Assessment
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West Africa Coastal Areas

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Preface

The diversity of coastal risks, their consequences as well as the actors involved in their management requires a coordinated response on a supranational scale for more effective mitigation measures. To this end, the development and regular updating of the West Africa Coastal Areas Master Plan (SDLAO) is an important lever of the coordinated response strategy to coastal stakes in West Africa. Initiated since 2009 by the Commission of the West African Economic and Monetary Union (WAEMU), within the framework of the Regional Program for the Control of Coastal Erosion (PRLEC), subject of Regulation 02/2007/CM/WAEMU adopted on April 6, 2007, the elaboration of the SDLAO is part of a multi-stakeholder participatory approach with the assistance of, among others, the International Union for Conservation of Nature (IUCN), through the Ecological Monitoring Center (CSE) in Dakar.

A regional platform for investment planning, the SDLAO covers the geographical area from Mauritania to Benin, including Senegal, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana and Togo. During the validation of the first edition of the SDLAO (2011), the ministers in charge of the environment of the countries concerned resolved to *"set up as soon as possible, the West African Coastal Observatory, to monitor the evolution of our coastal areas and guide the decision support in terms of development and reduction of coastal risks".*

In the wake of this, the West African Coastal Observation Mission (WACOM) was set up in 2012 as a transitional mechanism towards the establishment of the observatory, under the coordination of the Ecological Monitoring Center (CSE) in Dakar. Through this device, the first update of the SDLAO was carried out in 2016 and noted the rapidity of changes in the coastline, in relation to the evolution of socio-economic stakes and weather-climate-marine hazards.

This edition of the SDLAO demonstrates the commitment of the stakeholders to continue updating this important coastal management tool. It is part of the implementation of the West Africa Coastal Areas Resilience Investment Project (WACA ResIP), financed by the world Bank and the States concerned. This phase also marks the entry of São Tomé & Príncipe in the process, bringing to twelve (12) the number of countries covered.

The SDLAO is based on a list of priority indicators validated by countries and regional institutions for monitoring coastal risks related to the components "hazards", "stakes" and "risk management method". This important exercise was made possible thanks to the commitment and strong mobilization of institutions and actors at national and regional levels. In this regard, I would like to reiterate the WAEMU Commission's thanks to the main actors, including the Dakar CSE, IUCN, the Secretariat of the Abidjan Convention of the United Nations Environment Program (UNEP) and the World Bank.

I hope, on the one hand, that this edition of the SDLAO will further strengthen the process of integrated coastal areas management in West Africa and, on the other hand, that the partnership dynamics and the momentum of mobilization of regional stakeholders alongside the WAEMU Commission will be maintained and consolidated for a more resilient West African coastline, in the perspective of sustainable development.

Jonas Gbian,

Commissioner for Agriculture, Water Resources and Environment
West African Economic and Monetary Union (WAEMU) Commission

Foreword

The 2020 Assessment of Coastal Areas, like the West Africa Coastal Areas Master Plan (SDLAO) and its first update in 2016, has mobilized experts from all walks of life and many institutions at national, regional and international levels. This was done in the particular context of the Covid-19 pandemic, which destabilized the strategies and initial planning of the process. Remote work, through online internet tools, has been systematically introduced.

The focal points of the West African Coastal Observation Mission (WACOM), members of the regional scientific committee, have once again played a key role in updating the 179 coastal sectors, making available the changes observed on the hazards and stakes over the period 2016-2020. They were carefully reviewed and supplemented, as needed, by the World Bank's network of country staff. In this exercise, São Tomé & Príncipe, which joined the process, has really convinced with the commitment and availability of its team distributed in the WACA Project Management Unit (PMU) and the National Observatory. The zoning, the subdivision of the coast into sectors and their characterization representing the reference state could be done efficiently.

The major innovation of this edition of the Coastal Areas Assessment concerned the general report, which mobilized around 92 experts from approximately 46 institutions, each of whom dealt with the specific themes addressed by the Assessment in his or her own field. This is all the more comforting since all of these experts responded spontaneously and voluntarily to the said request.

The Ecological Monitoring Center (CSE), which was responsible for the preparation of the 2020 assessment, and which benefited from the constant support of the WAEMU, the World Bank and IUCN, warmly thanks all of these contributors who have undeniably benefited the document.

The innovation also involved, under the aegis of WAEMU, the establishment of a Task Force which closely monitored the process and validated the main steps. IUCN, the Abidjan Convention and the World Bank were the prominent members of this Task Force chaired by WAEMU.

Interactive mapping is also a new feature of this 2020 assessment: the data making up the SDLAO updates are available on the Regional Partnership for Coastal and Marine Conservation in West Africa (PRCM) web platform and accessible to users. This platform already contained the basic data for the master plan.

Finally, the organization of contributions was carried out with the technical support of Creocean.

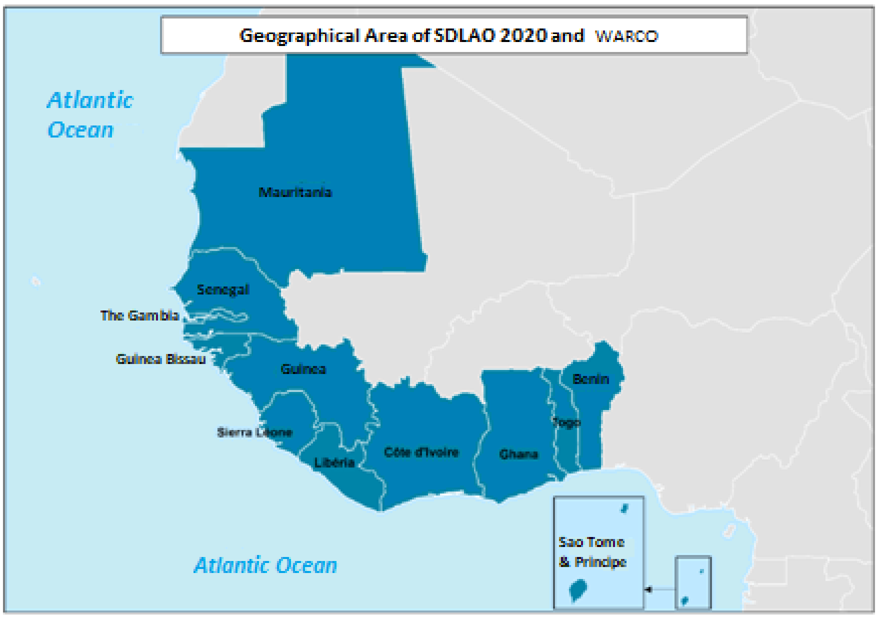
The next coastal areas assessment will already be able to count on this network of partners.

