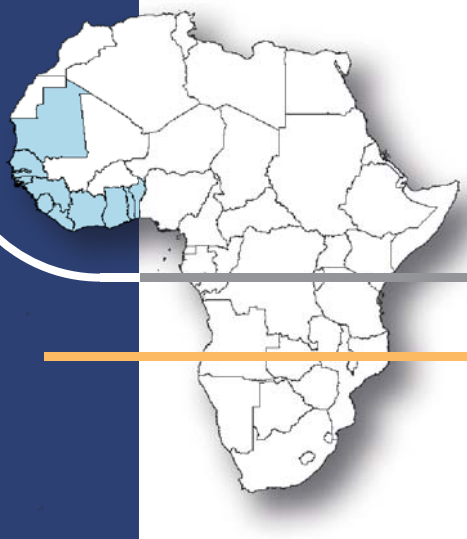
3B

Methodology



Etude de suivi du trait de cote et schéma directeur littoral de l'Afrique de l'Ouest

METHODOLOGY

2011

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.

IUCN, International Union for Conservation of Nature, helps the world find pragmatic solutions to our most pressing environment and development challenges. It supports scientific research, manages field projects all over the world and brings governments, non-government organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice.

IUCN is the world's oldest and largest global environmental network - a democratic membership union with more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries.

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.

Overall direction: Malick Diallo, UEMOA, Director of the Environment and of Water.
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Overall coordination: Mathieu Ducrocq, IUCN, marine and coastal Programme Regional Coordinator for Central and West Africa:

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

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

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1. INTRODUCTION

This procedural framework document was drawn up during the first weeks after the study started, with a view to defining the modes for implementing the operational system, the principal elements of methodology, and the approximate phasing of the work.

2. BACKGROUND TO THE STUDY

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 followed 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.

The study is positioned between the first and second of the four components of UEMOA's Regional Programme to Combat Coastal Erosion (PRLEC):

- Component no. 1: Research and Development.
- Component no. 2: Drawing up of a coastal development scheme
- Component no. 3: Studies for the execution of works.
- Component no. 4: Development and/or protection works.

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

⇒ **The PRLEC-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.

Given its establishment in the sub-region, the quality of its scientific and technical networks and experience acquired in other operations, such as the Mauritania Coastal Development Plan (PDALM) and the PRCM[1], UEMOA chose the IUCN[2] as project manager of the study.

This study is part of the remit of the 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) located in Ouagadougou.

[1] Regional Marine and Coastal Conservation Programme
[2] International Union for the Conservation of Nature

2.1. SYNERGIES TO BE ACHIEVED WITH OTHER REGIONAL PROGRAMMES

The study in question constitutes a key component of the system implemented by UEMOA to combat coastal erosion, in particular due to the fact that **the regional vision of coastal development** it promotes will constitute the backbone and consolidate the detailed studies and development action to be undertaken subsequently through other parts of the programme.

The desire for consistency, coordination and complementarity that characterises the UEMOA initiative should also express itself in the synergies to be found and developed with other programmes, including, in particular:

⇒ **Guinea Current Large Marine Ecosystem (GCLME):** this programme, funded by the GEF[3], started in 2004. The current phase is expected to achieve completion in 2010. It involves all the coastal countries from Guinea Bissau to Nigeria, and the countries of Central Africa to Angola. The programme broaches all the compartments of coastal management, starting from a diagnostic approach (national coastal profiles) with a view to drawing up a strategic regional plan. Demonstration projects are implemented in different domains and sectors: evaluation of fish stocks, conservation of biodiversity, prevention and control of different forms of pollution, legal and regulatory aspects. **GCLME coordination was associated with the initial interviews with the representatives of UEMOA.**

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

⇒ **The regional programme Adaptation to Climate and Coastal Change in West Africa (ACCC[4]):** the adaptation to climate change programme is financed by the GEF and covers Cape Verde, the Gambia, Guinea Bissau, Mauritania and Senegal. It allows for the implementation of pilot protection and adaptation operations in the five countries concerned. The implementation of the current phase will end in 2010.

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

The scheduled works have already been preceded by the WACAF III programme, which visibly involved different players of importance in the region. The results of this programme will be **effectively used** by the study, in particular through the diachronic analysis to be carried out in comparison to the situation described in 1985 in the Coastal Erosion in West and Central Africa report[5].

We should also mention the GIWACAF programme, set up by the International Maritime Organisation (OMI) and International Petroleum Industry Environment Conservation Association (IPIECA).

3. EROSION CONTROL AND/OR COASTAL DEVELOPMENT?

Initial contacts established with a view to commencing the work quickly revealed a variety of different interpretations of the actual content of the study.

The monitoring and updating of the shoreline constitute a specific aspect related to mobility and the dynamics of coastal formations. On the other hand, a coastal development scheme covers a much vaster reality, incorporating multiple problem issues related to development and the human use of land

[3] Global Environment Facility
[4] Adaptation to Coastal and Climate Change in West Africa
[5] Regional seas reports and studies no. 67.

in proximity to the sea. These problem issues should also be apprehended with the future in mind, in relation to more or less distant dates (2020 and 2050).

Limiting the study to a focus on coastal erosion alone runs the risk of ignoring the development dynamics that underpin and explain the current and future impacts and stakes involved in the observed mobility of the shoreline. Extending the ambition of the work to include the production of a coastal development scheme would inevitably lead to a dead end, given the time frames and means made available for working on a total eleven countries.

As an example, the process which led to drawing up the development scheme for the coast of Mauritania lasted over 18 months, with the setting up of a forward planning project and corresponding support and communication operations, aimed at promoting the involvement of the different interest groups in the project.

Given the notion of **subsidiarity**, it could conceivably be difficult for a regional scheme to act as a "master plan", that is to say, to be binding on the States concerned.

The mission therefore proposed that the arbitration between an approach exclusively focused on coastal erosion and the more ambitious vision of a coastal development scheme be expressed through the objective of producing **a regional plan for climate change adaptation and coastal risk reduction in West Africa**.

This approach presented the advantage of incorporating the forward planning aspect through climate change adaptation, while at the same time proposing an approach not limited to coastal erosion, but which could also, depending on the available data, include other sets of coastal problem issues (development, pollution, natural resources, etc.).

This perspective also presents the advantage of **resulting in a rigorous framework** depending on three **risk** components[6]:

⇒ **HAZARDS**

Natural hazards: "Natural hazards comprise phenomena such as earthquakes; volcanic activity; landslides; tsunamis, tropical cyclones and other severe storms; tornadoes and high winds; river floods and coastal flooding; wildfires and associated haze; drought; sand/dust storms; insect infestations." (ISDR –International Strategy for Disaster Reduction).

Technological and/or industrial hazards: these are determined by technological and/or industrial accidents, but can also be dependent on or triggered by natural hazards (earthquakes and nuclear accidents, storms and oil spills, for example). **The international strategy for disaster reduction only applies to industrial, technological or environmental disasters when these are caused by natural hazards.**

⇒ **VULNERABILITY:** "The degree to which a system, community, structure, service or geographic region is susceptible to damage or serious disruption under the impact of a particular threatening disaster. Vulnerability is the expected degree of damage to people and property following a particular hazard."

⇒ **THE ISSUES AT STAKE** in social, economic, environmental and more generally developmental terms.

[6] The elements of definition below are taken from the e**valuation of the actions of France in terms of risk reduction in developing countries since 2000**. Ministry for Foreign and European Affairs - Assessment Bureau (JJ Goussard & al.)

3.1. UNCERTAINTIES RELATED TO THE NOTIONS OF SHORELINE AND COASTAL AREA

3.1.1. THE NOTION OF SHORELINE

At first sight, the notion of shoreline seems intuitively easy to understand: *the line that separates the ocean from the land.* In reality, drawing the shoreline would involve fixing a "static" limit within a milieu, the shore, that is primarily characterised by its dynamic, mobile nature and by the fact that it belongs to both land and sea. It should therefore be accepted a priori that the shoreline is generally mobile[7].

Conventionally, and in several programmes (such as EUROSION[8]), the shoreline is defined as the maximum level reached by the sea at the highest annual tides (for example, considered with a coefficient of 120 in Europe). Numerous factors (wind, swells, atmospheric pressure, etc.) can however, and with a same tide coefficient, alter this line, **which therefore remains primarily a convention**.

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 the 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 tidal watermarks". 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 (which is a fractal object) itself depends on the scale it is mapped on and the successive **generalisations** (simplifications of the line) made as the scale is reduced.

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 coastline today appears somewhat obsolete for geomorphological studies and tends to be replaced by morphodynamic shoreline monitoring making it possible to apprehend and characterise the processes governing change**, 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 bordering terrestrial plant formations characteristic of saltwater milieus.

3.1.2. THE NOTION OF COASTAL AREA

In practice, how the coastal area is defined often depends on why it is being defined, from the "state" coastal area limited to the PMD[9], 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

[7] Especially on soft coasts, but rocky coasts also evolve on other time scales.
[8] European Coastal Erosion Programme.
[9] Public Maritime Domain

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.

Acknowledging 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 a wider, more social than territorial consideration of a band of land that, from the point of view of a legal system, remains divided between public law, that applies to the PMD, and private law that applies outside the PMD[10]. In West Africa, common law land tenure 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 both 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 stakeholders, 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 public maritime 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, often applicable, consists in considering the sediment formations originating from deposits and fashioned by marine currents, and linked to the interaction of the two sedimentation systems, terrestrial and marine (intertidal zone, dune belts, lagoon systems, delta formations, brackish waters and wetlands) whose regime is in particular linked to tides.

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[11] 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 corollary of the diversity of players and stakeholders is a variety 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 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

[11] Exclusive Economic Zone

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.

4. SPECIFIC PURPOSE OF THE STUDY

The specific purpose of the study is to provide the countries in the sub-region with a coordinated, forward-looking vision of coastal risks and the measures to be considered to cope with them.

In the work to be conducted, the accent will be placed on the following points:

- ⇒ Harmonisation of national coastal development approaches and coastal erosion risk management.
- ⇒ Modes of national capacity building for the management of coastal risks.
- ⇒ Modes of organisation of a regional coastal erosion monitoring system.
- ⇒ Promotion of new approaches to controlling coastal risks, making use of natural infrastructure and structural measures for territorial development.

Including this intermittent study within the wider framework of the UEMOA Coastal Erosion Programme **implies thinking in terms of process**. It is not solely a question of producing the deliverables defined below, **but also of making sure that the work to be done contributes to creating long-term dynamics at the service of the development of the coastal areas of West Africa. It is therefore a question of taking into account existing processes, committing to them, and as far as possible reinforcing them while at the same time making optimal use of the resources and current efforts invested in each country.**

5. COORDINATION AND SYNERGIES TO BE DEVELOPED

The viability of the results of the study will depend on how successfully it is integrated within long-lasting, active regional networks. In the same way, optimising the means allocated implies the necessity of working in close cooperation with the other projects and actions currently underway.

5.1. THE ABIDJAN CONVENTION: **A FRAMEWORK OF CAPITALISATION AND VIABILITY OF THE APPROACHES ENGAGED**

The countries in West Africa signed the Abidjan convention in 1981. This convention is intended to control terrestrial and marine sources of pollution, harmonise and strengthen national coastal management policies, and cooperate with the other countries in the sub-region, to improve environmental management. The signatories of the convention are also obliged to take the necessary measures to control and attenuate coastal erosion and its causes, and draw up emergency plans to prevent and treat pollution caused by the oil and transport industries. Under the terms of the convention, the countries should also conduct environmental impact studies for new projects in coastal areas, in order to control uncoordinated, unplanned projects that could accelerate pollution and erosion. The difficulties encountered by the convention in setting up an effective regional coordination unit led UNEP[12] to create a common secretariat for the Abidjan and Nairobi conventions, which has been operational since September 2000. The new work programme for the countries in the Abidjan convention comprises the evaluation of coastal erosion, and activities aimed at improving the management of coastal ecosystems, with a particular interest for mangroves and oil pollution.

[12] United Nations Environment Programme

5.2. THE IMPLEMENTATION OF A FUTURE REGIONAL COASTAL OBSERVATORY

This initiative, mentioned by some of the mission's contacts, remained an option when the study commenced. Such an observatory nonetheless constitutes a perfectly legitimate focal point for the supervision and coordination of the coastal erosion monitoring programme the study is intended to help define.

5.3. TOWARDS THE IDENTIFICATION OF BANKABLE PROJECTS FOR ADAPTING TO CLIMATE CHANGE AND RISK REDUCTION BY THE STATES IN THE SUB-REGION.

The different States in the sub-region ratified the United Nations Framework Convention on Climate Change (UNFCCC) and therefore internalise its provisions in national sectorial policies and development plans.

Different sources of funding for adaptation in West Africa are currently being set up, in particular at the level of the AfDB[13] as part of the ClimDevAfrica initiative, steered by the joint AfBD – African Union, United Nations Economic Commission for Africa secretariat. The World Bank, along with 13 other national contributors, has also set up the Global Facility for Disaster Reduction and Reconstruction (GFDRR), the vocation of which is to finance actions and projects to reduce and attenuate risks.

The data and directions gathered through the study should facilitate the formulation of national and/or regional adaptation initiatives for the coastal zones of the countries of the sub-region.

5.4. EFFECTIVE NETWORKING OF NATIONAL, REGIONAL AND INTERNATIONAL RESOURCES FOR MONITORING AND DECISION-MAKING SUPPORT IN TERMS OF COASTAL EROSION CONTROL AND COASTAL RISK REDUCTION

One of the direct effects of the study concerns **the networking of researchers, research centres and centres of excellence in the sub-region** in terms of combating coastal erosion and reducing coastal risks.

This networking should be extended to other programmes in the North-South framework, such as, for example, the Atlantic Network for Coastal Risk Management (ANCORIM) programme - a network of the regions in the European Atlantic Arc for the reduction of coastal risks, currently in the start-up phase, and already contacted by the mission.

This programme is geared, in particular, towards the **production of teaching guides and a coastal risk management portal** intended for decision-makers and elected representatives in the European regions concerned. These products should provide access to all European resources on the management of coastal risks, including erosion. Other networks, such as the European scientific network ENCORA, will also be contacted. These contacts will be stimulated by the involvement in the study of European laboratories such as GEOMER in Brest, and the involvement of other technical and scientific institutions which have for example worked with the European EUROSION programme.

Other organisations will also be contacted with a view to initiating a cooperative approach, such as the European Conference of Peripheral Maritime Regions (CPMR) and nrg4SD[14]

[13] African Development Bank
[14] Network of regional governments for sustainable development.

5.5. POSSIBLE COLLABORATION WITH NATIONAL PLATFORMS SET UP WITHIN THE FRAMEWORK OF THE INTERNATIONAL STRATEGY FOR DISASTER REDUCTION (ISDR).

Within the framework of the international disaster reduction scheme, national cross-sectoral platforms have been set up. These are not always operational, but when they are, they may constitute important relays for rapid access to the different sectors around coastal problem issues, often considered a priority in terms of adaptation and risk reduction.

Senegal, for example, has adopted different measures, including the integration of risk reduction within its SFPR 2, following the adoption of a national strategy for social welfare and disaster risk management. It has also committed to drawing up a national disaster risk management programme, which is to be hinged to the good governance strategy and scheme. All of these initiatives have been integrated into a programme supported by the UNDP: ***Project to provide support to the National Prevention, Major Risk Reduction and Natural Disaster Management programme in the context of poverty alleviation in Senegal.***

6. IDENTIFIED CONSTRAINTS AND RECOMMENDED PROCEDURAL OPTIONS

6.1. TIME SCALES

The time frame for conducting the study, initially in the order of 18 months for a study covering eleven countries, implied the implementation of efficient procedures, and a certain number of methodology choices:

- ⇒ **Optimisation of information gathering from reliable, recognised existing sources :** the means available should be mobilised as far as possible in favour of the national teams, and not for resuming large-scale geomatics work (assembly and mosaicking of national topographical coverage to obtain a regional map, for example) which is both too expensive and too "time consuming", for results that are not always dependable. Recourse to uniform geomatics coverage in public distribution for the whole of the region should make it possible to achieve pertinent results within the time frames, given the scale of the work, if the visual interpretation of the remote detection products is high quality and based on the cross-referencing of different existing sources of information. On the other hand, image acquisition will be envisaged in support of the detailed studies (case studies) on vulnerable or priority sites, to be identified in each of the countries.

- ⇒ **Amplification of the study according to an iterative principle,** enabling the global regional vision to be integrated at each stage with the detailed analysis at national level (analysis principle "---" globalyse).

- ⇒ **The study will be based on existing information**, with added value residing mainly in the summarising, analysis and integration of this information on a regional scale.

- ⇒ **Involvement of the stakeholders to be managed:** under this considerable time constraint, the priority is to establish an adequate balance between two necessities: (i) make sure the process is as open and cooperative as possible; (ii) reduce the inevitable slowness of consultations on a regional scale.

6.2. MAP RENDERING SCALES

The terms of reference of the study mention a working scale of 1/250,000, which is relatively suitable for a regional map (this map would cover approximately 15 metres, which is approximately fifteen A0 sheets), but too small for an effective representation of the situation and the local dynamics that have an impact on the shoreline. These are more easily perceptible and represented at larger scales, from one in 5,000 to one in 25,000.

Map rendering should therefore combine (i) a geodynamic analysis and the issues at stake on a regional scale with (ii) local case studies of sites of interest at greater scales, which may be variable.

For practical reasons and enhanced legibility, the various maps have been presented on a scale of 1:500,000, even when the actual analysis was conducted at 1:250,000 (see document 3A).

