposite materials (at least 2 layers: a permeable filter covered with a shell that is resistant to abrasion, UV rays, alkalines, micro-organisms, etc.). It forms a closed but permeable envelope, which, once injected with sediment, constitutes a monolithic body with an elliptical cross section, thereby reducing reflective phenomena. Stabiplage can be used in groynes or longitudinally to raise the foot of the dune.[18]

Re-sanding of beaches: this is the soft solution the most often adopted today when the issues at stake justify it. A large-scale operation (2,400,000 m3 of sand) was adopted in the Gambia as part of the operation

[18] Cariolet. J.M. 2008.**- Evaluation of the STABIPLAGE® technique implemented on two beaches in Finistère: Sables Blancs at Plobannalec-Lesconil-Loctudy, and Boutrouilles at Kerlouan**. Xèmes Journées Nationales Génie Côtier. 10p.

to restore/protect the Banjul coastal area). Note the large granulation of the materials to be employed. This solution is expensive (depending on the distance form the source of supply)

Drainage of beaches: this solution was considered back in 1975, and is today systematic and implemented under the brand name Ecoplage®. The procedure consists in laying drains under the beach, parallel to the shoreline and connected to a pumping station. The drainage dries out the foreshore, which slows down erosion and favours beach nourishment. The water produced by the system is perfectly filtered, and can be used to supply reverse osmosis desalination units, to reoxygenise eutrophied pools or lagoon .