Introduction

The development of the West Africa Coastal Areas Master Plan (SDLAO) in 2011, within the framework of the WAEMU Regional Program for the Control of Coastal Erosion (PRLEC), marks an important step in the willingness of States to integrate the management of coastal risks in policies or initiatives to improve the resilience of populations to climate change. The Dakar Declaration of May 2011, following the restitution of the SDLAO to the Ministers in charge of the Environment of the different States, was very innovative in recommending the establishment of the West African Coastal Observation Mission (WACOM), bringing together eleven countries (from Mauritania to Benin), under the coordination of the Ecological Monitoring Center (CSE) and the technical support of IUCN. The periodic updating of the SDLAO is therefore instituted, through regular Assessments, highlighting changes in hazards and stakes at the level of 44 areas and 179 sectors of the West African coastline determined in the detailed master plan; while the general management scheme analyzes the conditions of manifestation of hazards, the vulnerability of environments (physical and socio-economic), the forms of responses provided and the modalities of financing projects and initiatives to respond to coastal hazards.

WACOM's national offices, the regional unit's correspondents at country level, along with governance bodies (Regional Scientific Committee and Regional Orientation Committee), have largely supported the process through a participatory approach to producing and making available data and information, without, however, having a clear institutional framework and well-established operating resources. Between 2011 and 2016, the regional technical workshops organized by the regional unit of WACOM, made it possible to circumvent this difficulty and to carry out the 2016 assessment corresponding to the first update of the SDLAO.

The validation of the 2016 Assessment, in July 2018 in Abidjan, by the meeting of ministers in charge of the environment of the various countries (see Final Communiqué in Annex 1) had raised hopes of strengthening the data production mechanism, recommending, among other things, the transformation of WACOM into a West African Regional Coastal Observatory (WARCO) with dedicated funds. The implementation of this strong recommendation is captured under the West Africa Coastal Areas Resilience Investment Project (WACA ResIP) launched in November 2018, of which São Tomé & Príncipe is a stakeholder, bringing the number of countries involved to twelve.



This 2020 Assessment of West African Coastlines is the third version, developed within the framework of the WACA ResIP project. The inclusion of São Tomé & Príncipe brings the number of SDLAO zones to 47 and the number of sectors to 186. The country has two main islands: São Tomé, whose coastline is subdivided into 2 zones and 5 sectors, and Príncipe, which has 1 zone and 2 sectors, making a total of 3 zones and 7 sectors for the whole country. More details are provided in the detailed diagram on the characteristics of zones and sectors.

More than for the previous versions of the SDLAO, the elaboration of the 2020 assessment took place in a difficult context, marked by the Covid 19 pandemic, which did not allow the organization of regional technical workshops, privileged moments of data and information collection on the evolution of hazards and stakes at the level of the coastal sectors of countries (validation of experts' statements). The regional unit has adapted to the situation by organizing several online meetings with each country (national offices and scientific committee) to discuss the evolution of each sector between 2016 and 2020. This work has been extensively verified, sometimes supplemented by the World Bank's network of in-country partners.

The conditions of sectors (biophysical, socio-economic, hazards, stakes) are mapped at the scale of 1/500 000, the number of sheets passing from 9 to 10 with the inventory made for São Tomé & Príncipe.

In the SDLAO 2020, for the assessment of risk, the concept of "criticality" has been introduced instead of "priority" used in previous versions. It is the combination of the severity of an effect, the frequency of its occurrence, its duration or other attributes of a failure, as an expression of the need to implement avoidance and/or reduction measures. In this case, criticality concerns mainly coastal risks (coastal erosion, exceptional meteorological and oceanographic events) having an impact on people and property. It may also be higher for the "environment" compartment and have a significant impact on biodiversity or ecosystem services.

The criticality scale adopted here has four levels:

Low :	No action is required in the current situation.
Medium	Consideration of the recommendations in the projects and development plans that may concern the sector in question. There are no prescribed actions to be taken in the near future.
High :	Consideration of the recommendations of the Master Plan in all planning and development operations undertaken at local level. Assessment of the effects and impacts of operations and changes that would occur in adjacent areas.
Very high :	Implementation of actions as soon as possible, as the situations observed are already critical or tend to become so in the near future.

In the process of updating the SDLAO in 2020, criticality was assessed in a collegial manner during workshops (videoconference in 2020) that included, at a minimum, the country's Ministry of the Environment and the CSE. This is defined by experts from the territories.

TRENDS NOTED IN 2016 ARE CONFIRMED

The coastal zone of West Africa is characterized by sandy formations subject to the direct action of the coastal drift current (Mauritania to the Cape Verde peninsula), rocky capes and sandy coves (Cape Verde peninsula to the Lower Casamance, Liberia, central Ghana), several estuaries including the Senegal River delta and the Volta delta (Côte d'Ivoire), mangroves from the Sine Saloum in Senegal to the Sherbro Islands in Sierra Leone, large sedimentary basins of loose coastlines from Côte d'Ivoire to Benin. This feature predisposes the West African coastline to a certain fragility in the face of marine weather hazards.

The version of the SDLAO proposed in 2016 had noted rapid changes in the coastline, primarily related to marine weather hazards, concentration of economic activities, pressure on resources and the natural environment, and demographics. This dynamics continues in 2020, generating the densification of the habitat and sometimes anarchic occupation of the coastline. It is necessarily accompanied by more important uses of space (fishing pressure, modernization, development and construction of new commercial and fishing ports, development of the road network necessary for the growth of the private sector), but also by the development of activities such as offshore oil and gas exploitation which today extends to Mauritania, Senegal, Côte d'Ivoire, Ghana and Benin.

Coastal erosion is the main hazard on this coastline to which is added the flooding hazard linked most often to 3 combined phenomena: flooding by marine submersion, flooding by runoff and river flooding whose occurrence and power are aggravated by the effects of climate change. We can also mention the pollution hazard, whether continental (industrial, urban...) or maritime (maritime traffic, offshore oil and gas activities...), the disturbance of ecosystems (degraded mangroves...), and saline intrusions.

Given the impact of these hazards and the effects of climate change on the various components of the territories (environment, socio-economic development) of West Africa, several studies have been carried out to define the vulnerability of certain coastal areas and, for some, the cost of the inherent environmental coastal degradation and cost-benefit analysis of interventions.

The vulnerability of territories was assessed using various methodologies ("Coastal Hazard Wheel", "Coupled Model Intercomparison Project 5" and "Coastal multi-hazard risk assessment"). Therefore, in order to allow comparison between different territories with similar levels of granularity, it will be necessary to use comparable methodologies. To this end, a methodological note has been written as part of this assessment to guide managers in their approach to the vulnerability of coastal areas (Annex 5).

It appears, moreover, necessary to complement this approach with an in-depth analysis of socio-economic impacts that would provide a more reliable quantitative assessment of projected losses along the coast in the years to come.