6.3. DATA ACCESS

Data access constitutes a major difficulty, the reality of which was observed by the preparatory mission. Depending on the sector and type of data sought, it is very rare to be able to bring together sets of homogeneous data for the whole of the area, which is both reliable and up to date.

Furthermore, access to this data remains problematic, in particular for spatially explicit data, often brought together for projects that are closed today and the archives of which are not always accessible.

The work should, as far as possible, be based on a common information platform available at regional level for all the countries concerned (satellite imagery, databases from the international public domain, from the IUCN commission on protected areas, the works of the Sahel Club, ECOWAS data, the GEOPOLIS programme run by the French National Scientific Research Centre and French Development Agency (CNRS/AFD), from the NOAA shoreline programme, etc.). This information archive will then be validated and possibly added to during the work of diagnostics by the experts recruited in each country.

In certain critical domains, the information available is very fragmented, or even incomplete and difficult to obtain. This is the case, for instance, regarding bathymetry, especially of the nearshore and the nature of the sea floor. An approach will be made to the French Naval Hydrography and Oceanography Service (SHOM[15]) to try to recover this indispensable information.

7. OVERALL ORGANISATION OF THE STUDY

7.1. COUNTRIES CONSIDERED

The study concerns the entire Atlantic seafront of West Africa, from Mauritania to Benin. Steps have been taken to include Cape Verde, but so far there has been no response.

7.2. CONTRACTING OWNERSHIP AND SUPERVISION

The study will take place under the supervision of two bodies representing the contracting ownership: the steering committee and the scientific committee, set up by UEMOA. The list of the principal members of these committees is given in appendix 1.

7.3. GENERAL PHASING

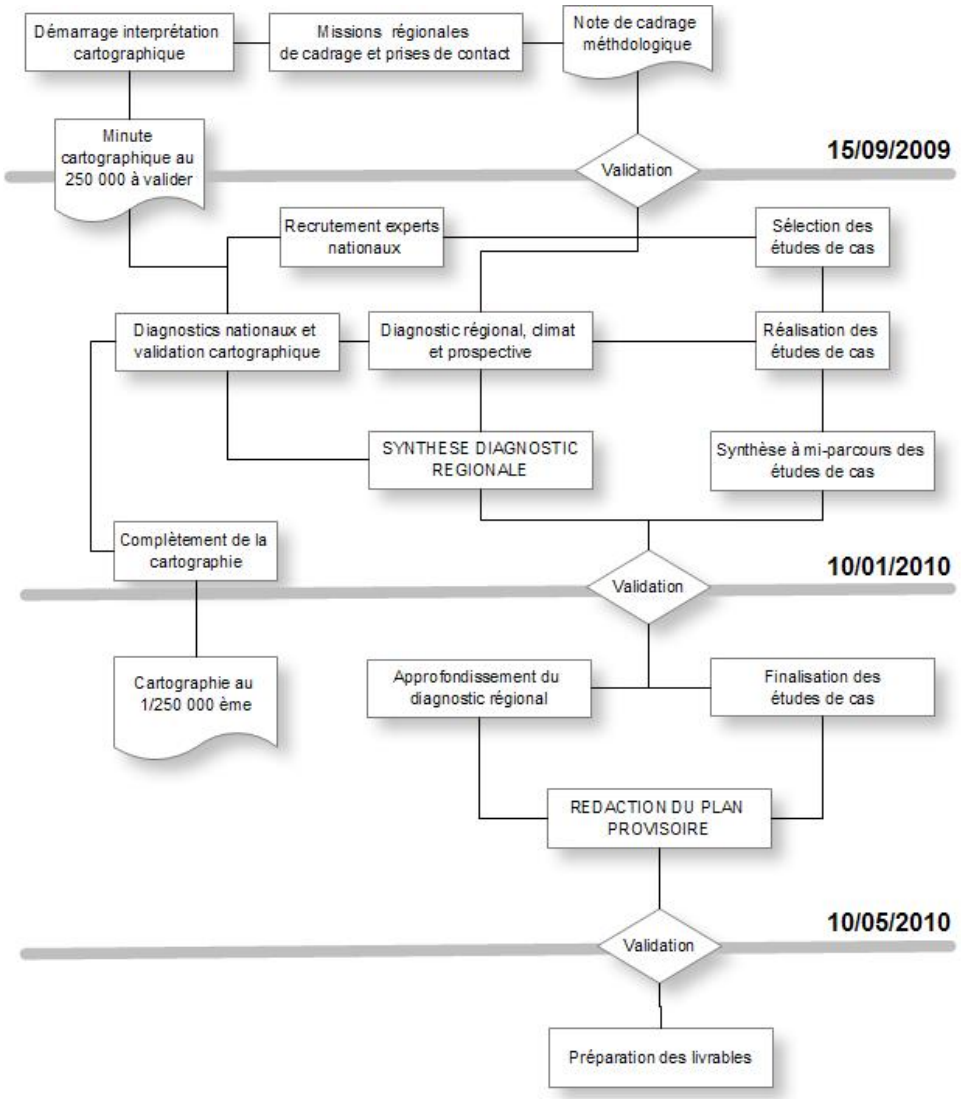
The general phasing of the study is built around four stages:

⇒ Preparatory phase

[15] Service d'Hydrographie et d'Océanographie de la Marine

⇒ Diagnostics and provisional regional summary
⇒ Further elaboration
⇒ Restitutions and handing over of deliverables.

These four phases are paced with stages of restitution-validation by regional committee. These regional meetings involving the UEMOA scientific committee and steering committee will give rise to the presentation of the results of each phase, with reports being submitted in advance. There are three separate restitution stages (see schema below):



7.4. REGIONAL SUMMARY AND CASE STUDIES

Given (i) the necessity of achieving an integrated regional vision of the problem issues broached; (ii) at the same time respecting the constraints of scale for the characterisation of coastal risks, a division of the work is proposed in various separate but complementary spatial and time scales:

Spatial scales:

⇒ Global scale, for the treatment of topics which cannot be reduced to a regional scale.

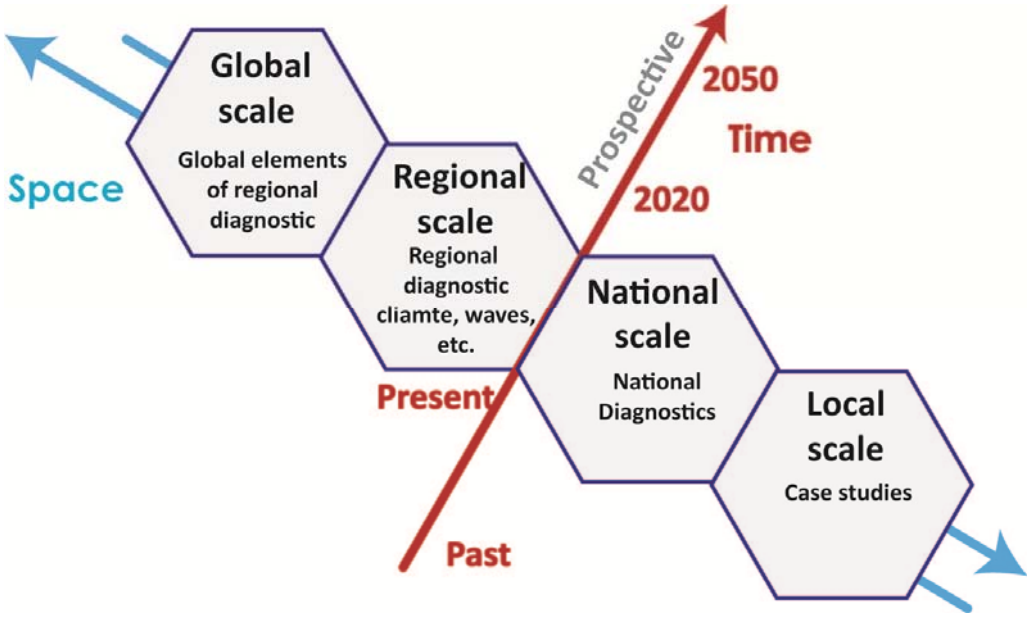
⇒ Regional scale, for the treatment des topics shared by the States in the region and cross-border (ocean waves, oceanography, etc.) supported by regional maps.

⇒ National scale: through the national diagnostic reports

⇒ Local scale: a level of detail based on localised case studies in the different countries.

Time scales:

The work conducted on the different scales mentioned above allows the current situation to be characterised taking the past into account. An exercise in demo-economic forecasting has been implemented to 2020 and 2050.



Spatial and time scales considered in the study

7.4.1. REGIONAL SUMMARY AND NATIONAL DIAGNOSTICS

The regional summary will be spatially expressed through **an ov erall 1/250,00 0 m ap** of the geodynamic analysis of the coast. This analysis will identify the sensitive and vulnerable areas of the coast, but also specify and pinpoint the issues at stake geographically.

This is a unique, original production on a regional scale, a fact which deserves to be pointed out. This cartography does not constitute the central objective of the study, however, and it is important to correctly size the means to be assigned to it, which has led the mission to recommend work based on public data that is accessible and homogeneous for the entire study area, as the acquisition and processing of new data would be very expensive and not justified given the footprint of the area. Complementary elements about the approach developed for this cartography are given in the cartography information presented in document 3A.

For the diagnostic, there is a distinction between: (i) the compartments handled directly at regional level (climate, currents systems, bathymetry, geodynamic characterisation of the coast, conservation of biodiversity, etc.); (ii) the compartments approached at national level, which will be the subject, in a second instance, of a regional summary (all other sectors).

In the national diagnostics, the spatialisation of information is essential. It will be produced on a base map at 1:250,000 which will be provided with the terms of reference. The national consultants will also validate and possibly amend the mastercopy of the coastal geodynamic analysis map.

This work of regional summary and national diagnostics will be produced by a group of consultants including:

- ⇒ **International resources:** group of experts from the consultancy firm EOS.D2C including an ecologist, a geographer/cartographer; an expert in demo-economics; a climate specialist and various resources, in particular in hydrology and sedimentology, who may be sought out depending on needs from specialist public bodies such as the French BRGM. The work concerning aspects related to climate change and its impact (prospective depending on IPCC scenarios) will be entrusted to the African Centre of Meteorological Application for Development (ACMAD) which will have the capacity to provide results validated by its various international partners (World Meteorological Organisation, Météo France, UK Met office, NOAA, national weather and hydrology services, etc.).
- ⇒ For statistical data, other sources will be solicited, such as the OECD's Sahel and West Africa Club or certain specialised programmes such as AMMA[16] or the CNRS' AFRICAPOLIS
- ⇒ A quality circle will be set up by EOS.D2C combining an extended skills network, which will be called upon to review all the documents produced.

- ⇒ **National resources:** these will be placed, for each country, under the direct responsibility of a national consultant hired by the IUCN (individual consultant, public institution or consultancy firm) to be entrusted with specifications (given in appendix 2), and responsible for mobilising the different thematic resources required at national level. These national consultants will be supported and accompanied in their work by the international consultant.

Phasing of the regional summary

The work of diagnostics will basically include four phases:

- ⇒ National and regional diagnostics
- ⇒ Provisional regional summary
- ⇒ Reports going into greater depth on national diagnostics
- ⇒ Final regional summary

September 2009	Validation of the overall methodology of the study, the terms of reference and the specifications documents for the national consultants
September-October 2009	Hiring of national consultants
October 2009	Launch of works with the support of the international consultant
October to end November 2009	National diagnostics
December 2009	Provisional regional summary
January – February 2010	Reports going into greater depth on national diagnostics
March 2010	Final regional summary and finalisation of 1:250,000 cartography Expressed at 1:500,000.

[16] African Monsoon Multidisciplinary Analyses

7.4.2. FORWARD PLANNING

Due to the heterogeneous nature of national data, and the time frames involved, it is not possible to envisage the setting up of a formalised forward planning project at regional level. On the other hand, other data existing at regional level will enable the sketching of various scenarios:

- ⇒ Data from the Sahel and West Africa Club, particularly on the basis of the Vision 2010 work on West Africa.
- ⇒ AFRICAPOLIS data on the dynamics of urban expansion.
- ⇒ The work of climate change scenario analysis which will be entrusted to the ACMAD.

The horizons for this forward-thinking exercise were set during the validation workshop in September 2009. The demo-economic forecast study will be conducted according to the methodology developed for the OECD's WALTPS study.

7.4.3. CASE STUDIES

The case studies concerned all of the sites chosen for their relevance, illustrating one of the following situations:

- ⇒ **Analysis of active coastal erosion** and/or accretion processes corresponding to significant social and/or economic stakes**.**

- ⇒ **Analysis of the impacts and effectiveness of coastal defence solutions and developments** already in place for a long time**.**

The feasibility of these case studies involved, in every case:

- ⇒ **The availability of historical data** (profile surveys, aerial photographs, topographical surveys, photographs of sites, etc.).

- ⇒ **The existence of teams and/or researchers already involved** in these sites**:** it is desirable to make use of existing research work and/or theses, as the means mobilised for the needs of the study could incidentally allow researchers already working on coastal erosion to complete their studies, while making use of their results and providing them with visibility.

The diversity of the situations encountered and of the teams called upon to intervene ran the risk of leading to a heterogeneous body which would make it difficult to identify lessons to be generalised. For this reason, it was deemed appropriate to set up specific coordinated support. This methodology support was embodied by the GEOMER laboratory, in particular through the mobilisation of Mr Ibrahima Faye, who was completing his thesis on the coastal erosion of four sites with this laboratory.

In parallel, the centralisation of data and the associated cartographic production was, for reasons of homogeneity, entrusted to CSE in Dakar, with the support of GEOMER for defining unified cartographic semantics and expression on the scale of all the work of the case studies. This harmonisation of the map rendering methods was the subject of a document produced by GEOMER and provided in annex 3.

The map rendering of case studies was therefore be assisted by the CSE in Dakar, which centralised the data. The centralising of data is an opportunity to build a database of spatial data on coastal erosion on a regional level, located within the CSE and, in the long term, any institution chosen by the countries represented in the steering committee.

Selection of case studies

The case studies were selected following an open, regional call for proposals, with the technical assessment of the proposals being aided by the GEOMER laboratory in Brest. These proposals were

also examined by the IUCN and selected according to (i) feasibility; (ii) the relevance of the sites chosen to obtain a set of case studies that is representative of the coastal erosion problems at regional level; (iii) the available budget.

Launch of the case studies

The first stage of the case studies included the production of brief procedural guidelines and the initiation of dialogue between the study operator teams and the GEOMER laboratory. The researcher-operators also went to the CSE in Dakar to establish the format for data restitution in each case depending on (i) the structure of the database of spatialised data to be set up; (ii) prescriptions established by the CSE and GEOMER for map rendering.

Phasing of case studies

Beginning of September 2009	Preparation of the terms of reference for the methodology support and the implementation of unified cartography from GEOMER (GEOMER's contribution) Preparation of the terms of reference for cartography support and the implementation of a CSE database of spatial data on coastal erosion Finalisation of the format for case study proposal and the call for proposals document
September 2009	During the seminar for the validation of the procedural guidelines for the study, the launch of the call for case study proposals from all the representatives of the countries concerned.
October 2009	Submission of proposals and selection of case studies. Defining of contracts for the teams.
Beginning of November 2009	Start-up of case studies. Start-up of GEOMER methodology support Start-up of the work of CSE
End of December 2009	Submission of a progress report by the teams in charge of the case studies, GEOMER and CSE
End of March 2010	Finalising of the work of case studies and submission of provisional results
End of June 2010	Submitting of final results and maps of the case studies

8. ANNEXES

Annex 1: Preliminary elements of methodology for the geodynamic analysis mapping of the coast at a scale of 1:250,000.

Annex 2: Specifications and format of national diagnostic studies.

Annex 3: Segmentation of the study zone for the national diagnostic studies.

Annex 4: Form for presenting case study proposals.

Annex 5: Recommendations for the large-scale mapping of case study results

Annex 6: Detailed list of national, regional and international expertise involved in producing the study.

ANNEX 1. CARTOGRAPHY DOCUMENT ON THE GEODYNAMIC ANALYSIS OF THE COAST AT 1:250,000, PRELIMINARY REFLECTIONS ON METHODOLOGY

1. THE OBJECTIVES OF THE DOCUMENT

The document aims to encourage a comprehensive approach to the present day dynamics of the coastline of the region, and present hypotheses as to future trends. These objectives require the prior availability of a document:

- ⇒ Produced using the same norms across the entire study zone, to enable a comparative view of all the countries concerned, and an overview of the regional coastline.
- ⇒ Presenting a systemic review of the natural coastal milieus and of their surrounding land and sea environment.
- ⇒ Locating the main stakes resulting from human land use in and around the coast in the present day and the future trends.
- ⇒ Identifying inland wetlands and lagoons directly or indirectly affected by regular tides or exceptional marine intrusions.
- ⇒ Enabling the spatialisation in the course of the study and in the final phase, of the relevant data collected during field surveys (historical date on trends in the coastal area, various erosion control developments, etc.).

2. DOCUMENT PRODUCTION

Conventionally, the work will proceed according to the following three stages:

Stage 1: Preliminary cartographic analysis based on the analytical interpretation of a colour composition produced from Landsat CIRCA 2000 pictures presented on a scale of 1:250,000 after processing carried out within the framework of the study. This detailed analysis work (visual interpretation) will lead to an unpublished working document which will be (i) completed; (ii) generalised to obtain the final map expression.