The most notable impacts of coastal degradation on the population (mortality, morbidity, quality of life) and on the economy of countries are directly related to air and water pollution, runoff flooding and river flooding. The cost of coastal degradation can now be estimated. The results of two methods (world Bank approach, CoCED method) are presented in the report. They cover Senegal, Côte d'Ivoire, Ghana, Togo and Benin.

This approach can be complemented by a cost-benefit analysis of disaster reduction through different adaptation options as carried out in some pilot sites in Côte d'Ivoire, Ghana, Togo and Benin. To achieve greater comprehensiveness, this approach could include ecosystem goods and services. A specific study on the degradation of the mangrove, supported by the world Bank, is underway. The findings of this study can be used in the next update of the master plan.

VARIOUS ANSWERS OR SOLUTIONS

In order to fight against coastal erosion and coastal risks, several responses have already been made and new tools could be deployed at local and regional levels. The responses are multisectoral, complementary and are intended to be operational. They relate to the regulatory and institutional framework, spatial and multi-sectoral planning, investments for coastal protection and risk reduction, coastal observation and early warning systems, financing mechanisms, knowledge, research and education, dialogue within the public sector, but also the private sector and through awareness-raising.

The consideration of coastal hazards (erosion, submersion, landslides) in coastal development can be broken down into four types of solutions: strategic retreat, non-intervention, limited intervention (management and rehabilitation of coastal ecosystems, use of soft solutions) and maintenance of the coastline (use of hard and/or soft solutions). If soft solutions are to be preferred, grey solutions (traditional civil engineering works: groynes, dikes) are often favored because of their efficiency and their costs that are easy to determine and compare (even if very expensive), but also because of the need to protect immediate stakes and to fix the shoreline. Nevertheless, a few coastline management projects using soft solutions have taken place in West Africa (stabilization of the dune ridge in the Saint-Louis Marine Protected Area (MPA) [Senegal], maintenance of the beach profile of Diogué Island in Casamance, stabilization of coastal dunes on the Nouakchott coast [Mauritania], and hydrological restoration of the Ouidah mangroves [Benin]).

Therefore, in addition to physical measures to reduce vulnerability, building community resilience must be integrated into any risk management strategy or project. This is possible through the mobilization of these communities with multi-sectoral capacities in the various links of the response brought to the management of coastal hazards, but also through the financing of Income Generating Activities.

However, development strategies have often and for a long time overlooked the value and interest of the coastline, perceived as a space "apart" or possibly the exploitation of only private entrepreneurs. This situation contributes to the degradation of the coastline, which is more visible in large cities, and the implementation of more or less authoritarian procedures or regulatory bodies can conceal the absence of a global policy.

However, such measures, although essential, are proving to be insufficient and numerous reports have highlighted the need for a new vision in coastal development policy. Among the many considerations, the need for new governance appears essential to achieve Integrated Coastal Zone Management (ICZM).

In order to better assess the state of the coastline and the pressures on it at regional level, and to support the management of coastal areas and marine activities, the Regional Observatory for Spatial Analysis of the Community Territory (ORASTEC), should be operational during 2021.

The Regional Program for the Control of Coastal Erosion (PRLEC) materializes the consideration of the issue of coastal erosion and coastal risks and the desire to provide operational responses from an institutional and organizational perspective. One of the main achievements is the establishment of the WACA program and in particular the West Africa Coastal Areas Resilience Investment Project (WACA ResIP) whose implementation is facilitated by the Regional Support Office (WACABAR) set up by IUCN and the local support of Project Management Units and advisory bodies. Around this project, a coalition of national and international actors are committed through the PRCM (Regional Partnership for the Conservation of the Coastal and Marine Zone), the RAMPAO (Regional Network of Marine Protected Areas in West Africa), the GI WACAF (the result of collaboration between the International Maritime Organization (IMO) and the International Petroleum Industry Environmental Conservation Association (IPIECA) with a view to improving the level of preparedness and response to oil spills in the West, Central and Southern African regions).

The operationality and efficiency of these bodies are, to some extent, linked to national and international rights and policies. These evolve and are enriched, but certain inconsistencies and imprecisions between legal provisions remain, making them difficult to apply. Shortcomings in the governance of the coastline may indeed hinder the implementation of certain measures (poor application of policy and legal tools, poor compliance with regulatory standards, dysfunctional inter-sectoral coordination bodies, overlapping jurisdictions).

Nevertheless, spatial and multi-sectoral planning is part of the concerns of various actors in the region (Abidjan Convention, WAEMU, IUCN, and CSE) and allows for the emergence of regional, national and local action plans. Among these, at regional level, the action plan for the Integrated Coastal Zone Management, the action plan for the sustainable management of mangroves, the action plan for the management of pollution from land-based sources, the action plan for oil and gas business, the Regional Strategic Action Plan for Investments (PARSI).

Although various measures have been taken at different scales, mainly at local level, there is a need to improve management at regional level (Alves et al., 2020). Additional studies on extreme climate events, sea level rise, and storm surges are needed at both national and regional levels to assess their future effects on coastal erosion and flooding.

The strengthening, monitoring, promotion of an observation network, the generalization of centralization and exchange of public data for a better understanding of coastal dynamics and pressures are encouraged. It is also necessary to identify and involve not only stakeholders, but also communities and scientists with multi-level inputs.

The WARCO, which is currently being designed, will be supported by national observation systems and will contribute to the provision of marine and coastal data useful for risk prevention, early warning and decision-making. Scientific organizations already associated with the project include the World Meteorological Organization (WMO), the French Naval Hydrographic and Oceanographic Service (SHOM), and the European Space Agency (ESA). These organizations are already actively involved in satellite observation (land use, bathymetry, water quality - chlorophyll a, monitoring of land-based pollution and oil spills at sea) and the development of early warning systems against floods.

The current feasibility study has identified a network of 19 wave gauges for the collection of atmosphere-ocean data, while the quality of the existing tide gauge network is being assessed. This is accompanied by an assessment of acquisition costs and capacity building needs for data exploitation and equipment maintenance.

The acquisition of this data will inform the expanded list of indicators for monitoring coastal risks related to the "hazards", "stakes" and "risk management method" components that are identified and prioritized in the WARCO feasibility study (see Appendix 3). Among these, fifteen (15) indicators related to stakes and hazards are validated for short-term monitoring at regional level (see Appendix 2).

SHORT AND MEDIUM TERM PERSPECTIVES

Strengthening the coastal risk observation/monitoring system

The production of updated and quality coastal and marine data that can feed forecasting models and algorithms is essential; it should be realized through the WARCO, which is being designed, in relation with national mechanisms that are also being strengthened. The foundations for the sustainability of such a system are found in the bodies currently involved in coastal risk monitoring in the countries, which are over 85% public bodies. Even if human resource capacities still need to be strengthened in this area, they are not a major constraint; it is mainly the equipment that needs to be modernized and integrated into the global observation network.

Use of satellite earth observation data

Satellite Earth observation provides valuable information for many disaster-related applications. In marine and coastal areas where the use of in situ measurement techniques is particularly costly and difficult, satellite Earth observation data can provide access to valuable information for decision making at a lower cost. The development of partnerships with ESA, NASA and other satellite data production and management consortia on a global scale is strongly advocated.

Developing the early warning system

The design of an Early Warning System (EWS), Coastal Inundation Forecasting Initiative (CIFI) is proposed for West Africa (WA-CIFI) within the framework of the Climate Risks & Early Warning Systems (CREWS) international initiative and the WACA program. It will be implemented at national and regional levels through a partnership between the World Meteorological Organization (WMO) and the World Bank Group.

The WA-CIFI EWS will provide critical forecasts and alerts on coastal hazards, such as storm surge and coastal swell, in combination with natural tidal influences and riverine and flash flooding.

The early warning system planned under WARCO will complement this initiative by integrating coastal erosion and pollution.

Integrating social investments

In particular, planned relocation is a strategic process, undertaken as part of national resilience planning that engages communities to voluntarily resettle to safer land. It can be better integrated into the coastal risk response mechanism in West Africa by combining the following principles that can contribute to the acceptance and success of the process:

- engaging all stakeholders from the design phase;
- taking into account the livelihoods of people in the new area;
- providing for measures to prevent the reoccupation of the area at risk;
- maintaining socio-cultural links;
- developing resettlement action plans.

Income-generating activities also provide people with resources and means to improve their ability to cope with shocks and adapt.

Promoting coastal hazard response funding

Within the framework of the WACA program, the WAEMU Commission, in collaboration with its current partners, has initiated the generalization of the investment planning and facilitation process through:

Technical assistance to States in the definition and preparation of the identified investments, in particular through the development of National Multi-Sector Investment Plans for Coastal Resilience (MSIP);

coordinating investments between countries and encouraging new countries to join the initiative;

The Regional Strategic Action Plan for Investment (PARSI), which reflects a harmonized regional vision of priority investment needs, the planning of these investments and the monitoring of their implementation;

The West Africa Coastal Areas Assessment, which provides an overview of coastal risks and guides responses through investment planning with a particular focus on priority areas.

To this end, a strategy will be put in place to mobilize funding for all the projects identified in the MSIP and/or the strategic development documents of the countries on the issue of erosion, pollution and flooding.

Focusing the coastal assessment on the detailed master plan and the WARCO mechanism

The integration of the strategic guidelines recommended in the general report is more difficult to measure and monitor at the time of the assessment because of the complexity of evaluating their consideration at the level of each country.

On the other hand, the information and guidelines contained in the detailed master plan seem more likely to be integrated into coastal risk management processes and tools in West Africa. This has been verified in studies and plans already completed or underway in several countries (Côte d'Ivoire, Senegal, Togo), including framework studies undertaken through the WACA program (Benin, Côte d'Ivoire, Ghana, Togo). The location of the coastline segments to which well specified hazards and stakes are attached, probably contributes to this situation.

Despite this interest, the information and data collected in the detailed master plan still lacks completeness and precision in some places, mainly due to structural and institutional constraints at national level.

To respond to this observation, the next assessment may focus on a detailed and harmonized update of the detailed master plan based on indicators monitored at regional level by satellite imagery within the framework of the WARCO. This should be the central element in the production of data and information on the coastal zone in West Africa. The scientific committee at country level will be mobilized to validate the data at local level and provide additional information on national policies and strategies in terms of spatial planning and land use in relation to the risk of submersion and erosion. This additional information will also cover the priority actions defined by the States in this field.

1. West Africa Coastal Areas: elements of the current situation

1.1 Biophysical context

The West Africa coastal areas, from Mauritania to Benin, extend over approximately 10,000 km of coastline (WAEMU, 2017). In this coastal line, rocky coastlines constitute less than 3% of the coastline formed by rocks often altered and fractured, sometimes not very coherent, and subject to landslides and erosion, such as the cliffs of Dakar for example.

1.1.1 A mainly sedimentary coastline

The rest of these coastlines, mainly composed of sedimentary basins, are divided between (WAEMU, 2017 ; Figure 1) :

- Very dynamic, unstable and mobile coastlines:
  - ✓ Mangroves in constant evolution (48%);
  - ✓ Sandbanks, estuaries, river mouths, free point spits and islets by nature also very unstable and dynamic (12%);
  - ✓ Sandy formations of lidos (thin sandy cordon intercalated between a lagoon and the sea shore), also unstable and strongly evolving (7%).
- Also sedimentary, dynamic coastlines but whose mobility is organized over longer time scales, even if they are subject to natural episodes of accretion and erosion, seasonal or during exceptional meteorological and marine events:
  - ✓ More or less rectilinear sandy coasts, relatively stable, but subject to cyclical phases of erosion and accretion, also very sensitive to any disturbance of the littoral drift (16%);
  - ✓ Coasts in steps or in capes and coves (14%) where the coves are as many compartments more or less separated by rocky or less loose outcrops. Their stability depends strongly on the orientation in relation to the swells and currents. The sedimentary stocks here are often very limited.

The high representation of mangrove coasts is related to the high fractal dimension that characterizes the shoreline in these environments (WAEMU, 2017).

The rocky outcrops that structure this coastline through less loose but fragile capes are few: basalts and other rocky formations of the Cape Verde peninsula (Senegal), outcrops of Cape Verga and the Conakry peninsula (Guinea), Freetown breakwater (Sierra Leone), relics of sandstone rocks or armourstone spared by erosion (sandstone of the Senegalese Petite Côte, Bijagos [Guinea-Bissau] and the periphery of Accra [Ghana]), granites and metamorphic rocks present on the whole of Liberia, the west of Côte d'Ivoire and the central part of the Ghanaian coast.