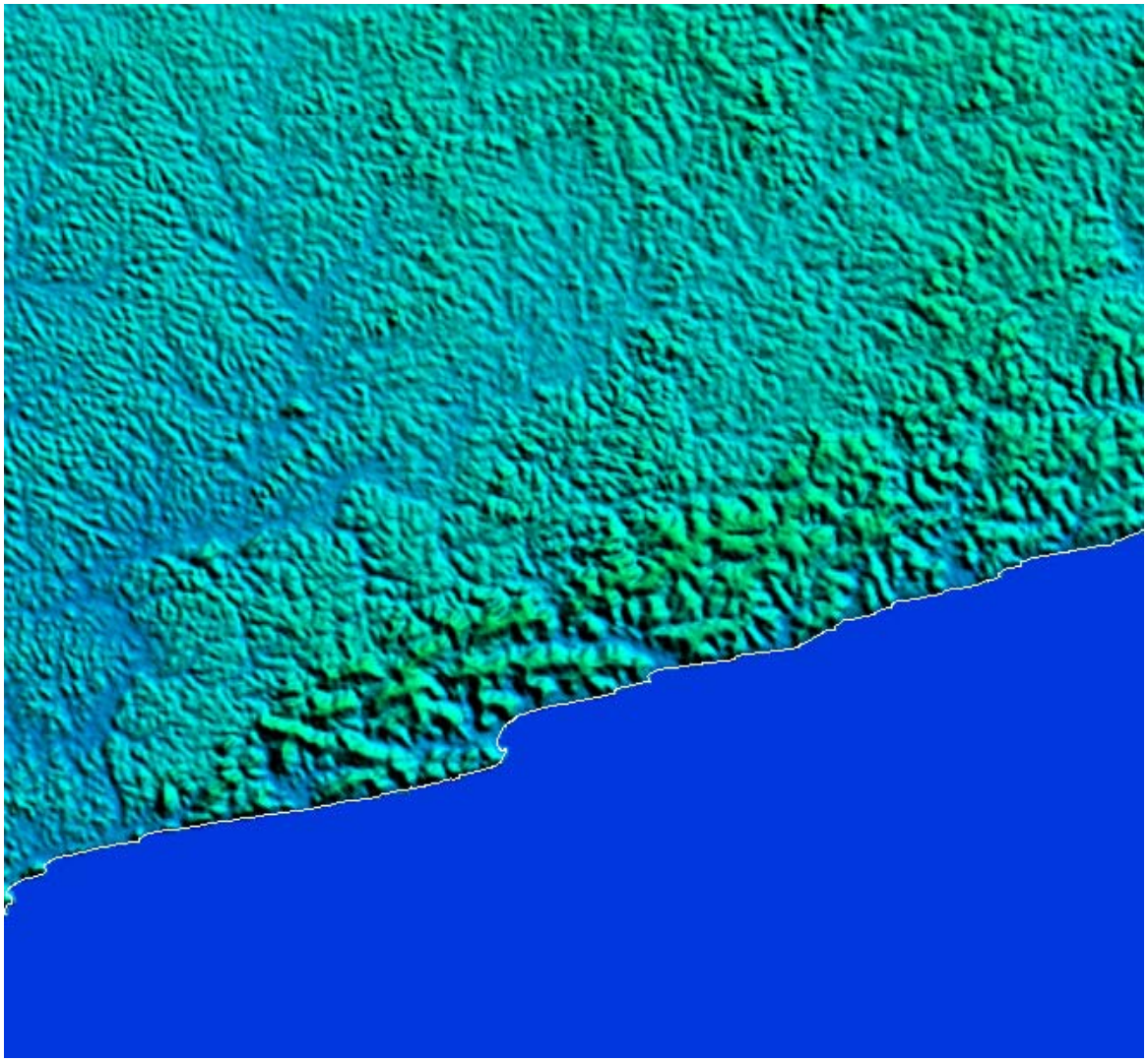
The visual interpretation work takes into account and cross-references the various sources of geographic data available (other Landsat 7 TM images, topography maps, ecology maps, pedology maps, topical maps, etc.). The provisional 1:250,000 document obtained in this way will be used to:

- ⇒ Establish an initial diagnostic of the dynamics and the stakes across the entire study area.
- ⇒ Provide a base to facilitate the planned ground surveys, which should focus on geographic and topical priorities enabling data collection to be targeted. These surveys will also be used to validate and complete the document.

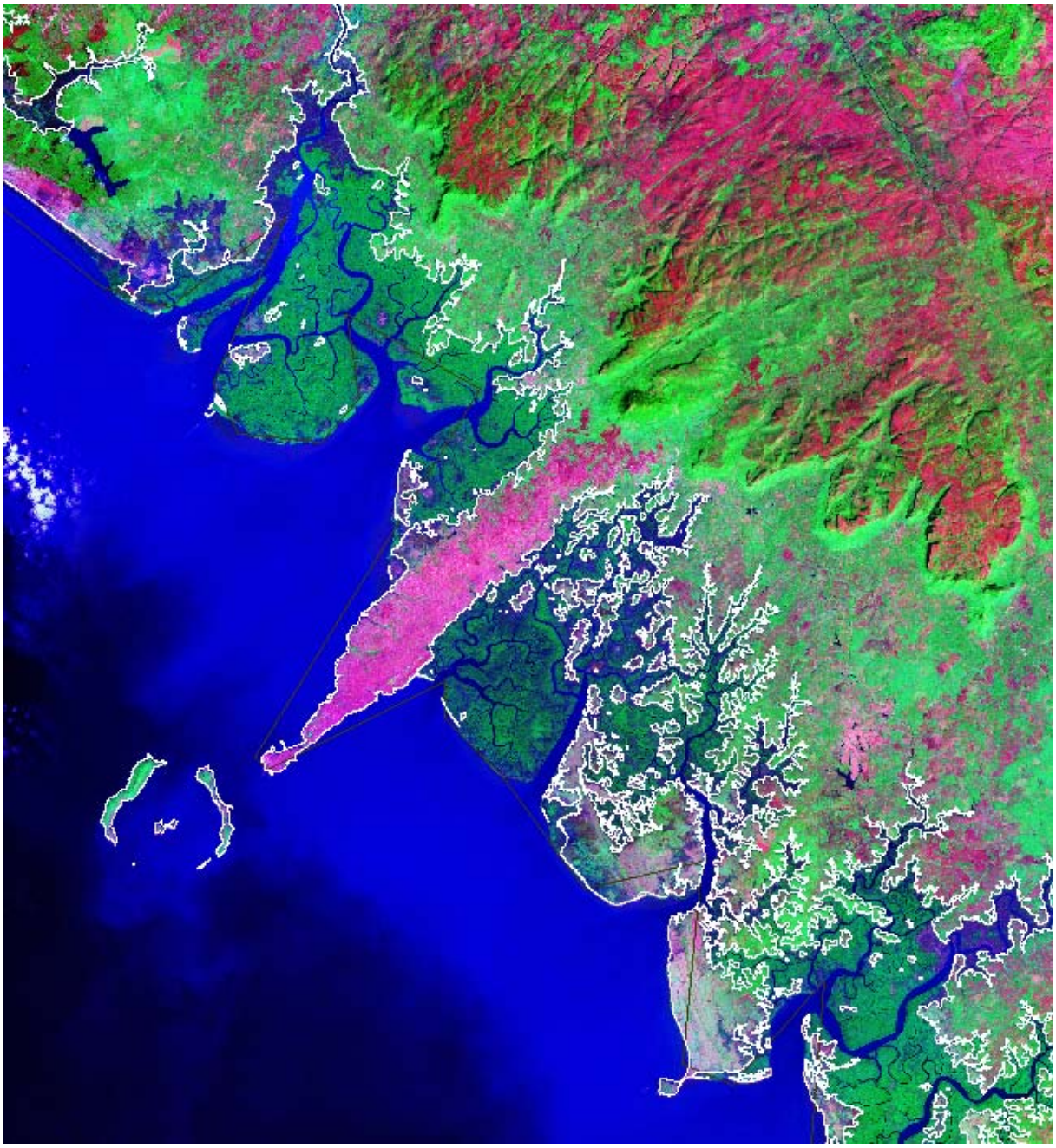
It should be pointed out that the large number of information sources, sometimes on large scales (aerial photographs for example) leads to an interpretation grid that is not 1:250,000, but more often 1:50,000. Rendering this level of detail on a scale of 1:250,000 will require an intermediate phase to establish a more concise typology suitable for the legible representation of areas too complex to be directly reproduced at this scale (generalisation).

Stage 2 : Document complement based on information localised and spatialised by the national experts.

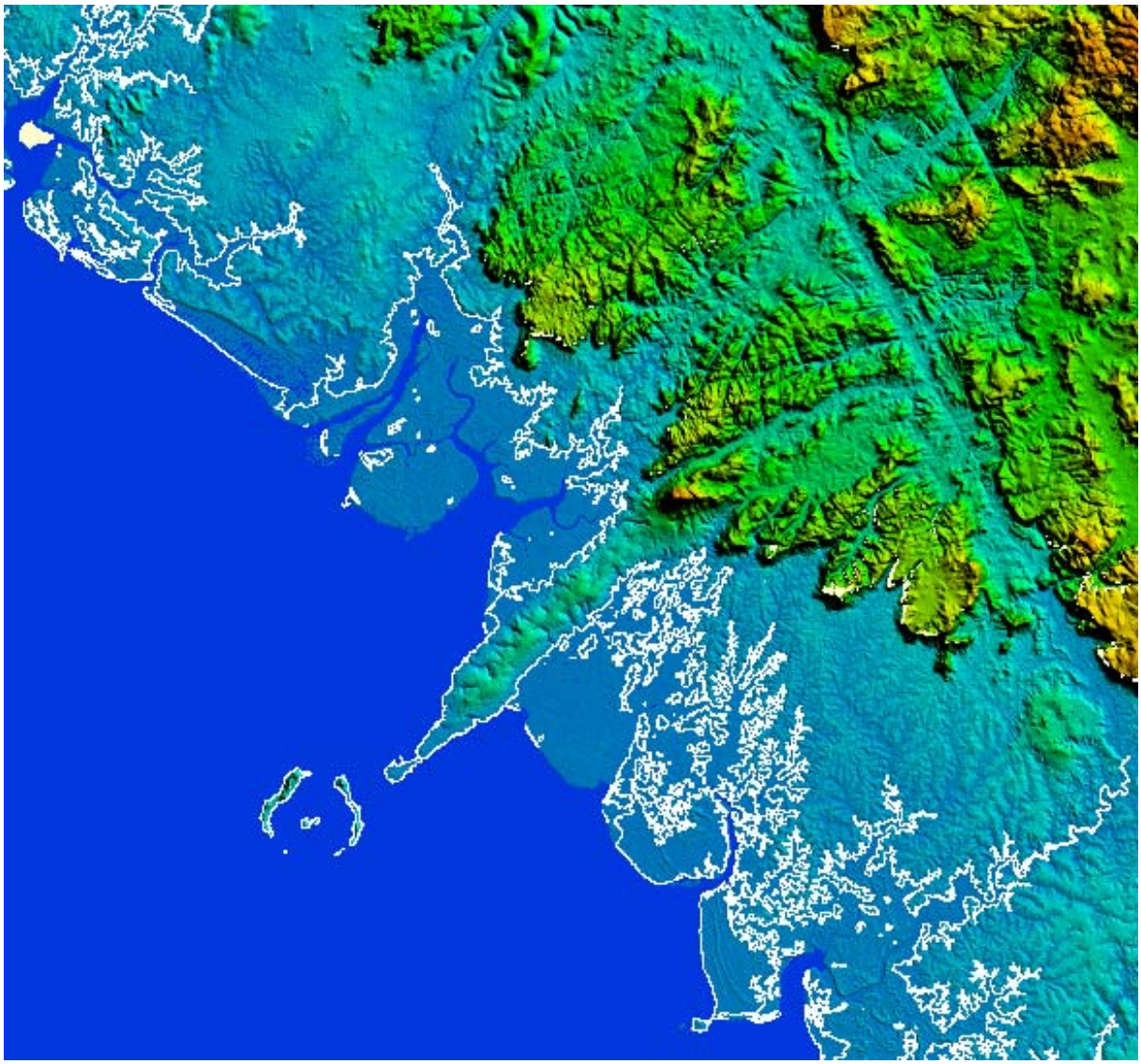
Stage 3: Summary of the previous stages and perfecting of a map, a working tool, designed to serve as an aid for managing the coast at a national level and at the level coordinated by the UEMOA countries.



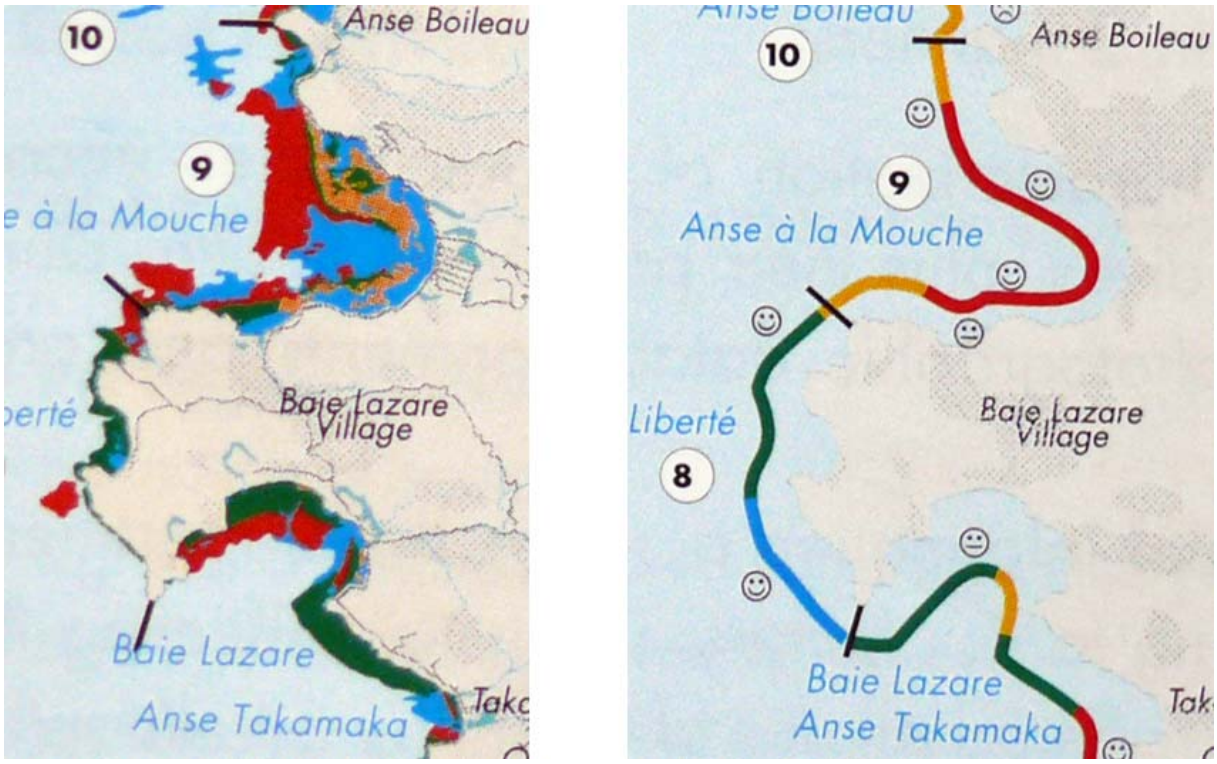
Digital Elevation Model SRTM/90 metres (Côte d'Ivoire) with the NOAA shoreline (tide mark) in white.



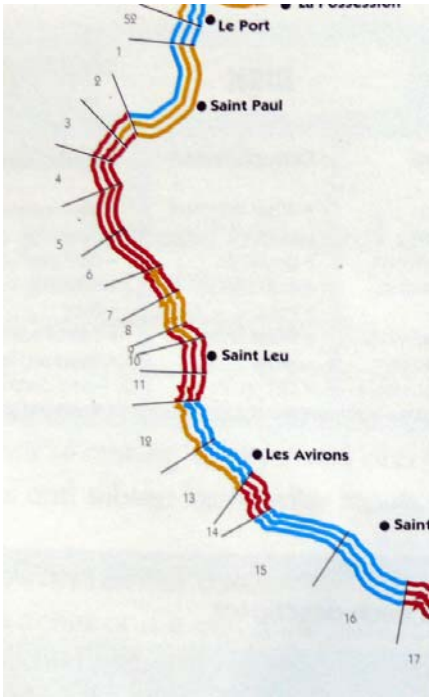
Landsat CIRCA view of Conakry with the NOAA shoreline (tide mark) in white.



Extract from Digital Elevation Model with the NOAA shoreline (tide mark) in white.



On the right, summary view of a vulnerability map (on the left). Based on IOC-UNESCO.2000. - **Guidelines for vulnerability mapping of coastal zones in the Indian Ocean**. Manuals and guides, 38.



Summary view of different types
of vulnerability of coastal zone.
Based on IOC-UNESCO.2000.-.**Guidelines for vulnerability mapping of coastal zones in the Indian Ocean**.
Manuals and guides, 38.

3. DOCUMENT CONTENTS

The contents are a result of a compromise between:

- ⇒ The aims of the study
- ⇒ The possibilities but also the limits of reliability and resolution typical of the satellite imagery used.
- ⇒ The geographic and topical information available, in the knowledge that the exhaustiveness is subject to considerable variations from one country to another within the study area.
- ⇒ The scale of 1:250,000, which provides a certain overview of the whole coast, but requires a very simplified representation of certain complex sections of the coast.
- ⇒ Lastly, the complementary information that it was possible to collect and locate during the field surveys.

4. INFORMATION PROCESSING

While conserving a systemic view of the geodynamics of the coast, the information will be distributed according to the following spatial entities:

4.1. The coastline itself[17] on the Atlantic seaboard subject to recurring ocean waves or storms and coastal drift currents

4.2. The coast of estuarine areas largely open on the sea, undergoing fluviomarine change, the distinction with the previous category being sometimes arbitrary at the mouths of the major estuaries (The Gambia, Casamance, Corrubal, etc.).

4.3. Indicators concerning the foreshore (offshore at shallow depth), some are detectable locally using satellite imagery (sand banks, mud flats, blocks of rock); others are taken from the available bathymetric data.

4.4. Areas under the direct influence of the tides (mangroves, mudflats, traditional rice-growing areas with dykes) or indirect influence (lagoons, channels with various types of vegetation), continually or seasonally connected to tidal flows and in water systems with highly variable salinity.

4.5. The continental coastal zone

The knowledge of its characteristics concerns two types of data:

The physical milieu (geology and pedology), its erosion resistance capacity and the nature of the sediment likely to transit to the sea (marine and near continental erosion).

Human land use (urban, tourism and residential, rural agricultural, or more or less dense fishing, infrastructure). And consequently the importance of the stakes in the face of the present level or the potential level of the sea and storm surges.

The definition and scope of the mapping of the coastal zone will be limited here to an average distance of between 5 and 10 kilometres from the coastline, essentially depending on the extension of the milieus connected to the sea.

For the main coastal rivers, and to the extent that the information is available, an indication of the surface area of catchment areas and the existence of facilities that hamper flood peaks and sediment supply to the sea will be given.

[17] The coast drawn on the scale of 1:250,000 on the basis of satellite images recorded with unknown tidal levels topographically encompasses a part of the backshore, the beach and part of the foreshore, the width of which is difficult to determine.

5. PRELIMINARY TYPOLOGY OF THE COASTLINE ON THE ATLANTIC SEABOARD

The typology was elaborated on the basis of the experience of a certain number of countries that were studied previously and following a review of the entire coastal area covered by the satellite imagery available on Google Earth (the resolution of which is very variable), completed in places by the examination of aerial photographs. Tested on the imagery processed at 1:250,000, it seems most adequate for the cartography work and the study objectives, while it is understood that a few local corrections will be necessary.

The table below summarises the criteria for defining each of the selected categories. These units relate to the physical milieu and its potential for change and vulnerability to erosion phenomena.

Preliminary typology of Atlantic seaboard coastline (cartography on a scale of 1:250,000)

Highly unstable sandy and/or silty coast	Highly dynamic milieu	A1	River estuaries
		A2	Mangrove estuaries
		A3	Complex of spits and sand banks undergoing continuous, active change, headlands, islets and points
	Mangrove milieus	B1	Narrow sandy rims adjacent to mangroves
		B2	Continuous coastal mangroves
		B3	Discontinuous mangroves and mudflats
		B4	Narrow fringe of mangrove adjacent to other milieus not covered by seawater
Sandy coast with straight longitudinal profile	Adjacent to sandy dune formations:	C1	More or less stable dune formations subject to wind erosion
		C2	Idem C1 adjacent to more or less brackish low-lying areas
			Idem C2 with narrow, relatively low coastal rim
	Adjacent to recent, sandy terraces	D1	Sandy rims and terraces more or less undulating in ridges and channels
		D2	Sandy rims separated by vegetated lagoon channels more or less connected to the tides
		D3	Idem D2 with very narrow sandy rim
	Adjacent to terraces of varying age and altitude	E1	Complex of recent sandy rims and terraces, ferralitic hills in places
		E2	Sandy rims adjacent to vegetated lagoon channels more or less connected to the tides
		E3	Idem E2 with very narrow sandy rims
Sandy coast with slightly undulating profile	Adjacent to loose or highly altered geological formations	F1	Long sandy coves marked off by small headlands of rock or hardpan
		F2	Alternation of small headlands of rocks or hardpan and sandy coves
Sandy coast, rocky in places, undulating profile	Adjacent to soft or more or less altered geological formations	G1	Sandy beaches and small sections of rocky coast in places
		G2	Alternation of rocky coast in headlands and sandy beaches
Predominantly rocky coast	Adjacent to hard, scarcely altered geological formations	H1	Rocky coast with soft rock, small sandy beaches in places.
		H2	Rocky coast with cliffs in places.

From a preliminary analysis, the salient points are briefly as follows:

⇒ The complexity of the estuary mouths, with map representation at a minimum precision level of the scale of 1:50,000.

⇒ The vulnerability of the sandy coasts adjacent to recently formed rims isolated from the continent by flood-prone channels and lagoons parallel to the shore located a short distance from these rims (categories D3 and E3).

⇒ The considerable expanse of sandy coasts with no rocky obstacles, shaped by the coastal drift current (categories C, D and E).

⇒ The particular case of coasts with sandy coves bounded by small rocky headlands that affect the coastal drift current (categories F and G).

⇒ The scarcity of true rocky coast, which can be explained by the widespread deep weathering of rock (category H).

⇒ The situation of continental Guinea (Conakry) and Guinea Bissau where the coast almost entirely comprises a thin sandy rim adjacent to mangroves regularly subject to tidal waters.

⇒ Estuaries largely open to the sea, regularly subject to tidal waters over an occasionally very large distance inland (The Gambia, Casamance, Corrubal, Konkouré, etc.) over a width of several kilometres. Their topography is similar to that of the rias, as is the case in Guinea Bissau. The apparent shores are mainly constituted by mangroves, with, in places, a thin rim of fluviatile alluvial deposits and fine loamy sediment supplied by the tides.

6. INFORMATION PROVIDED BY SATELLITE IMAGERY ON THE NEAR OFF SHORE OF THE COAST

This data should be considered with caution depending on the time and the season the images were acquired. Some is reliable, such as the rocks which are more or less covered or uncovered by the tide, and some must be taken as an indication to be compared with the available bathymetric data. This concerns, in particular, the mudflats, sand banks, traces of currents and more or less turbid plumes (loaded with suspended sediment).

In the final phase of the analysis, a selection will be made from this information which, even with varying degrees of reliability, may be useful for a comprehension of coastal geodynamics.

7. THE AREAS UNDER THE DIRECT OR INDIRECT INFLUENCE OF THE TIDES

7.1. The areas under the direct, regular influence of the tides

These areas encompass different milieus, such as:

⇒ Recently formed mudflats partially colonised by mangrove trees.
⇒ Mangroves with different populations of mangrove trees distributed according to depth and intensity of tidal submersion.
⇒ Degraded mangroves
⇒ The low-lying areas on the edge of the intertidal zone, salinized, of the “tanne” type.
⇒ Polders for traditional rice-growing where the tidal flows are interrupted in the growing season and resume in the dry season.

7.2. Areas under the mixed influence of tides and continental freshwater flows

These are characterised by great variability:

⇒ In the salinity of the waters, depending on the local topography and the climatic season.
⇒ In the land cover (lagoons, marshes, small mangroves, flood-prone wooded areas, etc.).

7.2.1. Alluvial channels topographically subject to the tides, but receiving freshwater flows, or even flood peaks, prone to considerable seasonal variations and opening onto estuary areas close to the coast.

7.2.2. Wetland complexes colonised by vegetation and small lagoons close to the coast, isolated from it by a sandy rim. Either continuously open to the sea or open and closed depending on the season. This category typically receives the waters from small coastal rivers with high local and seasonal variations in the salinity of the surface waters and aquifers.

7.2.3. narrow channels close to the shore, sometimes isolated and with a brackish water system connecting underground to the salt aquifer from the nearby sea, sometimes under the direct influence of the tides by means of an opening towards the sea.

7.2.4. The major lagoons communicating with the sea through a channel.

7.3. Areas under the indirect influence of the tides

This category covers the wetlands on the near edge of the previous ones; the indirect influence is exerted at the level of the aquifer system and/or more or less long periods of submersion. The vegetation comes in various forms of marsh, savannah or other wetland plant formations. These are frequently situated on the periphery of the large lagoons or in transition between the continental alluvions and the mangroves.

7.4. Low-lying saline areas (the case of the sabkhas in Mauritania)

8. ANALYSIS OF THE COASTAL STRIP

This is concentrated on band arbitrarily defined as 5 to 10 km from the shoreline and concerns some of the characteristics of the physical milieu related to geodynamic changes in the coast, as well as human land use and corresponding stakes.

8.1. The physical milieu

Two main criteria are taken into account:

- ⇒ The geological/pedological formations adjacent to the coast and their resistance to various forms of erosion, oceanic or near continental.
- ⇒ The type of sediment likely to be mobilised by the coastal currents.

A distinction is made between:

8.1.1. The very loose, sandy formations with no rock or hardpan with:

1A. The backshore sandy rims of contemporary deposition
1B. Sandy fluvio-marine terraces from the recent Quaternary era often with undulating topography in ridges and channels (Sierra Leone, for example).
1C. More or less stable dune formations subject to wind erosion/sedimentation (examples: Senegal, Mauritania).
1D. complexes that are indistinct at this map scale (recent rims, sandy terraces of varying ages and altitudes).

8.1.2. Geological formations that are very deeply weathered, but present a few elements of resistant rock or hardpan creating small headlands that affect coastal drift.

2A. formations with a heavy sand load from the continental terminal to discontinuous ferruginous hardpan (example: Casamance).
2B. Deeply weathered geological formations of the primary basement which has conserved, in places, some blocks of rock or banks of hard rock present on the coast in the form of headlands, small sections of rock or more largely in the form of islets or reefs (Example: Liberia, Côte d'Ivoire). The sediment that is potentially mobilised by erosion transits towards the coast through small coastal rivers and more rarely under the direct action of the sea, the nearby hinterland being very generally separated from the coast by a recent sandy rim.

8.1.3. The geological formations with uneven levels of weathering or moderately resistant.

3A: Quartzite-based metamorphic formations.
3B. Sandstones
3C. Limestone and marl-limestone (Senegal).

8.1.4. Slightly weathered, highly resistant geological formations

Their presence on the coastal zone studied is atypical (Dakar, Conakry, a few headlands in Ghana), along with the rare rocky coasts observed. In the main part they are very hard metamorphic intrusive rocks of the basalt or quartzite type.

8.2. Human land use and the stakes involved

The varying density of human land use and infrastructure on the coast depends on different factors:

- ⇒ The colonial heritage and the location of the capital cities and main towns around harbours, and the current urban and "rurban" expansion on the edge of the coast.
- ⇒ The most recent development of residential and tourist accommodation on the coast.
- ⇒ The location of a more or less dense rural habitat close to the shore favouring an economy based on both local subsistence farming and the exploitation of products from the sea (fishing, salt collection, wood from the mangroves etc.).
- ⇒ In association with the previous or in isolation, a habitat of temporary fishing camps occupied by migratory fishermen depending on the seasonality of migratory fishing resources.

The socio-economic stakes are ostensibly concentrated in the densely populated cities and their sometimes considerable "rurban" expansion. These areas are developing rapidly and recent studies have shown that the main sources of data concerning them are not very up-to-date. The appeal of luxury residences on the coast and the development of tourism are factors that bring public or private investment into confrontation with coastal erosion, leading to relatively high stakes.

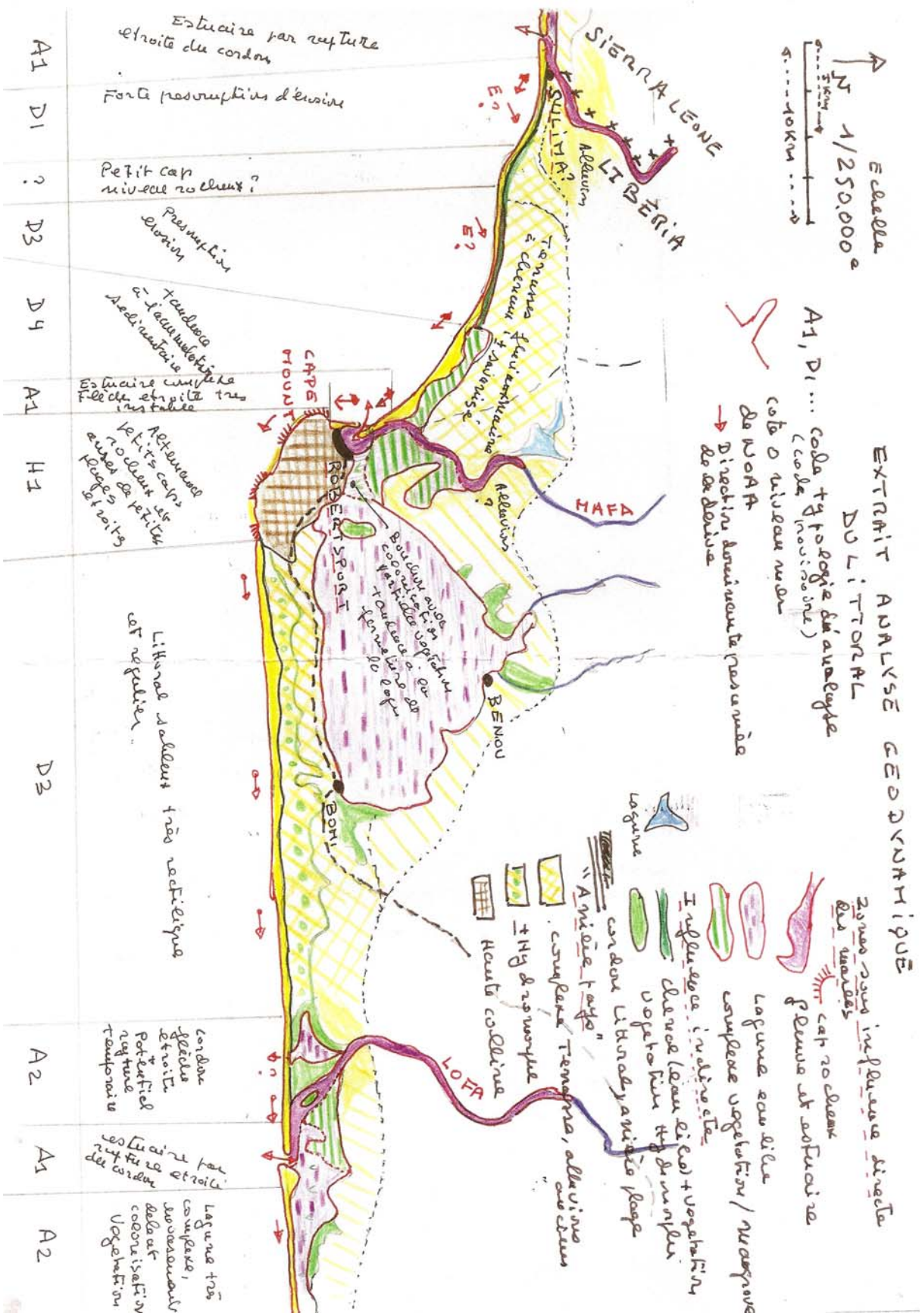
However, the impact of erosion on the habitat and light coastal infrastructure in certain areas with dense farming and fishing livelihoods should not be ignored, as the disappearance of buildable land creates social and land tenure problems which should be taken into consideration.

9. BASIC VECTOR LAYERS COMBINED FOR THE STUDY

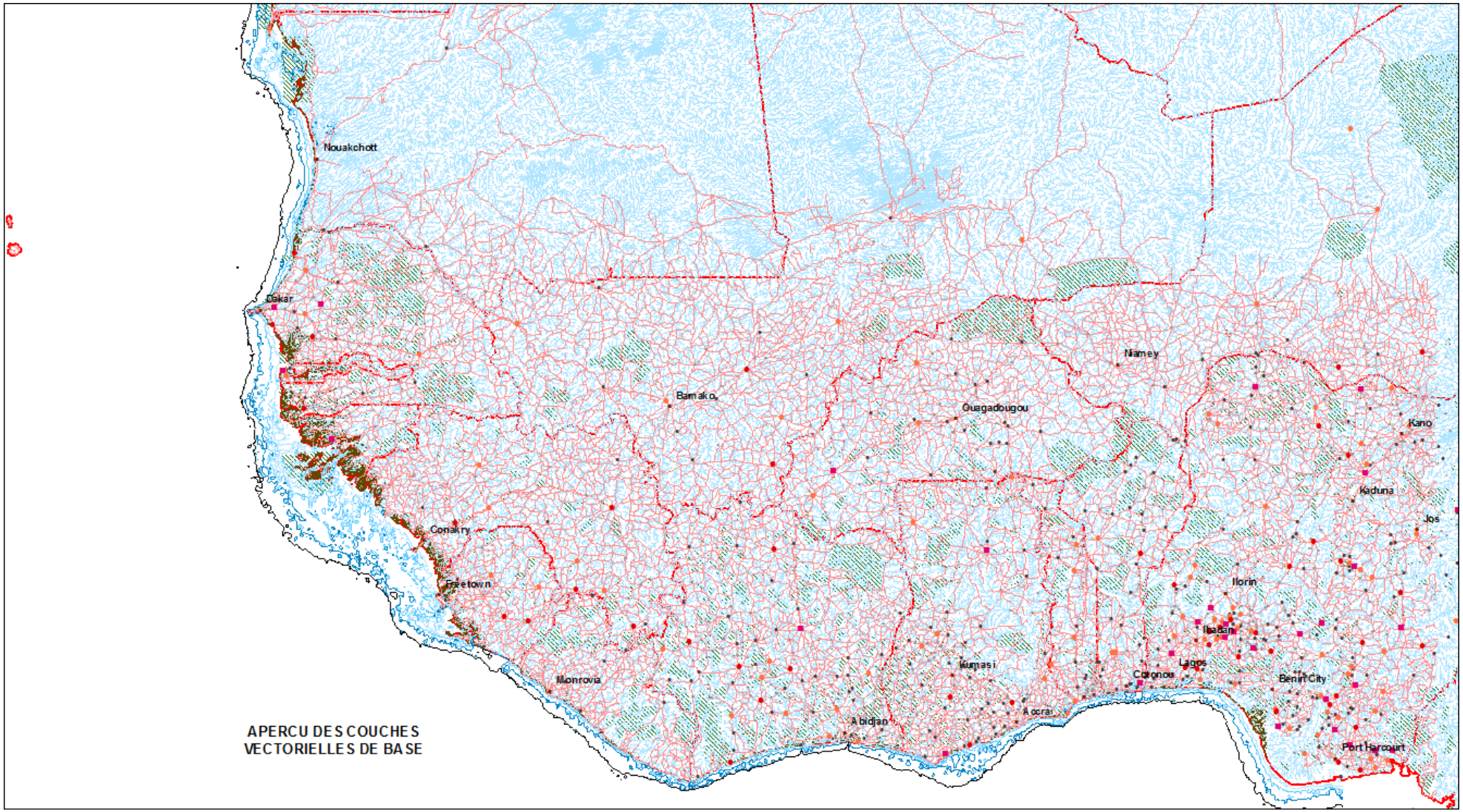
The necessity of having a uniform geographical reference base for the cartography of the study and the reprofiling of the interpreted data implied a search for different reliable data sources, which would cover the entire area under study. At this stage, the following layers have been collected:

Coastline	NOAA (scale 1:75,000).
Bathymetry	Curves generated from the 30 arc seconds model of the General Bathymetric Chart of the Oceans — IOC/IHO UNESCO
Hydrographic network	Hydrosheds USGS Data
Protected areas	IUCN World Protected Areas Commission
Roads and transport	VMAP 1 and 0
Agglomerations with populations over 5,000	GEOPOLIS
Hypsometry	Curves generated from the SRTM digital elevation model (CGIAR-CSI)[18] at 90 metres

[18] The quality of this digital elevation model was confirmed by a study carried out by CIAT: *Comparison of SRTM derived DEM vs. Topographic map derived DEM in the region of Dapa*.