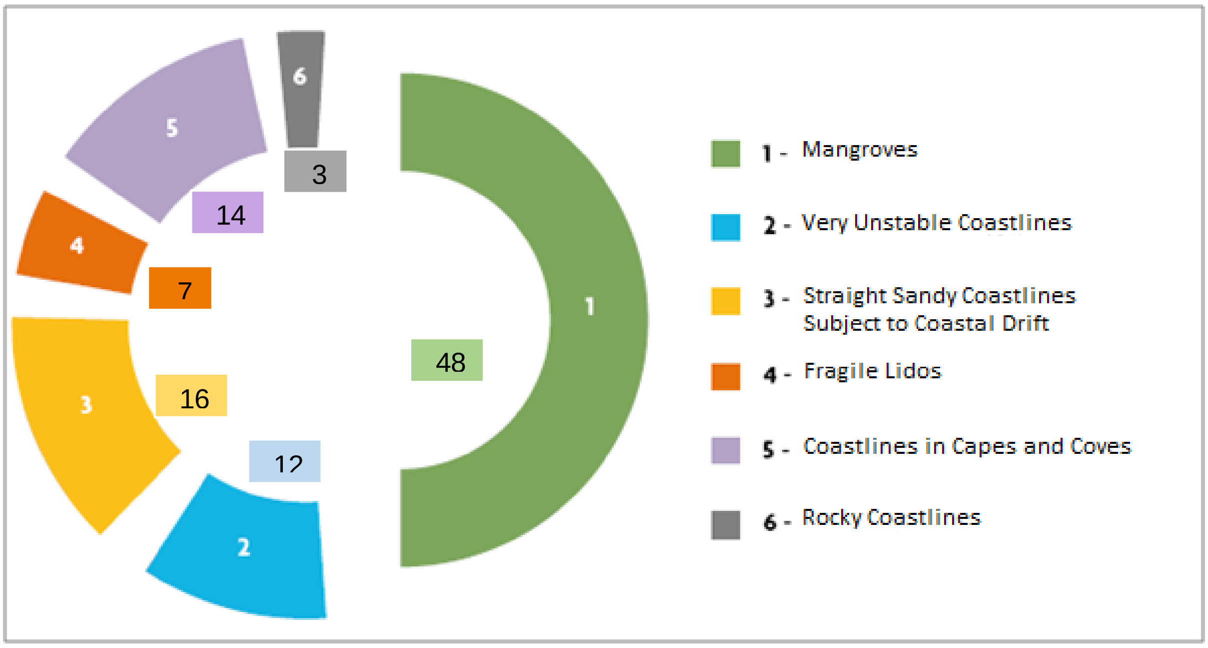


Figure 1 : Percentage of shoreline according to the different coastal facies (WAEMU, 2017)

Overall, five different major coastal facies can be distinguished from north to south (WAEMU, 2017):

- The straight coastlines from Mauritania to the Cape Verde peninsula (Dakar region in Senegal), essentially composed of sandy formations subject to the direct action of the littoral drift current. In the immediate vicinity and behind the cordon, there are vast salt depressions, locally located below sea level;
- A coastline of capes and coves softened from the Cape Verde peninsula to the Sine Saloum (Senegal), outside the large estuaries. This coastline is structured by rocky outcrops of sandstone and ferruginous armor, very degraded and fragile;
- Mangrove coasts from the Sine Saloum in Senegal to the Sherbro Islands in Sierra Leone;
- A coastline more strongly structured in rocky capes and sandy coves from Liberia to western Côte d'Ivoire. This profile is found in the central part of Ghana;
- A loose coastline from the west of Côte d'Ivoire to Benin characterized by two large sedimentary basins of loose coastlines (Côte d'Ivoire and Dahomey basins) and important systems of lagoons and channels parallel to the coast, located behind a locally very narrow sandy cordon (lidos). These two large sedimentary basins are separated by the Cape Three Points in Ghana and the few adjacent formations that are more or less rocky (sandstone) or in capes and coves up to the mouth of the Volta.

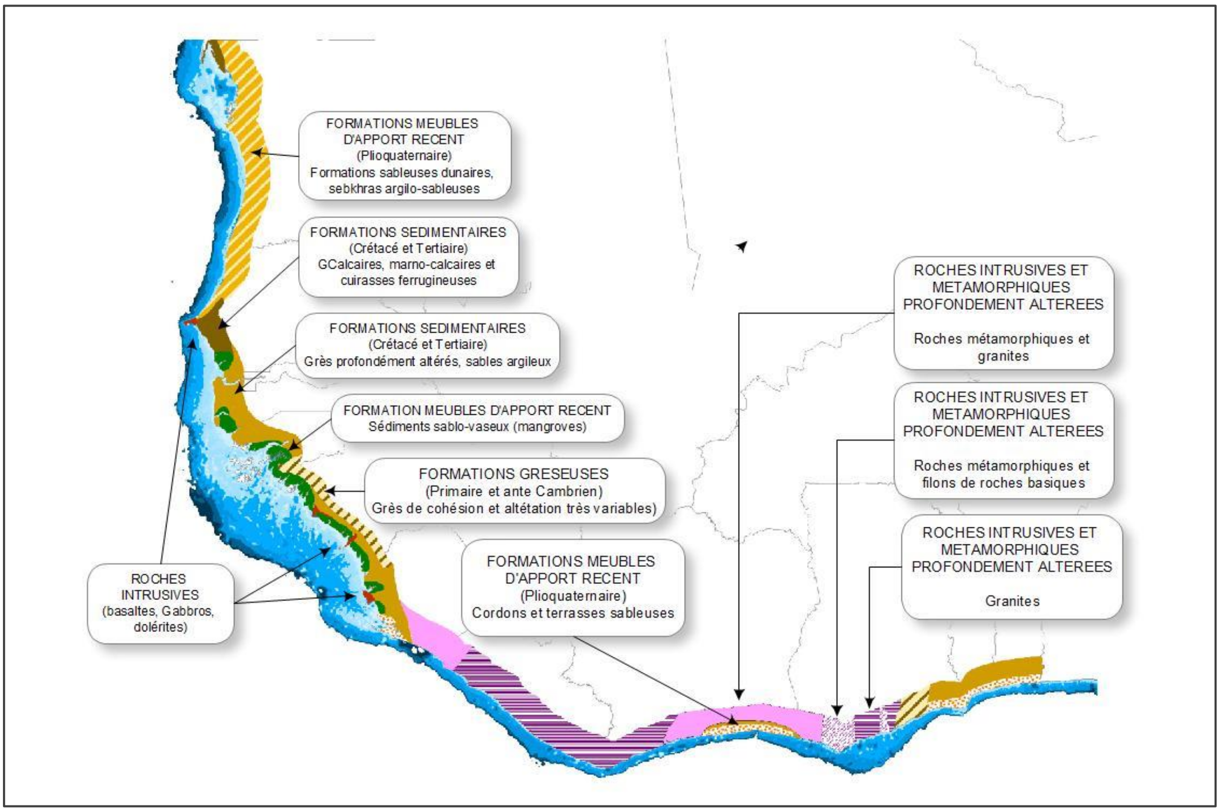


Figure 2 : Simplified lithology of the West African coastline (sources: SDLAO 2011 and SDLAO 2016)

1.1.2 Under the influence of a marked sedimentary transit

The West African coast is characterized by numerous river deltas, the largest being the Niger, Senegal and Volta (Ghana). Large sediment reserves and strong wave-induced littoral drift have favored the formation of several sand barriers, especially at the mouth of the three deltas. Nearby is a vast coastline off which lies the West African Atlantic continental shelf, a relatively flat extension of the coastal plain.