Mastercopy taken from the preliminary work of coastal geodynamic analysis at 1:250,000.


Nouakchott
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Benin City
Port Harcourt
Conakry
Freetown
Monrovia
Abidjan
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ANNEX 2: PROVISIONAL SPECIFICATIONS FOR NATIONAL DIAGNOSTIC STUDIES

SPECIFICATIONS
FOR NATIONAL EXPERTS
"National Diagnostic Studies and Regional Summary"

1. Introduction

Introduction concerning the study …….

2. Procedure for national diagnostic studies

The first phase of these national diagnostic studies is intended to gather basic information on the different aspects of coastal development, and to collect "expert opinions" on the state of the coastal systems.

The diagnostic study should be based on existing documents and information. Two aspects should guide the work of the consultants: (i) the diagnostic report's capacity to summarise and formulate key issues; (ii) ranking and prioritising of issues.

The implementation of national diagnostic studies is based on the following guidelines:

⇒ The consultant appointed to carry out the study is solely responsible for handing over the deliverables.

⇒ Within the framework of the contract and the corresponding fixed fee, the consultant will call upon all the resource people deemed useful for providing the up-to-date information necessary in the different sectors mentioned in the specifications.

⇒ The specifications in the appendix are not restrictive and other sectors or aspects deemed pertinent should also be documented.

⇒ The products of the service provision are the exclusive property of UEMOA.

⇒ The information sources should be systematically stated.

The person in charge of the national diagnostic report will receive, at the start-up of the work, or in the two weeks that follow, the following items:

⇒ Terms of reference with the specifications appended.

⇒ Extract from the mastercopy of geodynamic coastal analysis to be completed and approved.

⇒ 1/250,000 base map to be completed. **This basemap includes, in particular, a breakdown of the coastal area into segments. This base map will contain other layers of information: Road network, populated areas, borders, hydrographic network, etc… The information given in the text should refer to these segments (by number), or specify in more detail the location of the items mentioned in the text within these segments. Each item of spatialised information should therefore bear a serial number marked both on the map and in the text referring to it. The base maps may be processed thematically, with the consultant free to reproduce them and to work on different copies.**

The consultant will carefully collect and transmit any relevant digital coverage (vector layers in formats such as shp, map info, dxf, etc.) to the study coordinator. If access to such data requires an official request, the consultant will make sure he informs the study coordination as early as possible, so that they can intervene via the representatives of the country considered in the steering committee and the scientific committee set up by UEMOA.

The commented description of the issues at stake may be redundant (if the same issues are found in several chapters); this does not pose a problem. The different sources should be quoted systematically.

The consultants are encouraged to organise the items presented into typologies and fill out the text with relevant data, which could, if necessary be placed in the appendix.

The methodology for the national diagnostic studies will be examined at launch seminars at sub-regional level when the work commences (dates and places to be defined).

3. Deliverables

The deliverables comprise:

⇒ The diagnostic report compliant with the model given in the appendix.
⇒ The mastercopies of the maps, annotated and completed.

RESOURCE PERSONS MOBILISED FOR THE WORK

Give the contact details of the resource persons and skills mobilised for the work

Name job	position	Institution	email	telephone(s)	address	specialty

LIST OF ELECTRONIC DOCUMENTS COLLECTED AND TRANSMITTED TO THE STUDY COORDINATOR

Documents will be transmitted by email or uploaded to a secure server; these procedures will be specified later.

The consultant will take care to collect and forward existing recent strategy documents: Country review of the World Bank and UNDP, SFPR, National Indicative Programmes of the European Commission, National environmental profiles and any other strategy documents available.

Country: …….

Consultant in charge: …….

PART I – STATE OF COASTAL ENVIRONMENTS

The data below concerns the coastal strip and area only and not all national information.

CHARACTERISATION OF CLIMATE

One to 2 pages covering at least the following points:

- ⇒ *Wind patterns, temperatures, precipitations, evaporation-evapotranspiration. Attach data in the form of tables and, where relevant, graphics to be placed in the appendix.*
- ⇒ *A possible climate zoning should be marked on the base map.*
- ⇒ *Exceptional events in the last 10 years having affected the coastal regions: Short summary and location of each event.*

Reference documents *(only list the main ones on the subject considered indispensable in the country under consideration).*

Principal projects involving climate change adaptation *and dealing with the coastal area.*

Project name	Start-end period	Donor(s) A	uthority	Name and contact details of person in charge	References on the web	Comments

Principal issues at stake with comments (if possible marked and annotated on the base map)

……..
……..
……..

GEOLOGY, GEOMORPHOLOGY AND PEDOLOGY

1 to 2 pages

Depending on the chosen segmentation of the coast, describe the geological, geomorphological, pedological and landscape units of the coastal area. Concerning the landscape, landscape appeal suitable for tourism and seaside resorts should be examined in particular.

For these major units, the consultant will specify aptitudes and constraints, in particular in relation to agriculture and road services.

Remarkable landscape sites will be mentioned and situated.

Reference documents (only list the main ones considered indispensable on the subject in the country under consideration) and geology or pedology maps.

Analysis and location on the map of the problem issues of erosion or accretion with comments by coastal segment.

HYDROLOGICAL AND HYDROGEOLOGICAL CHARACTERISATION

1 to 2 pages

- ⇒ *Surface water: river flow rate measurement data from the stations the closest to the estuaries of the main rivers (in particular spates, minimum flows).*
- ⇒ *Exceptional historical events (floods) and those occurring in the last 10 years should be mentioned, with location of the zones affected on the map.*
- ⇒ *Water tables: data on superficial or shallow aquifers and on deep aquifers.*
- ⇒ *Mark on the base map any zoning of water resources and drinking water supply difficulties (quantity and salinity), according to a typology to be established by the consultant.*

Reference documents (only list the main ones on the subject considered indispensable in the country under consideration).

Principal projects involving the topics of water in the coastal area

Project name	Start-end period	Donor(s) A	uthority	Name and contact details of person in charge	References on the web	Comments

Principal issues a stake with comments (if possible marked and annotated on the base map)

……..
……..
……..

CHARACTERISATION OF THE COASTAL MARINE ENVIRONMENT

2 to 3 pages covering at least the following points

- ⇒ *Current regime*
- ⇒ *Tides*
- ⇒ *Ocean waves*
- ⇒ *Continental shelf, bathymetrics and types of sea floor*
- ⇒ *Temperatures of the waters*

Detailed data can be given in the appendix.
Exceptional events such as marine intrusions, storm surges and combinations of spates-tides should be mentioned and situated.

Reference documents (only list the main ones considered indispensable on the subject in the country under consideration) maps and bathymetric studies.

Principal institutions and projects involved in the coastal marine environment.

Project name	Start-end period	Donor(s) A	uthority	Name and contact details of person in charge	References on the web	Comments

Principal issues at stake with comments (if possible marked and annotated on the base map)

……..
……..
……..

LAND BIODIVERSITY

2 to 3 pages covering at least the following points

- ⇒ *Principal plant formations and ecofloristic zoning*
- ⇒ *Flora and fauna, remarkable and/or emblematic communities and species*
- ⇒ *State of inventories of continental wetlands.*

Reference documents (only list the main ones on the subject considered indispensable in the country under consideration).

Principal issues at stake affecting land biodiversity with comments (if possible marked and annotated on the base map):

……..

……..
……..

MARINE BIODIVERSITY (INCLUDING MANGROVES)

2 to 3 pages covering at least the following points

- ⇒ *Principal marine and foreshore plant formations*
- ⇒ *Flora and fauna, remarkable and/or emblematic communities and species*
- ⇒ *Data regarding migratory species*

Reference documents (only list the main ones on the subject considered indispensable in the country under consideration).

Principal issues at stake affecting marine biodiversity with comments (if possible marked and annotated on the base map):

……..
……..
……..

ARCHITECTURAL, BUILT, HISTORICAL AND ARCHEOLOGICAL HERITAGE

Note and situate on the map the principal heritage sites - built, historical and/or archaeological - of national importance on the coast. Write a short notice for each site stating the nature, conservation status and possible tourist development.

Reference documents (only list the main ones on the subject considered indispensable in the country under consideration).

PART II – PRESSURE ON COASTAL ENVIRONMENTS

DEMOGRAPHICS AND POPULATION MOBILITY, URBAN FRAMEWORK

2 to 3 pages covering at least the following points

- ⇒ *Population data and trends in the 10 kilometre coastal strip (distinguish between the data corresponding to towns with more than 5,000 inhabitants and the data for rural areas).*
- ⇒ *Population mobility*
- ⇒ *Situation regarding sanitation and water treatment, the main waste poured into the sea (spatialise, status of pollution practices leading to direct transfer to the sea.*
- ⇒ *Existence of urban development schemes.*
- ⇒ *Urban sprawl and expansion tendencies, projects for urban re-qualification, sanitation under study or in progress, sea front developments.*
- ⇒ *Trends in seaside residential habitat.*
- ⇒ *Trends in holiday home settlement.*
- ⇒ *Trends in precarious settlement.*
- ⇒ *Commented report on land control, speculation and any urban-rural conflicts.*

Principal projects and institutions involved in urban issues in coastal areas

Project name	Start-end period	Donor(s) A	uthority	Name and contact details of person in charge	References on the web	Comments

Important land subdivision projects on the coast (situate on the map).

Reference documents (only list the main ones on the subject considered indispensable in the country under consideration).

Principal issues at stake with comments corresponding to urban development (if possible marked and annotated on the base map)

……..
……..
……..

Identified trends projected to 2020 and 2050

ROAD INFRASTRUCTURE

2 pages covering at least the following points:

Inventory of road network, areas connected and enclaves to be situated on the map. The different trunk roads should be marked on the map according to the conventional typology (different colour or thickness of line for permanent, tarred roads - temporary roads and tracks – tracks on beaches - other tracks, ferry links, coastal shipping). The isolated zones should be identified and the causes of the isolation specified.

Projects for road building or rehabilitation under study or in progress.

Systemic summary of the state, organisation and operation of the road network in the coastal zone (do not hesitate to provide a diagram), flows of people and goods.
Specify areas where traffic uses the beaches.

Reference documents (only list the main ones considered indispensable on the subject in the country under consideration), road development scheme, for example.

Principal road projects in the coastal area

Project name	Start-end period	Donor(s) A	uthority	Name and contact details of person in charge	References on the web	Comments

Principal issues with comments corresponding to road network development (if possible marked and annotated on the base map)

……..
……..
……..

Identified trends projected to 2020 and 2050

DOCK AND AIRPORT INFRASTRUCTURE

Characterisation of national docks and airports.

For each one, indicate in particular

- ⇒ *The infrastructure that already exists and/or is under development (provide aerial views or plans; situate directly on the base map where possible).*
- ⇒ *Reception capacity in tonnage and traffic data.*
- ⇒ *Projects for extension or rehabilitation under study or in progress.*
- ⇒ *Statistics and flows of goods*

⇒ *Status*

Do not omit small ports equipped at local level (fishing, goods).

Data on interior and informal coastal shipping (in particular in lagoon and channel systems).

Reference documents (only list the main ones on the subject considered indispensable in the country under consideration).

Principal issues at stake with comments corresponding to the development of this infrastructure (if possible marked and annotated on the base map)

……..
……..
……..

Identified trends projected to 2020 and 2050

FORMS OF COASTAL TOURISM

2 to 3 pages covering at least the following points

⇒ *Current situation of tourist activities with data. Summary of the sector (situate on the map the centres of concentration, indicating growth or reduction trends in the activity). Differentiate between the local and international tourist sites.*
⇒ *State of urban and peri-urban leisure activities (frequentation of urban seafronts.)*
⇒ *Trends identified and framework studies (development schemes?)*

Principal issues at stake with comments corresponding to tourism development (if possible marked and annotated on the base map)

……..
……..
……..

Identified trends projected to 2020 and 2050

INDUSTRIAL, MINING AND EXTRACTION ACTIVITIES

Summary of the industrial activities that may generate impacts on the coast.

Situate the corresponding principal infrastructure on the map

Typology of mining activities, location of sites and infrastructure, production.

Activities of oil exploration in progress in the coastal area.

Principal mining projects in the coastal area

Project name	Start-end period	Donor(s) A	uthority	Name and contact details of person in charge	References on the web	Comments

Principal issues a stake with comments (if possible marked and annotated on the base map)

……..
……..
……..

Identified trends projected to 2020 and 2050

COASTAL FISHING

2 to 3 pages

Typology of fishing methods, with, for each one: statistics on catches, trends, population concerned.
Situate fishing zones, landing points, work camps, villages, artisan fishing ports and processing sites on the map, according to a typology of establishments to be defined.
Mobility, migrant or "shifting" fishing, origin, evaluation of numbers of non-local fishermen
Impact of fishing activities on the other natural resources to be assessed.

Principal projects and institutions involved in fishing

Project name	Start-end period	Donor(s) A	uthority	Name and contact details of person in charge	References on the web	Comments

Principal issues a stake with comments (if possible marked and annotated on the base map)

……..
……..

……..

Identified trends projected to 2020 and 2050

FISH FARMING

Summary of fish farming with location of zones and estimation of the production from fish farming.
Outlook and potential (location of zones).

AGRICULTURE AND LIVESTOCK BREEDING

Typology and characterisation of the principal agricultural, pastoral, agro-fishing and plantation systems, etc.
Zoning and location of productions (in particular fruit and vegetables or traditional - rice growing)
Production and economic importance, population concerned.

Principal issues a stake with comments (if possible marked and annotated on the base map)

……..
……..
……..

Identified trends projected to 2020 and 2050

OTHER TYPES OF PRODUCTION IN THE COASTAL AREA

Brief description of other types of production (salt, for example)

PART III – RESPONSES AND COASTAL DEFENCE MECHANISMS

Principal anchor documents (to be submitted): *Territorial development scheme, Coastal development scheme, strategy for combating coastal erosion, etc. Each document should be commented on briefly with a recap of the main orientations; attach the corresponding maps (photocopies) or geomatic files.*

LEGISLATORY AND LEGAL FRAMEWORK

The ratification status of international conventions and the enabling activities of the conventions

Convention	Ratification	Documents produced and approved	Names and coordinates of focal points

Documents attached (NAPA, communications, strategies, etc.): ……..

- ⇒ *Principal legislation governing activities on the coast and in the public maritime domain, as well as construction in the coastal zone.*
- ⇒ *Principal legislatory provisions bearing on the environmental impact studies.*
- ⇒ *Principal legislatory provisions bearing on the protected areas.*

Summary concerning, in particular, the match between legislation and practice.

This topic is particularly important and the corresponding documents should be provided.

WEATHER FORECAST AND CLIMATOLOGY

Marine weather forecast system? (description)
Specific studies conducted on the theme of climate change adaptation

MARINE AND LAND PROTECTED AREAS

Commented list of protected areas in the coastal strip (all conventions and IUCN categories), year of creation, names, constitution, management and development plan, surface areas, management methods. Most of the recognised protected areas are featured on the 1:250,000 map given to the consultant. This information should be verified and completed.

New protected areas anticipated or currently being instituted.

Remarkable, fragile and/or vulnerable milieus which could benefit from conservation measures (situate on the map and comment).

COASTAL EROSION DEFENCE MECHANISMS

By segment of coast, list the developed zones and situate them on the map. A distinction will be made between:

1. *The developments for mitigating coastal erosion*
2. *and developments for other purposes that generate significant impact on coastal sediment flows (harbour entrance breakwaters for example).*

For each zone developed:

⇒ *Location and problem issues*
⇒ *Year of the development and budget (funding)*
⇒ *Description of infrastructure implemented and current state*
⇒ *Brief, commented evaluation of effects*

PART IV – CAPACITIES

RESEARCH AND COASTAL GEOMORPHOLOGY

Human and scientific resources

List the principal institutions, researchers and laboratories working on the problem issues related to coastal erosion and geomorphology.