Sediment flow dynamics

The West African coast is exposed to the influence of long-distance North Atlantic swells generated in the southern hemisphere, as well as to tropical storms (Almar R. et al., 2019; Sadio et al., 2017). The two main sources of sediment on the West Atlantic coast are the above-mentioned rivers and coastal transport (Giardino et al., 2018). While most of these sediments are primarily supplied by rivers at the coast, the wave regime, nearshore sediment transport (Almar et al., 2015) and sea level variability (Melet et al., 2016) result in strong sediment dynamics and coastal morphology (Anthony et al., 2019) along this Gulf of Guinea coast, which are primarily influenced by the South Atlantic Southern Annular Mode (SAM) and its natural variability (Almar et al., 2015; Almar R. et al., 2019). The morpho-sedimentary evolution and sediment dynamics of the West African coast are dominated by strong nearshore sediment drift resulting from oblique waves (Abessolo O.G., 2020; Almar et al., 2015; Almar R. et al., 2019; Laïbi et al., 2014). For example, the decrease in eastward sediment transport of -5% over 33 years is related to a decrease in westerly wind intensity associated with the southward shift of pressure centers and an increase in trade winds, both of which reduce the potential for eastward sediment transport along the Gulf of Benin section of the West African coast (Abessolo O.G., 2020; Almar et al., 2015; O. A. Dada, Li, Qiao, Ding, et al., 2016; O. A. Dada, Li, Qiao, Ma, et al., 2016). The Intertropical Convergence Zone (ITZC) and the Southern Annular Mode (SAM), respectively, are related to the attenuation of wind- and swell-wave-induced transport in the Gulf of Benin, responsible for a slight decrease in wave energy or approach angle (Almar et al., 2015).

A recent sediment assessment conducted at the scale of Côte d'Ivoire, Ghana, Togo and Benin reveals the possible effects of major human interventions and climate change on sediment transport

A recent study was conducted by Deltares (Giardino A. et al., n.d.) to determine the large-scale sediment balance based on a unique numerical modeling framework for the following countries: Côte d'Ivoire, Ghana, Togo and Benin. The study provides quantitative information on sand moving along the shoreline in the "Sand River". The potential effects of major human interventions and climate change on sediment transport along the coastline and coastline changes were also investigated (Giardino et al., 2018).

A single input dataset for the entire region was created, largely based on open access global data, to overcome the current fragmentation of information across countries. The dataset was used to force a set of numerical models, including:

- a large-scale wave model and 15 nested wave models, based on the Delft3D-WAVE code;
- a model of sediment transport and evolution for the entire coastline, based on the UNIBEST-CL+ code.

Sediment delivery to the coast from each of the major rivers was estimated based on the WFLOW hydrologic model and combined with empirical formulas to estimate sediment yield.

A retrospective simulation was performed for the period 1985-2015 to compare the model results with literature values. The validated model was then used to simulate different scenarios for the period 2015-2100 to evaluate:

- the potential effect of major anthropogenic interventions in the region (i.e. major ports and river dams);
- the possible effect of climate change (Figure 3).

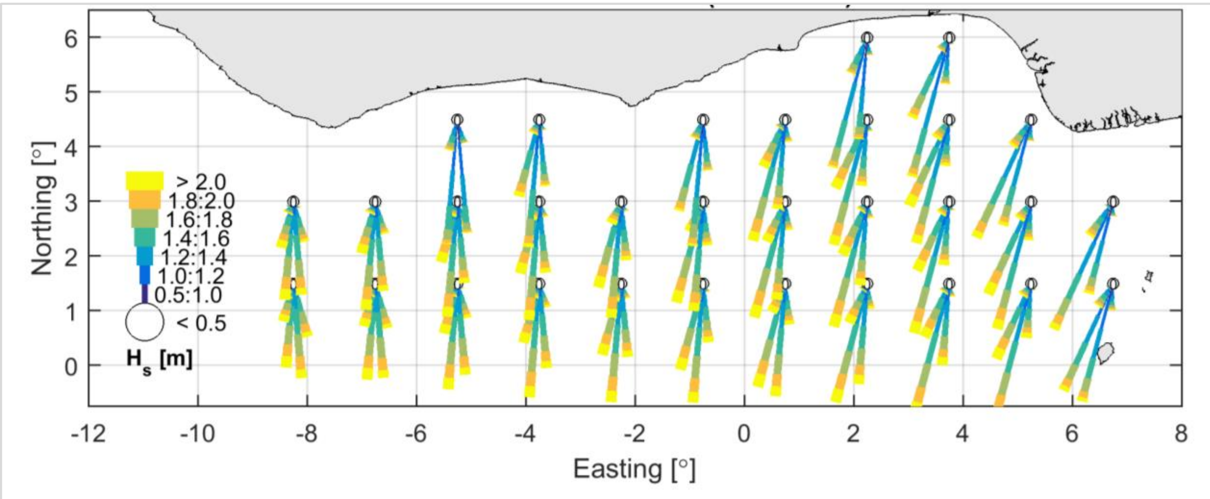


Figure 3: Wave roses in front of the WA coastline based on ERA-interim (1979-2014) (Deltares, ND).

Model validation showed that the modeling framework is capable of describing the large-scale sediment balance of the region (i.e. transport rates and coastline changes) (Figure 4).