Institution	Contacts	Contact details	Coastal research and monitoring programmes in progress

Shoreline monitoring systems in use over the past 10 years and currently operational

Institution	Names and contact details	Sites monitored (location and extent-measurement frequency) – current status of system	Period covered by the data	Measurement methods

RISK REDUCTION

National platform (ISDR) for disaster risk reduction? *If yes, give the composition. Indicate who the leader is.*

Institution	People in charge	Contact details	Headcount

Appreciation of how the national platform currently functions.

ANNEX 3: SEGMENTATION OF THE STUDY ZONE FOR THE NATIONAL DIAGNOSTIC REPORTS.

This segmentation of the study zone should enable the organisation of the national diagnostic reports. **The corresponding schematic map is currently being drawn up.**

No.	Country	Comments
1	BENIN	Middle terrace adjacent to lagoons, straight, sandy coastline Urban peripheral of Cotonou expanding eastward.
2	BENIN	Idem 1, high rural density
3	TOGO	Idem 1, high (r)urban and rural density, Lomé
4	GHANA	Volta delta complex, vast expanses of hydromorphic areas behind the unstable sandy coast and estuarine environment, rural density relatively low.
5	GHANA	Accra, predominantly sandy coast, unstable rock in places. Accra– Tema expansion, harbour infrastructure.
6	GHANA	Rocky coast, alternating with low sandy terraces. Hilly hinterland with average population density.
7	GHANA	Alternate rocky coast and sandy coves, Hilly hinterland with average population density.
8	GHANA	Middle terrace, straight, sandy coast. Dense rural land use with large villages.
9	COTE D'IVOIRE	Middle terraces, nearby lagoons. Straight, sandy coast, coconut palm plantations, low land use (except for Assinie residential area)
10	COTE D'IVOIRE	Middle terraces, nearby lagoons. Straight, sandy coast, coconut palm plantations, low land use Zone of residential expansion.
11	COTE D'IVOIRE	Middle terraces, nearby lagoons. Straight, sandy coast, coconut palm plantations, low land use Zone of residential expansion, on terraces with low occupation rate.
12	COTE D'IVOIRE	Alternate sandy coast and headlands. San Pedro Port. Hilly countryside, low occupation
13	COTE D'IVOIRE-LIBERIA	Middle terrace, straight, sandy coast. Coconut palms. Low occupation.
14	LIBERIA	Alternate rocky headlands, scree, sandy coves, small, low-lying terraces and micro lagoons. Low occupation.
15	LIBERIA	Monrovia. Large urban expansion on fanned plateau penetrated by hydromorphic areas .
16	LIBERIA-SIERRA LEONE	Straight, sandy coast adjacent to low-lying terraces. Low occupation.
17	SIERRA LEONE	Mangrove + low-lying sandy terrace Rice-growing
18	SIERRA LEONE	Freetown breakwater hill Rocky coast, with micro beaches for tourism
19	SIERRA LEONE. CONAKRY.	Mangrove, considerable degraded rice-growing area and mudflats. Potential for fish farming.
20	GUINEA (CONAKRY)	Rocky coast + Los island. Precarious settlement along the edge of the mangroves
21	GUINEA (CONAKRY)	Rock coast and sandy beaches with the only maritime site with tourist potential, mangroves
23	GUINEA (CONAKRY)	Mouth of the Kapatchez, mangroves
24	GUINEA (CONAKRY)	Mangrove coastline and + sandy terrace of Tristao island. Low rate of land use. Complex mangrove system relatively unsuitable for agriculture.
25	GUINEA BISSAU	Coast wholly mangrove, very narrow sandy rims in places

26	GUINEA BISSAU	The Bijagos islands coast highly diversified (low mangrove sandy terraces, headlands with hardpan and sandy coves, hardpan shallows, considerable rice-growing in polders.
27	GUINEA BISSAU-SENEGAL	Cap Varela, highly unstable sandy coast adjacent to low terrace, wind erosion.
28	SENEGAL	Undulating sandy coast with small headlands (hardpan) adjacent to high terrace of continental terminal. Important tourist centre at Cape Skirring + Agricultural land use for oil palm
29	SENEGAL	Casamance mouth area. Unstable, sandy coast adjacent to low-lying terraces. Hinterland of mangroves. Partial agricultural land use, fishermen, wind erosion.
30	SENEGAL THE GAMBIA	Middle terrace, straight, sandy coast. Agricultural land use
31	THE GAMBIA	Undulating sandy coast and hardpan cape adjacent to continental territorial. High density urban and rurban land use. Tourist complex. Coastal erosion and improvement at the level of the cape estuary of the Gambia
32	SENEGAL (SINE SALOUM)	Unstable sandy coast, rim adjacent to Sine Saloum mangrove. Breached spit. Low agricultural land use but high fishing activity
33	SENEGAL (PETIT COTE)	Undulating sandy coastline. Wide coves separated by rocky or hardpan headlands. Marked erosion in places. Dense tourism land use.
34	SENEGAL	Rocky point of DAKAR (basalt) problem beach south of Dakar (erosion?). Urbanised zone on high terrace.
35	SENEGAL	Straight, sandy coast adjacent to dune formations.
36	SENEGAL	ST Louis and the Barbary Spit
37	MAURITANIA	Straight, sandy coast, fragile, adjacent to channels and more or less brackish hydromorphic areas.
38	MAURITANIA	Straight, sandy coast adjacent to dune formations. Hinterland of low-lying hydromorphic areas, more or less brackish.
39	MAURITANIA	Nouakchott Site

ANNEX 4: FORMAT FOR CASE STUDY PROPOSALS.

CASE STUDY PROPOSAL FORMAT

COUNTRY

NAME OF THE SITE

DATE ……

ABBREVIATIONS

I – CONTEXT AND STAKES INVOLVED

Geographic context – precise location of the site, environmental
Stakes to be documented through the case study

II – REASON FOR THE CHOICE

Work already conducted on the site
Teams involved
Data available
Value of the choice of site regarding the issues mentioned above

III – DESCRIPTION OF IMPLEMENTATION

1. Project stakeholders

Contractor: the institution signatory of the contract.
The researchers concerned
Other stakeholders involved (local population, other institutions)

2. Description of actions to be undertaken

4. Phasing of implementation

A simplified schedule of the implementation of the actions should be appended.

IV – COST OF THE STUDY

Repeat the total cost of the budget as detailed in the appendix.

Allow for travel costs to CSE in Dakar for the researcher(s)

V – DELIVERABLES

Description of deliverables (reports, maps, data, etc.)

VII – FUND PROVISIONING

A priori, a 30% advance payment on start-up will be proposed; 30% will be paid on submission of the intermediate products and the remainder will be paid on delivery of the final products.

VII – LOCAL EXPLOITATION OF RESULT

Describe the measures recommended to ensure local exploitation of the results (conference, seminar, other communication operations).

IX – ANNEXES

Annex 1. Location map

Annex 2. Budget itemised by operation – *1 page*

Annex 3. List of the people involved and stakeholders with contact details

Annex 2 - Budget

DESIGNATION	AMOUNT
EXPERTISE	
PER DIEM	
AIR TRANSPORT	
LOCAL TRAVEL	
PUBLICATION/DISTRIBUTIOIN	
SEMINARS/WORKSHOPS	
HARDWARE/EQUIPMENT/IMAGES	

TOTAL	

EXPERTISE (A line for each type of expertise and role of the experts)

Designation (junior, senior)	Description and role	Unit	Quantity	Unit cost	Total
Sub-Total					

PER DIEM

Type (international, local)	Quantity	Unit cost	Total
Sub-Total			

AIR TRANSPORT

Type (international, local)	Destination	Quantity	Unit cost	Total
Sub-Total				

LOCAL TRAVEL

Type (air, land, etc.)	Destinations or locations	Quantity	Unit cost	Total
Sub-Total				

PUBLICATIONS/DISTRIBUTION

Description	Quantity	Unit cost	Total
Sub-Total			

SEMINARS - WORKSHOPS

Description	Quantity (people)	Unit cost (per person)	Total
Sub-Total			

HARDWARE - EQUIPMENT - IMAGES

Description	Quantity	Unit cost	Total
Sub-Total			

Regional study for shoreline monitoring and drawing up a development scheme for the West African coastal area IUCN/UEMOA

Regional coastal risk prevention plan in West Africa

Recommendations for the large-scale mapping of case study results (*)

Ibrahima Faye and Emmanuel Giraudet
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Institut Universitaire Européen de la Mer,
place Nicolas Copernic, 29280 Plouzané, France
February 2010

** In response to the CSE in Dakar's request for methodology support regarding the cartography principles for mapping the results of the "case studies" carried out within the framework of this study.*
Ref: *Regional study for shoreline monitoring and drawing up a development scheme for the West African coastal area IUCN/UEMOA - Regional coastal risk prevention plan in West Africa – Procedural framework document (chap. 8.4.2 – The case studies p.19).*

The aim of this document is to provide the cartographers at the Ecology Monitoring Centre (Centre de Suivi Ecologique - CSE) in Dakar with recommendations on the cartography principles to be used to map shoreline changes for the case studies. Some of the areas studied may be quite vast but most of them are relatively small, which requires large-scale mapping.
Given the geometric nature of the geographic entity of the "shoreline", the recommendations will mainly deal with the linear data presentation method. Furthermore, it is understood that the CSE possesses know-how in terms of conducting projects managed by a geographic information system (GIS), in particular ArcView from ESRI, for which it owns licences.

The forms of cartographic expression presented here are not "original" but correspond to representation systems commonly used by coastal geomorphologists. They were largely used by Ibrahima Faye in his doctoral thesis which included a considerable cartography component[19].

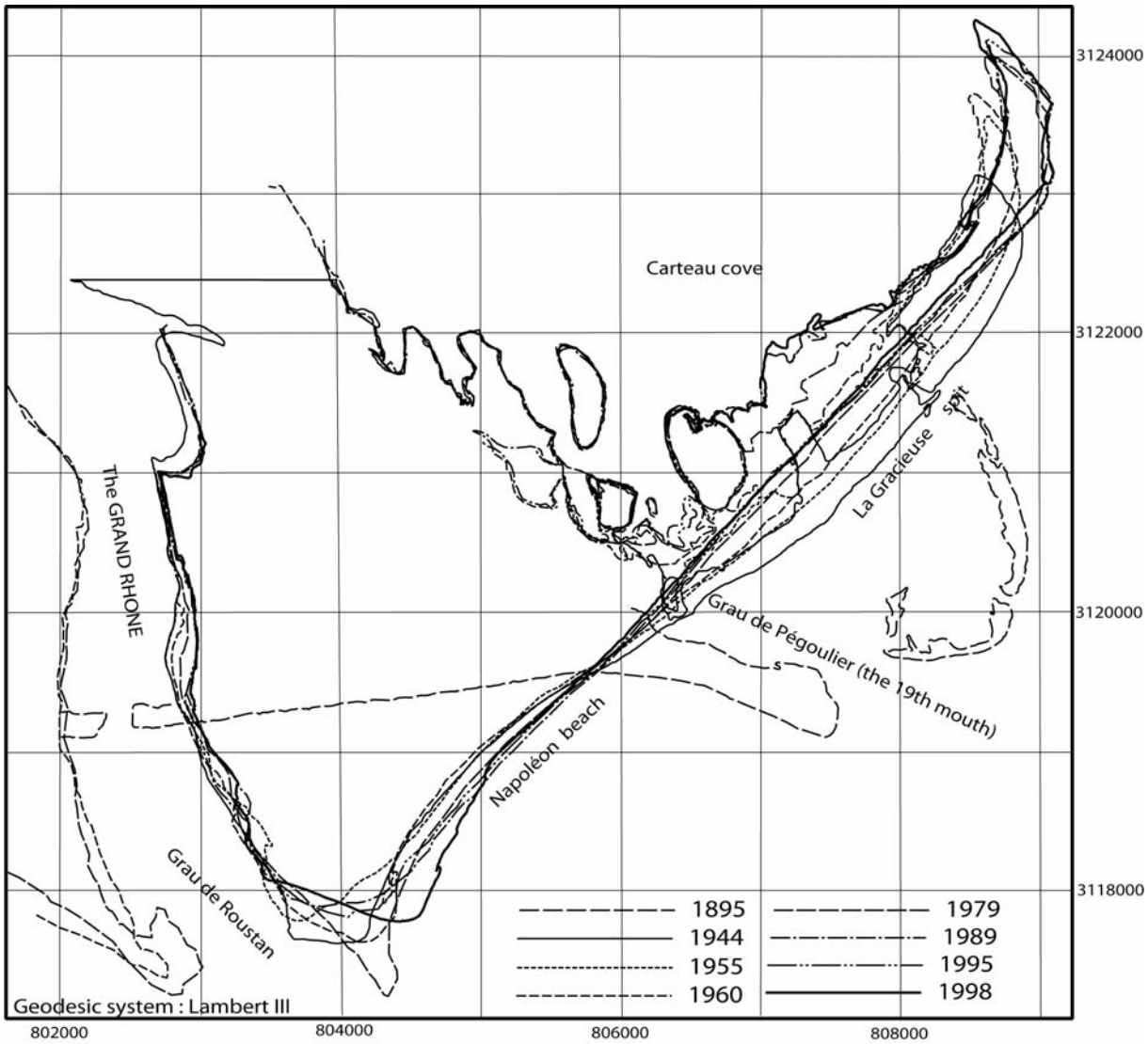
[19] Dynamics of the shoreline on the sandy coastline from Mauritania to Guinea-Bissau (West Africa): Regional and local approaches by photo-interpretation, image processing and analysis of old maps, vol. 1 and vol. 2: Cartography of the morphology of the dynamics of the shoreline in West Africa from Mauritania to Guinea-Bissau. PhD Thesis for Brest University, Ecole Doctorale des Sciences de la Mer, prepared at Géomer UMR – 6554 – LETG / CNRS under the supervision of F. Gourmelon and T. Diaw, 2010.

Scales

The diachronic analysis of low-mobility shoreline is a complex matter. In addition to the fact that it may generate a considerable error margin during results analysis, it can also cause difficulties in the cartographic expression of these results, sometimes even at very large scales. It will therefore be difficult to scrupulously respect the differentiation[20] rule if the changes caused by coastal progradation or erosion between two dates are very small.

In the example below (figure 1), the large number of shorelines mapped (8 dates) and the prohibition of the use of colour made mapping difficult and we see that the differentiation rule could not be fully applied at this scale of rendering (1:50,000): shorelines that are too close at certain dates merge at certain points on the coast.

Figure 1: The differentiation rule is sometimes difficult to apply



SABATIER F., SUANEZ S. (2003) - Evolution of the Rhone Delta coast since the end of the 19th century, *Géomorphologie : Relief, Processus, Environnement*, n° 4, pp. 283-300.

Enlarging the scale of rendering is not necessarily an effective solution to the problem, especially if the amplitude of the variations in the shoreline position varies greatly spatially:

[20] In cartography, the differentiation rule states that two features of the same type that are close together must be unambiguously differentiated. In our case, this rule means that two lines representing the shoreline at two different dates should be clearly identifiable with no risk of confusion.

the overview of the whole portion of the coast concerned becomes an important asset the reader should not be deprived of. For this reason, dividing the coast into several maps with different scales is not recommended.

Generally, the level of analysis, or "geographic scale" of the map theme depends on functional exchanges between the site of interest and the surrounding land areas. If progradation is observed in the study area, in absolute terms, a level of analysis should be adopted which encompasses the local land areas responsible for the sediment supply. It is this reflection on geographic scale which dictates the choice of geographic coverage and, ultimately, of map scale. To illustrate how a site works, it is in fact often necessary to use several embedded geographic scales or even several map scales in the same cartographic representation. The example below (figure 2) concerns the mapping of land cover in the Bao Bolon Nature Reserve. However, a change in geographic scale was necessary to situate the reserve on the West African coast (grey insert) whereas a reduction in map scale (from 1:114,000 to1:4000,000, "zoning" diagram), is used to map additional, more general information (zoning) which it would have been difficult to include on the main map without obscuring the main message (land cover in the Reserve).

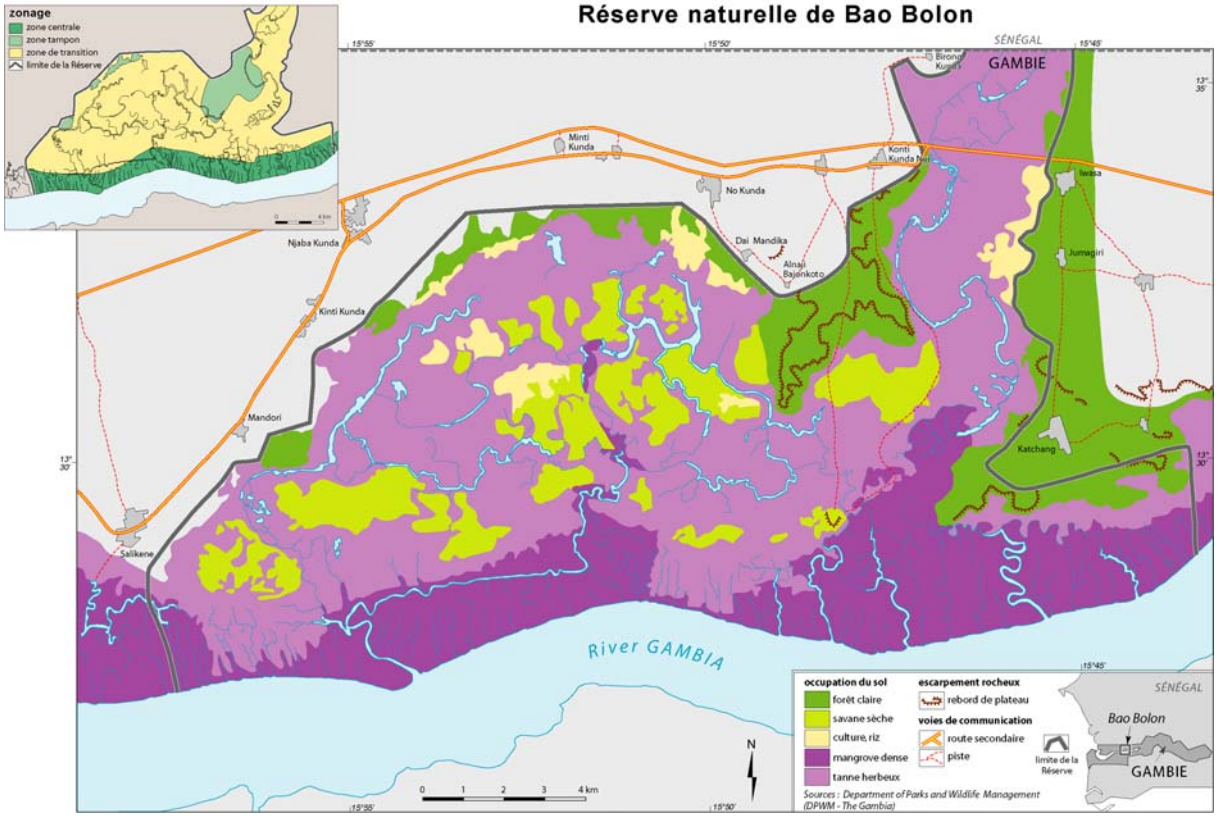


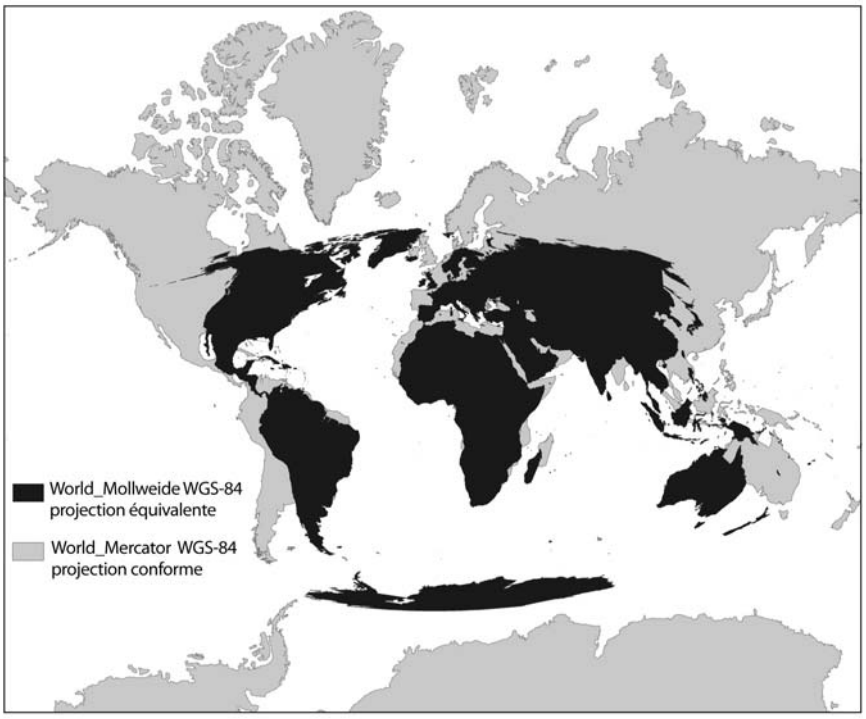
Figure 2: The use of inserts. Map taken from the annexes to the Regional Strategy for marine protected areas in West Africa, 2003.

For mapping the case study results, it may be useful to make use of these two scales to switch from "informative map", providing knowledge of the area, to "demonstrative map" which tries to reveal the inherent dynamics by showing the correlations between different agents (physical and anthropogenic) which are sometimes outside the scope of the study area for the observed changes.

Projection

The choice of geographic projection is often suggested by the document used to produce the base map. This choice is not always deliberate, to the extent that this reference is often omitted from the final map. This oversight is understandable when working with a large map scale: the deformation of angles, distances and surface areas due to the projection of the globe on a flat surface are effectively negligible in this case. On the other hand, there is much at stake in the choice of projection when mapping a phenomenon on a very small scale (continent, world). In the following example (figure 3), the two World maps have been drawn on the same scale but according to two different projections. The equal-area projection (black) respects the surface areas of the continents, while the conformal projection (grey) respects the angles and shapes of the continents but not the surface areas, especially in high latitudes: Africa is actually 14 times bigger than Greenland.

Figure 3: The vision of the World differs depending on the geographic projection used



Cylindrical, conformal projections (Mercator or UTM Universal Transverse Mercator) therefore generate few errors of area at low latitudes or locally, near the central projection point, whereas there are major area aberrations beyond 75° north and south. This is part of the reason why cylindrical projections, and in particular UTM, are used in the low latitudes (inter-tropical regions) and large scale representations. Approximately 80% of the large scale maps produced in the world (topographic maps) are based on the UTM grid. For the middle latitude regions (temperate regions), conical projections are used and for the high latitude regions (the polar regions), azimuth projections are recommended.

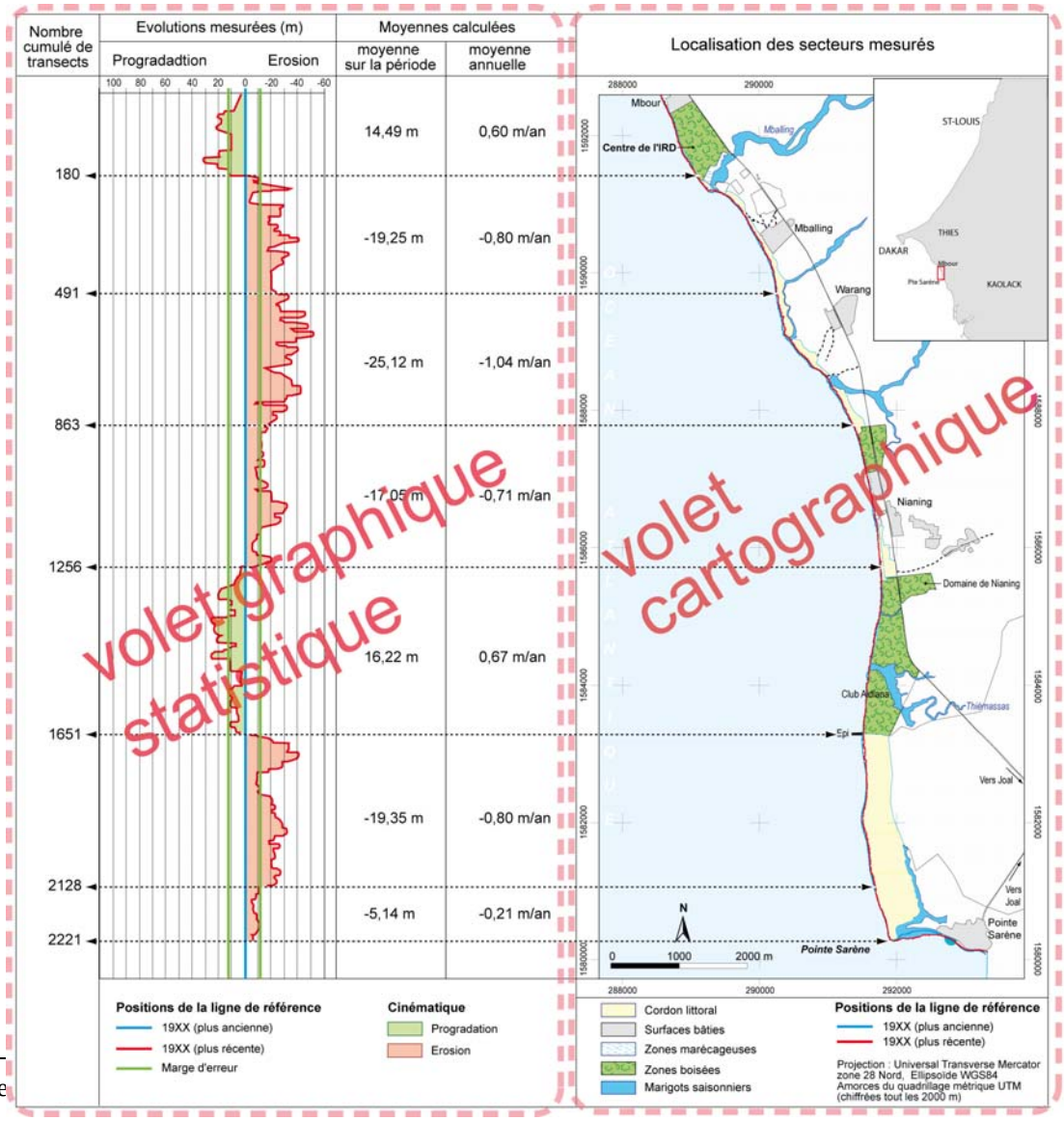
The UTM projection (like all projections) can be associated with different geodesic systems, but it is typically associated with the world geodetic systems revised in 1984: WGS84 (*World Geodetic System 84*) which has become the standard ellipsoid in cartography, especially with the current use of GPS.

Each map produced should clearly indicate both the projection used and the associated geodetic system[21]. This is a prerequisite for the resulting map to become in turn a reliable and reusable source of information.

Maps and graphics: the cartographic model

As we mentioned above, the amplitude of shoreline changes can vary greatly at different places in the study area during the observation period. On the map, this means it is impossible to represent displacements that are minimal in relation to the scale of drawing of the map. To be able to conserve and share this information in spite of this, a graphic representation model is used in addition to the cartographic representation model, to complete the qualitative information (position of the shoreline at different dates) with quantitative information (progradation/erosion expressed in metres, to render the changes).
The cartographic model (figure 4) recommended for case studies, given below, therefore makes it possible to:

-show and situate the changes in the shoreline; "cartographic section" of the model
- measure these changes through the use of shoreline change statistics; "graphics and statistics section" of the model.



[21] Pre

Figure 4: The two sections of the proposed cartographic model (Source: I. I. Faye, 2010)

The cartographic section

The coastlines at different dates are represented by a line-type feature. The use of colour is recommended to distinguish between the different lines. Colour is in fact the most selective visual variable; used at the same value (figure 5 A), it can effectively distinguish between phenomena that are of the same kind (land and sea boundary) but geographically close. The variation in the type of linear feature (figure 5 B) can also play this selective role, but it is less effective. Used as a complement to colour, this option could be envisaged when there are a large number of coast lines. The thickness of the linear feature should be avoided (figure 5 C) as it introduces too great a notion of hierarchy between the features at different dates. Lastly, the use of the value variable, even associated with a single colour (figure 5 D) is difficult to apply, due to a *length*[22] that is too short to be very selective in a linear presentation.

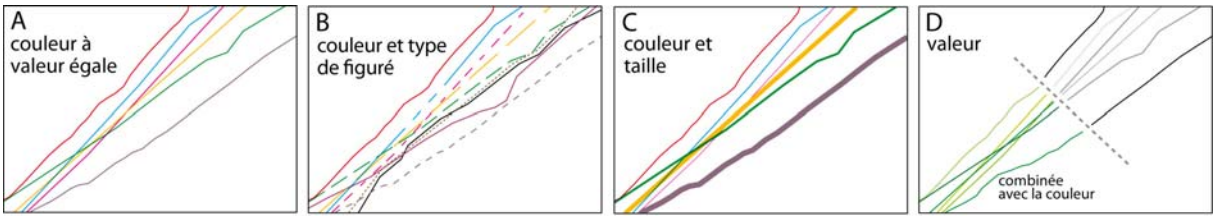


Figure 5: Examples of different visual variables used in a linear presentation.

We recommend the use of equal value colour (A) to represent the different shorelines. By convention, red is used for the most recent shoreline. After red, following the order of the spectrum: orange, yellow, green and blue (figure 6 A). However, if there are more than five shorelines, shades will have to be used between these five basic colours by combining the colours with one or two values at the most (figure 6 B). Also, by convention, when representing two shorelines, red is therefore used for the most recent date and blue for the oldest.

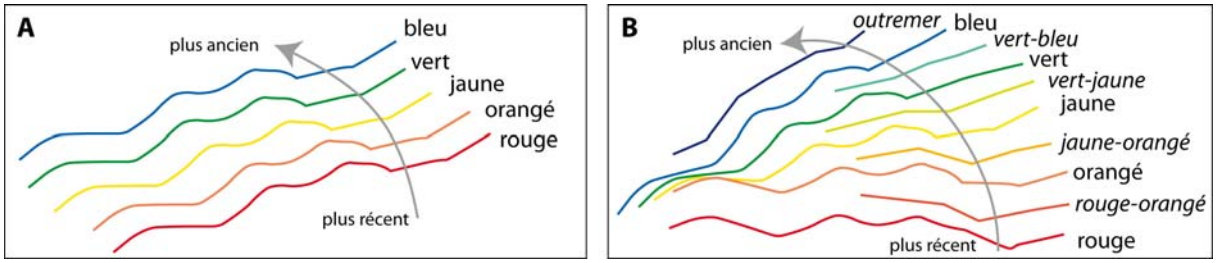


Figure 6: Proposed legend for the shoreline represented at several different dates

[22] In graphic semiology, "what we call the *length* of a visual variable is the number of shapes it can be used to distinguish between, therefore the possibilities it offers for differentiation". M. Béguin and D. Pumain in *The representation of graphic data*, ed. Armand Colin, 2001.

The linear feature of the shoreline should conserve the traces of the method applied to obtain it. When the shoreline is obtained from digital image processing, the "incremental" aspect of the line should be conserved, without trying to smooth it. This preserves the initial information from alteration and also constitutes a cartographic testimony to the techniques implemented to produce this information (figure 7).

Figure 7: Example of "crenulated" (black line) shoreline, produced by vectorisation of the objects obtained by processing satellite images. *Extract from the map of the Coastal environment of the Bijagos Archipelago 1:50,000. UMR 6554 Geosystems, CNRS, Brest 2001 .*

Land use around the coastal area, and the different facies will be represented in zones by light colours (low saturation) associated or not with features to avoid disrupting the legibility of the shorelines. Saturated colours used in zones in the neighbourhood of colours applied on linear features gives too much importance to area themes. In figure 8 A, the eye is first drawn to these large green, yellow and blue patches, whereas the coastline at three dates is read in the second instance, although it is the main theme of the map. In the other case (figure 8 B), we first see the shorelines then the area themes.

Conventionally, the information relative to human land use (individual housing or urban areas, for example) are represented by grey values. Saturated black can be used if the zones are very small (isolated housing). But there again, the use of saturated black should be avoided for relatively extensive areas, which would give too much importance to the theme, as we saw in figure 8 A.

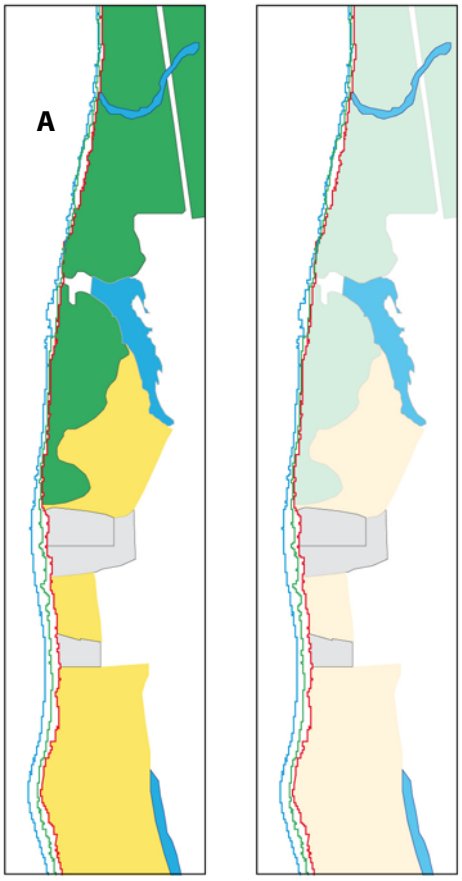


Figure 8 : Aplats de couleurs saturées et aplats de couleurs en tons clairs au voisinage de lignes en couleurs saturées

The colour black is also chosen for the linear mapping of land communication lines: roads, paths and railways (figure 9). The "size" variable can be used to establish a hierarchy between the different types of roads, if necessary. For railways, a particular line feature is introduced: the “hashed line” is the most commonly used.

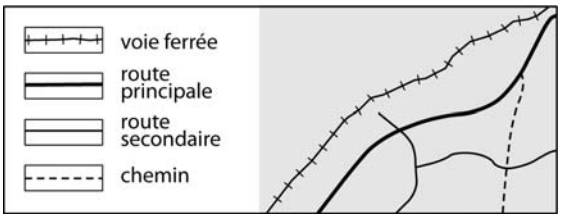


Figure 9: Examples of representations of road and railway lines

Lastly, it is proposed to reserve the colour violet to map all types of coastal defences to mitigate erosion (figure 10): seawalls, groynes, ripraps, dykes, etc. "Passive" methods or static defences making use of structures on the shore or directly in the sea are largely applied on all the coasts. The resulting defences are involved in different ways in the shoreline changes, particularly by disrupting littoral drift. For this important theme, the use of this distinctive colour is recommended.