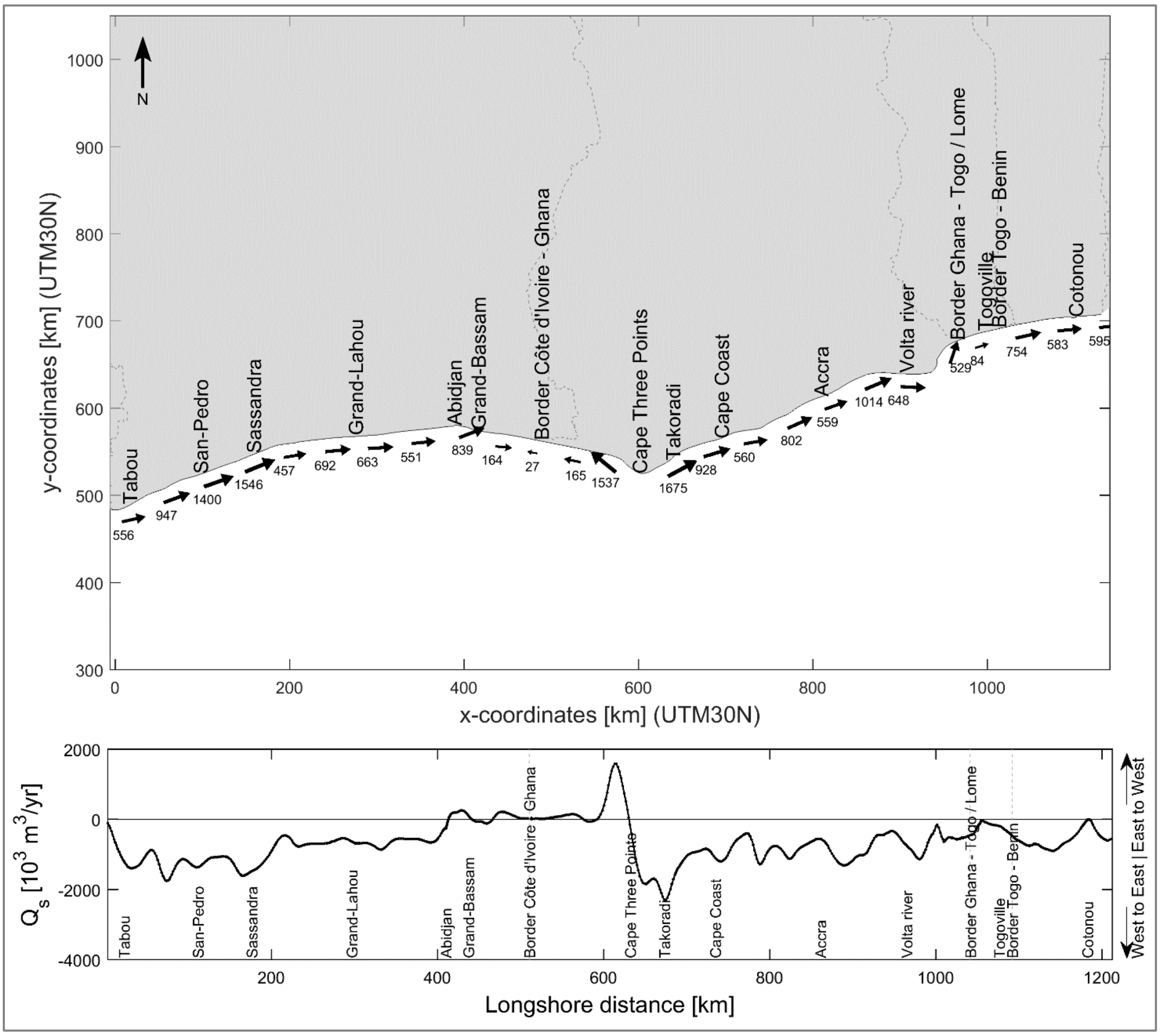


Figure 4: Evolution of longshore transport along the WA coastline (from Côte d'Ivoire to Togo) (Deltares, 2017).

Besides, the different scenarios simulated in the study highlighted the interconnection between coastal systems and rivers. Although some of the anthropogenic interventions have only a local effect, others can have a much larger spatial effect (e.g., the effect of the port of Lomé after 30 years extends to nearly 50 kilometers).

A large amount of sediment is also retained by river dams. Modeling showed that if this amount of sediment was released from the dams, it could promote sediment accretion on the coast up to several meters per year. This is particularly evident on the Volta River, which used to carry the largest volume of sediment to the coast, and where large river dams (e.g., the Akosombo Dam) have been constructed.

The study also showed that *the effect of major ports on coastal erosion will be of the same order of magnitude as the effect of sea level rise when considering lower sea level rise scenarios* (e.g. RCP 4.5). However, sea level rise could offset the effect of other anthropogenic interventions by the end of the century, if larger sea level rise scenarios are considered (e.g., RCP 8.5). This will of course depend on the actual rise, as well as possible developments of new structures along the coast and in the river basins, which could then lead to further erosion.

The study highlighted the interdependence between the different interventions, either along the rivers or on the coast, of the overall sediment balance. Because these effects do not consider geographic boundaries and given the severity of current coastal erosion problems in the region, a large-scale integrated sediment management plan is strongly advised.

The trend in average sea level rise at Cotonou has been estimated at 3.2 mm/yr (Melet et al., 2016), while it may be 12.9 mm/yr along the coast of Ghana (Marti et al., 2019). Continuation of this trend will have detrimental effects on the region as a whole, as sea level rise will result in a landward shift of the coastline and an increase in the space for sediment accumulation on the shoreline (Giardino et al., 2018).

Considering the magnitude of sediment transport rates along the coastline, small changes in nearshore gradients can result in massive local erosion or accretion. These disturbances, which have increased over the decades, are not only due to changes in the wave regime, but also to recent human intervention, including the construction of river dams, ports and other coastal infrastructure (Anthony et al., 2019; O. A. . Dada et al., 2015; O. A. Dada et al., 2018). At regional level, sediment dynamics models and eroded/stable/advanced shoreline alternations are essentially a response to the construction of dams on rivers, for example:

- Akosombo Dam on the Volta River (Addo et al., 2018);
- the Kainji dam on the Niger (O. A. . Dada et al., 2015; O. A. Dada et al., 2018);
- the Nangbeto dam on the Mono River (Laïbi et al., 2014), the installation of groynes (e.g. at the Keta erosion point(Angnuureng D.B. et al., 2013; Anthony et al., 2019)), beach nourishment between groynes, a dike and the landfill (Addo, 2015), the periodic creation of artificial breaches near the mouth of the Mono River (Ndour et al., 2018);
- localized sand extraction for urban construction (Ndour et al., 2018);
- the dredging of the Niger River canals for maritime transport (O. A. Dada, Li, Qiao, Ding, et al., 2016);
- Modification of the hydrodynamics in the Ébrié lagoon and closure of the Comoé entrance at Grand-Bassam due to the deepening of the entrance channel of the autonomous port of Abidjan (Giardino et al., 2018);
- The construction of an artificial peninsula and a dike along part of the Lagos coast, associated with fluctuations in river hydrology (Anthony et al., 2019; O. A. . Dada et al., 2015; O. A. Dada et al., 2018, 2020).

Although the effect of coastal area loss due to port infrastructure along the West African coast is of the same order of magnitude as the effect of coastal retreat due to sea level rise with a 0.3 m scenario by 2100, the latter will become the predominant cause of erosion in a 1 m scenario (Anthony et al., 2019; Giardino et al., 2018).

It is certain that human interventions, whether in the form of sustainable coastal management (environmentally positive intervention) or expansive coastal economic development (environmentally negative intervention), coupled with the effects of climate change on river hydrology, wave climate, and sea level, will continue to influence the sediment dynamics and coastal morphology of the West African coast in the coming decades and the livelihoods of coastal inhabitants.

1.1.3 Constantly modified by anthropogenic action: artificialization

The geomorphological and weather-marine contexts of West African coasts, from Mauritania to Nigeria (sandy beaches for the most part, strong monsoon winds, short and long swells) as well as the various developments (dams, protection works, port structures, etc.) favor their exposure to several coastal hazards and climate change (Sy B., 2006). In addition, they are under strong demographic pressure due to the concentration of economic activities (tourism, fishing, industries, mining, etc.) highlighting their vulnerability to climate change and exceptional weather-marine hazards.