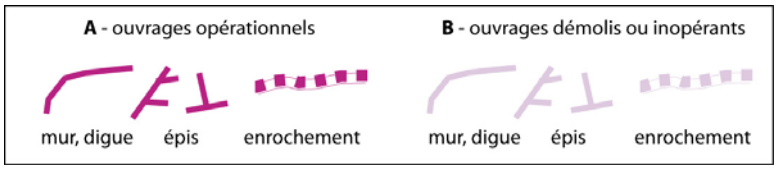


Figure 10: Legend proposed for defensive structures against erosion

The graphics and statistics section

As can be seen in figure 4, the graphics and statistics section is divided into two components. The part entitled “Measured changes” renders sector-based shoreline accretion/recession (sectors bordered by horizontal dotted lines) visually by means of curves. These sectors constitute the basic scale of analysis for the graphics and statistics section. They each correspond to a segment of coast along which the characteristics (rate of change and distances) of progradation and erosion are close or similar. The error margins, related to the shoreline extraction techniques, are also shown in this figure (vertical green lines). The areas bound by the crossing of the shorelines with the baseline (in black) are respectively the areas of progradation (left) and erosion (right).

In general cases, the warm colours, from yellow to red, symbolise positive states while cold colours, from greenish-yellow to ultramarine, express negative phenomena. However, the colour red can also denote a risk, prohibition, alert or some feature that should be noticed. The majority of maps that illustrate coastal erosion phenomena establish a link between the colour red and the situation of erosion; erosion is considered here as a significant coastal risk to which attention should be drawn. We therefore suggest that red (or at least a warm shade close to red) be conserved for representing areas of erosion, while areas of progradation will be shown in green.

In the part entitled "Calculated means", there is a table divided into two parts:

-the "mean for the period" column gives the mean displacement (in metres) of the shoreline for the entire study period, for each sector of the coast;

- the "annual mean" column also gives the displacement of the shoreline but calculated over an annual period (in metres per year).

The curve of the graphics section are drawn in the spreadsheet Excel (commercial software from Microsoft which can be replaced by the Calc module in the free OpenOffice software for example). These Cartesian coordinate curves represent:

- on the X axis, the number of measurements or profiles taken and
- on the Y axis, the values of the changes measured (between two successive coastlines) or the rates obtained by linear regression (if several shorelines are available for the entire study period).

In the following paragraphs, we present two illustrations produced using the DSAS (*Digital Shoreline Analysis System*) extension designed by Thieler et al. (2005). DSAS is a free "plug-in" for the host programme ArcView[23] (GIS from ESRI) which is used to analyse and quantify shoreline position changes (figure 11).
To perform this analysis, three steps are required:

-- define a fictional baseline;

-- automatically generate transects perpendicular to the shoreline according to a user-defined increment;

- calculate the mean values of shoreline changes over the study period.

This also presupposes that the layers of "shoreline" information at the different dates are all defined within the same projection system.

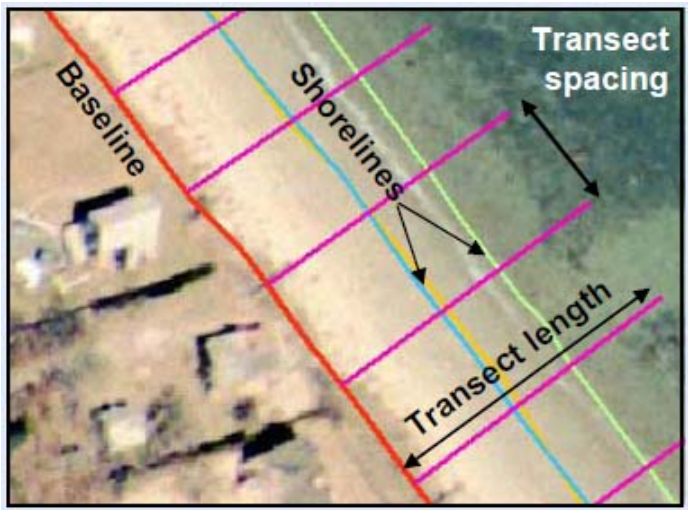


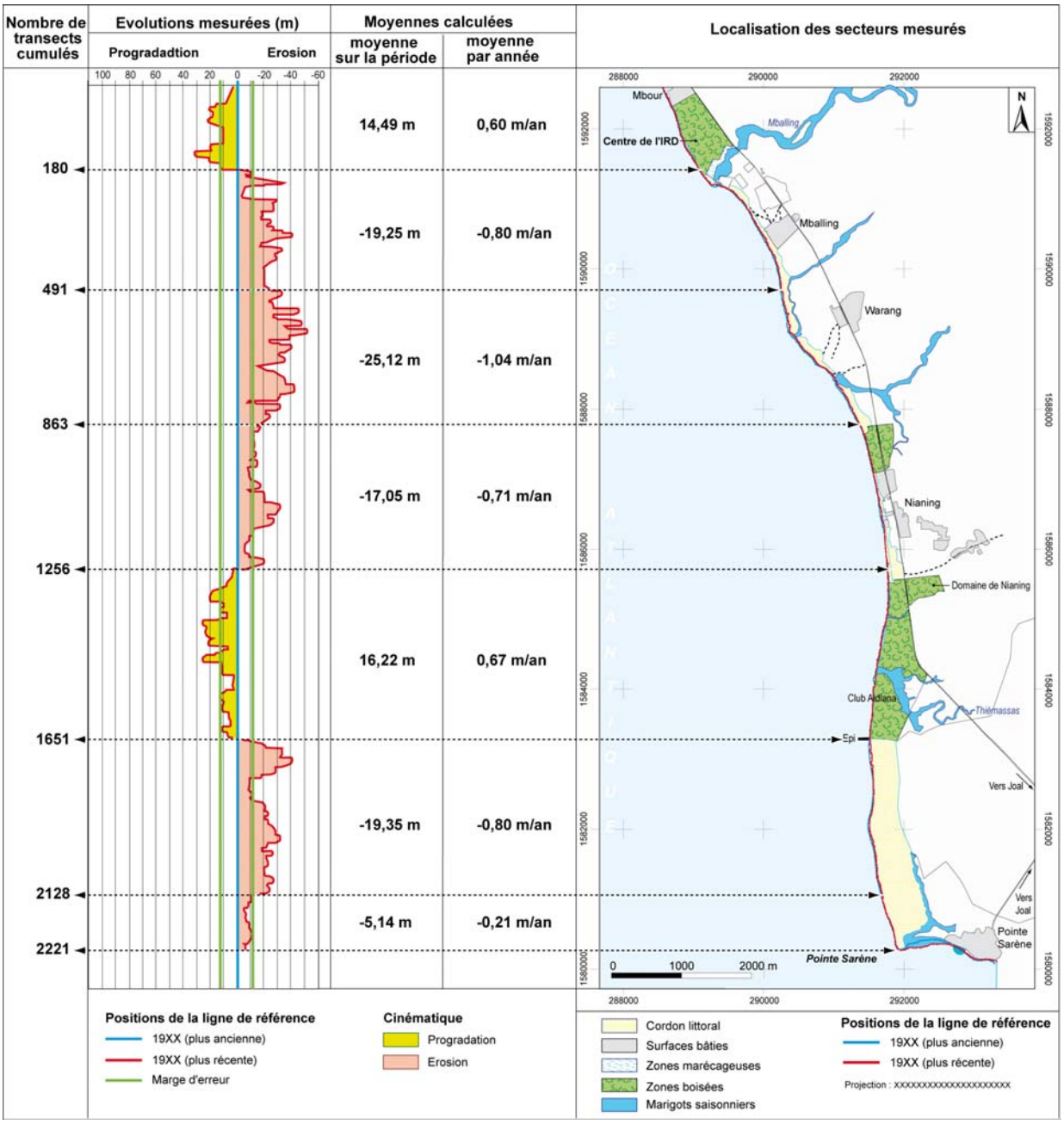
Figure 11: The concept of the DSAS plug-in. From *User Guide & Tutorial for the Extension for ArcGIS v.9.0 Digital Shoreline Analysis System (DSAS) version 3.2*

When all the transects are correctly in place, DSAS automatically calculates the mean displacement rates of the shoreline along each of them. In the model shown below (figures 12 and 13), the distance between the transects is equal to 5 metres. This automatic analysis of all the transects is used to define sectors (areas with close or similar change values) in order to group together and average the change values recorded along the length of the shore.
After the processing, in addition to the geographic attributes, the transect attribute tables contain different statistical attributes at least two of which should hold our attention.

[23] DSAS works with all versions of ArcView since version 3.2a

The first one is labelled EPR (*End Point Rate*). It is calculated by dividing the distance of total shoreline movement by the number of years elapsed between two dates. Expressed in metres per year, this is the attribute to be found in the cartographic model (figure 12), under the label "annual mean".
The EPR method is suitable when there are only two shorelines for evaluating coastal changes.

Figure 12: The cartographic model based on calculating the *End Point Rate* (EPR) between two



dates (Source: I. Faye, 2010)

The second attribute is the LRR (*Linear Regression Rate-of-change*). It corresponds to the slope of the regression line fitted to the distance measurements between the intersection points of each transect and the different shorelines. This attribute also expresses the annual change rate of the reference line along each transect and is of interest if coastal change is analysed for more than two dates, because the calculation method takes into account the trend in shoreline change over the whole period under consideration.

The cartographic model in figure 13 illustrates the use of this attribute for a case study based on three shorelines.

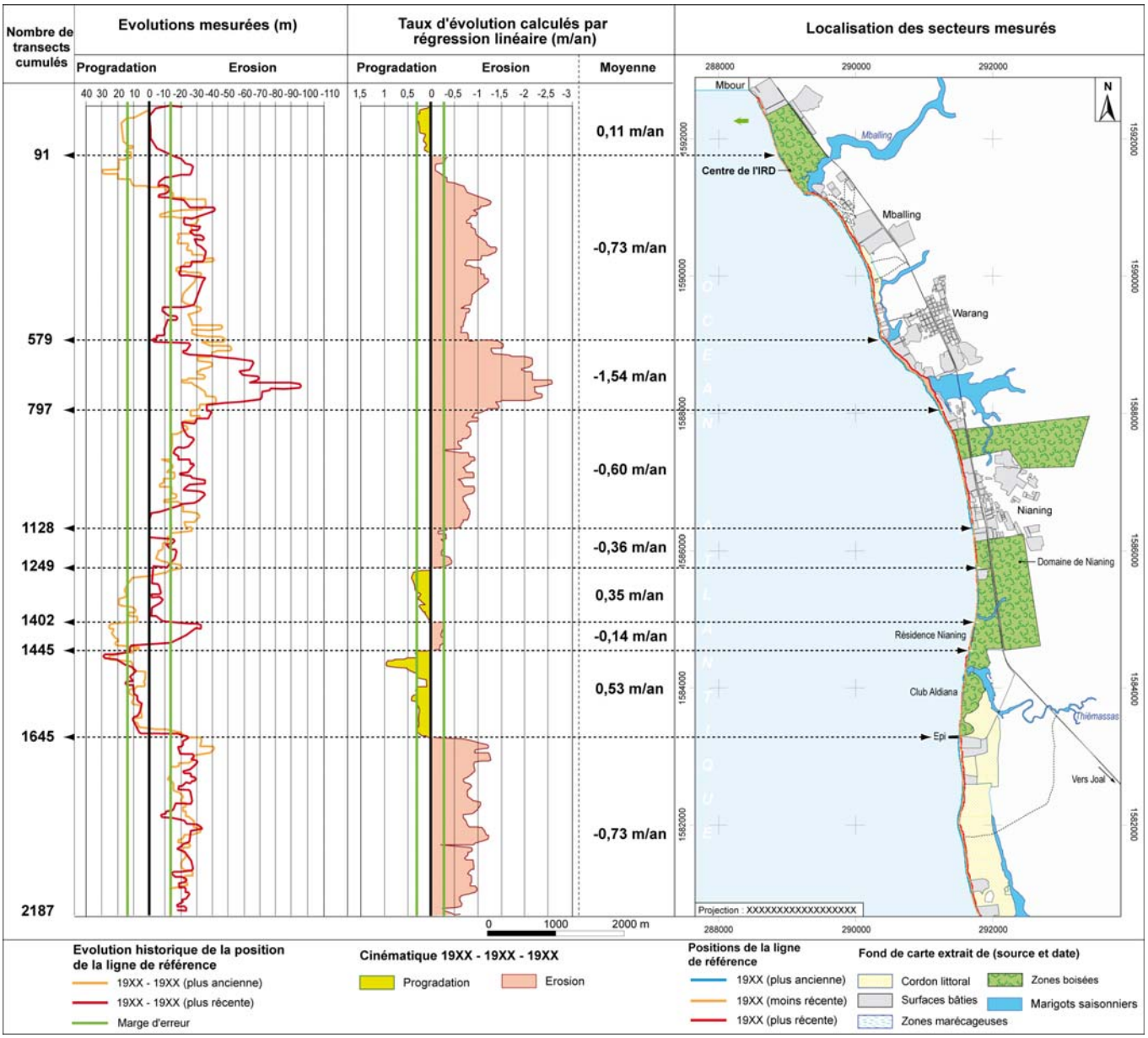


Figure 13: The cartographic model based on the calculation of the Linear Regression Rate-of-change (LRR) for a study period comprising three dates (Source: I. Faye, 2010)

Compulsory map components for any maps produced

The title: it should be explicit because it is the reader's first approach to the map. It should preferably be placed at the top of the map. Our twin-section cartographic model is a slightly special case: in situations where the two sections are present, the title is placed above the titles of the two sections to constitute a general title. Certain case studies will not be able to follow this model precisely and may present only the cartographic section. If this is the case, the title will be sole title of the map.

Inserts: at least one insert is necessary, to situate the site geographically, either in its region or country. This insert may use a succinct nomenclature. Additional inserts may be used to complete the information on the main map (see figure 2).

The scale, which must be graphic on the large-scale map, can be accompanied with a numerical scale. The facility with which the cartographic documents can be reproduced without having to take into account enlargement or reduction factors should encourage the generalised, priority use of the graphic scale.

The orientation is compulsory if the North of the map is not at the top of the page (for example, if the map bases are turned to make optimum use of a page format). The use of the simplest evocative symbol is recommended.

The sources of base maps: With the advent of electronic data circulation, an increasing number of diversified readers can view maps, sometimes outside their scientific context, and without the accompanying comments. It is therefore important to fill in as clearly as possible, on the actual map, the source of the basic data used.

Projection and ellipsoid: this subject was already partially covered in the section devoted to the choice of projection. It is in fact the accuracy with which the geographic references of the drawings are described, which will condition the reuse of the map as a reliable data source. This information should be preserved, as the data used to map the case studies will be stored and handled in a geographic information system.

The ticks and their definition are mentioned on the map. They usually correspond to the projection grid used, but ticks can also be added for the coordinates of another projection or the geographic coordinates.

The legend should be exhaustive and faithful. A symbol should be the same size in the legend as on the map and be unambiguous. For example, if the same symbol appears in different sizes on the map, this variation should be explained in the legend!

Notice to the reader

Over the years, developers have gradually extended the cartographic drawing functionality of geographic information systems. In recent versions of GIS programmes, for example, it has become quite easy to produce a map in a layout that is ready to print.
Nonetheless, there are still constraints with GIS technology and it does not enable the easy implementation of slightly special cartographic presentations like those presented in figures 12 or 13. In this type of representation, even if the graphics section is geographically linked to the map in the cartographic section, the link is not dynamic (in the Database sense); the rates of change measured and calculated are not included in the attribute tables of the basic information layers (shoreline, land use) and are handled graphically in spreadsheets or in Computer Aided Design (CAD) software programmes.
In this case, it is evident that the final map was not fully conceived in the GIS layout module. A succinct layout comprising only the items in the cartographic section can be exported in a specific format accepted by a CAD software programme. For example, in figures 12 and 13, the layout of the cartographic section has been exported in "EPS" (Encapsulated PostScript[24]) format then opened using DAO Illustrator[25]. It was in Illustrator that the graphics section was joined to the cartographic section and the map surround of the entire cartographic model was finished off.

Note that the cartographic model recommended above can only be implemented if the people in charge of the case studies provide the CSE cartographers with the basic data, including at least the following:

- digital base maps of their study areas that are sufficiently documented (scales, projections, sources and attributes of the mapped items)
- Digitally exploitable data on the measurements of erosions and/or accumulations as well as the exact location of the measurement points.

[24] Encapsulated PostScript (EPS) is a format created by Adobe Systems. It is a computer language that describes images containing raster and vector objects. The EPS format is widely used in exporting maps created with vector GIS, for it conserves the integrity of vector plotting.
[25] Adobe® Illustrator® is a commercial software vector drawing environment.

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Definitions

Map scale: the scale of a map is defined as the ratio of a distance on the map to the corresponding distance on the ground. It is therefore expressed as a fraction and so the larger the denominator the smaller the scale.

Geographic scale: this equals the level of observation of the phenomena. It is also sometimes called "level of analysis". It corresponds to the boundaries of the physical terrain mapped. Switching to a larger geographic scale means changing to a higher level of observation and therefore taking into account a greater surface area.

Length of a variable: number of perceptible stages that can be built within a visual variable" (BERTIN J., 1967): for example the value variable has a length equal to four in a linear presentation.

Differentiation: along with graphic density (optimum quantity of information per square cm) differentiation is one of the general rules of legibility. The human eye can only differentiate between a limited number of value stages (the ratio of black to white on a given surface area): no more than four in a linear presentation. This is why the use the colour variable is recommended, for its strong "differentiating power", to represent a high number of linear phenomena simultaneously.

ANNEX 6: DETAILED LIST OF NATIONAL, REGIONAL AND INTERNATIONAL EXPERTISE INVOLVED IN PRODUCING THE STUDY.

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Technical Coordination: **Jean-Jacques GOUSSARD,** chargé de mission EOS.D2C, réseau de conseil environnement et développement, consultant EAM-GEOME.

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BENIN	**Marc OYEDE**, Chercheur à l'Université de Cotonou

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