1.1.3.1 *History and chronology*

Based on old and recent aerial images and photographs, the coastal structures of 6 countries located on the western coast of Africa have been mapped. They are **Mauritania**, **Senegal**, **Côte d'Ivoire**, **Togo**, **Benin** and **São Tomé & Príncipe**. This mapping concerned port structures (piers, quays), protection works (coastal dikes, groynes, breakwaters, riprap) and other structures including constructions and fortifications. It did not take into account the structures that are in the estuaries and inside the ports.

A spatialized database of 418 structures was produced in the WGS84 projection system (EPSG 4326) and in ESRI Geopackage format. The information on the attributes "year of appearance and construction" made it possible to trace the construction history of the structures. A statistical analysis of the database, a research and bibliographic analysis made it possible to reconstitute the context of coastal development as well as their dynamics over time.

The history of development in the different countries studied shows a similarity of development contexts. A comparison of the latter with the evolution of the different categories of structures allowed us identifying several phases of development.

First phase: pre-colonial period (from 1400 to 1848). In 1444, the date of the first deportation of African captives to the Iberian Peninsula (Zurara G., 1960), the West African coasts were unoccupied by the populations. The African kingdoms and empires considered these estuarine spaces where rivers flowed and which were mostly wetlands as dangerous and worthless places (N'Bessa B., 1997). One example is the Kingdom of Dahomey, the most powerful kingdom in Benin at that time, to which the town of Cotonou (the current capital city) belonged. This locality was then considered dangerous: its real name was Kùtɔ́nû, a name derived from the Fon language and meaning "at the edge of the river of death." Cotonou was unoccupied and was eventually ceded to the French colony in 1818 through the signing of treaties. The traffic of goods between the different kingdoms was done by the rivers (Pétré-Grenouilleau O., 2009). During this period of slave trade, some developments were made on the coastlines of these countries. These were essentially constructions linked to the slave trade, such as fortified slave trading posts (the Slave House built in 1536 by the Portuguese and then in 1776 by the French on the Gorée Island) (Homet J-M., 2001) and the piers used to transport the slaves to the slave ships (the Door of No Return in Ouidah, 1717). This period will end with the abolition of the slave trade in 1848.

Second phase: colonial period (1848 to 1950s). This second phase marks the colonial period. A key date is November 15, 1884, the date of the Berlin Conference where the colonial powers fixed the borders of African countries (Brunschwig H., 2009). The powers then settled on the coastal areas, because at the time they were the only points of access to the colonies, they were not occupied by the indigenous populations and the climatic conditions, unlike those of the center and north of the countries were more clement. To develop and facilitate the trade of goods as well as agricultural and mining products (cotton, tobacco, cocoa, gold, etc.) from the colonies to the metropolises and to other countries, but also to transport construction materials for the development of colonial cities (railroads, factories, housing, etc.), the powers began by building port facilities. These were wharves built of metal or wood allowing ships to berth (Port-Bouêt wharf in 1932 in Côte d'Ivoire, Lomé wharf in 1904 in Togo, Cotonou wharf in 1892 in Benin, etc.). We also note in this period great developments as the construction of artificial channels to drain the waters of rivers to the sea to fight against flooding in these cities that were now occupied by Europeans. It is noted that during this period there was no construction of port structures that could impact the coastline. The exception is the construction, in 1861, of the first port infrastructure in West Africa in Dakar (Senegal). 6.7% of the identified port structures were built during this period. This is due to the fact that Dakar was the closest point of entry into Africa to Europe. It was therefore a strategic commercial and military point that had to be developed early. It is also noted that there are no protective structures at that time, because there were few stakes on these coastlines. Until the 1950s, these areas were considered industrial zones and processing companies settled there because of the proximity of the port infrastructure. For example, Cotonou was not the capital city of Benin at that time, it was an industrial zone and was sparsely populated (N'Bessa, 1997).

Third phase: recent post-colonial period or period with low developmental stakes (1960s to 1990s). This phase began with the series of independences negotiated by the African countries under the presidential mandate of General de Gaulle. Benin, Côte d'Ivoire, Mauritania, Senegal and Togo acceded to international sovereignty in 1960, and São Tomé & Príncipe, which was dependent on Portugal, acceded in 1975. Once independent, these countries, which had been involved in international maritime trade for several decades, were faced with the inefficiency of their port infrastructure to support the increase in cargo traffic. Most of these countries had also become transit ports for countries without access to the sea. It was therefore necessary to build modern port infrastructure. Several port facilities were built during this period to meet this need. 13.3% of port infrastructure was built during this period. It is also noted the appearance of protective structures during this period. Most of these structures are sand barriers associated with port infrastructure to reduce the impacts related to the erosion of beaches located upstream of port piers (we can cite the sand barriers of the Vridi Canal, sand barriers of the Autonomous Port of Cotonou, etc.). These works were few in number. 0.9% of the identified protection structures were built in this period.

Fourth phase: post-colonial period with intensification of development stakes (1990s to present). Increased needs due to population growth have led to an increase in maritime traffic. It was therefore necessary to adapt to the new needs and several other port facilities were built. These include the extension of existing ports through the construction of new quays and terminals, the construction of new ports such as fishing ports. This explains the increase in port structures at that time with 80% of port structures built during this period. With the presence of ports, real economic engines for these countries (port of Cotonou contributing to 60% of Benin's GDP) (Ministry of Economy, 2019), the population of port cities has grown significantly, thus multiplying the stakes on these spaces. The population of Dakar, for example, has grown from 400,000 in 1970 to 3.6 million in 2018, an increase of nearly 5% per year, and that of Abidjan has grown from 500,000 in 1970 to 4.4 million in 2014 (National Statistics Institute, 2015). During this period, these coastal cities also experienced the emergence of new economic activities such as tourism (inauguration of the first seaside resort in Senegal in 1984) (Diagne K., 2001). Port construction has also increased coastal hazards by reducing the sediment balance of beaches. The increase in stakes combined with the various coastal hazards has led to the construction of several works to protect against and combat coastal risks. This explains the curve of the protection works which increases during this period. Almost all the works of protection and fight against coastal hazards are realized in this period, that is to say 99, 1% of them. This shows that the current trend in these countries is the construction of this type of works (Figure 5).

The constitution of the history and evolution of the various West African coastal structures and developments is very important for the knowledge of the functioning of these coastlines in an observation process.

For several decades, West African coastlines have undergone several changes due to various developments. These occurred in very specific contexts. This study shows that the first developments of these coasts were linked to commercial activities, at the time when the slave trade flourished. The same is true for the period of colonization, during which the metropolises invested in the exploitation of colonial resources, but also in the development of the coastal areas they occupied. It was during this period that the major West African urban centers were created and developed: Cotonou, Dakar, Lomé, Saint-Louis, Abidjan.

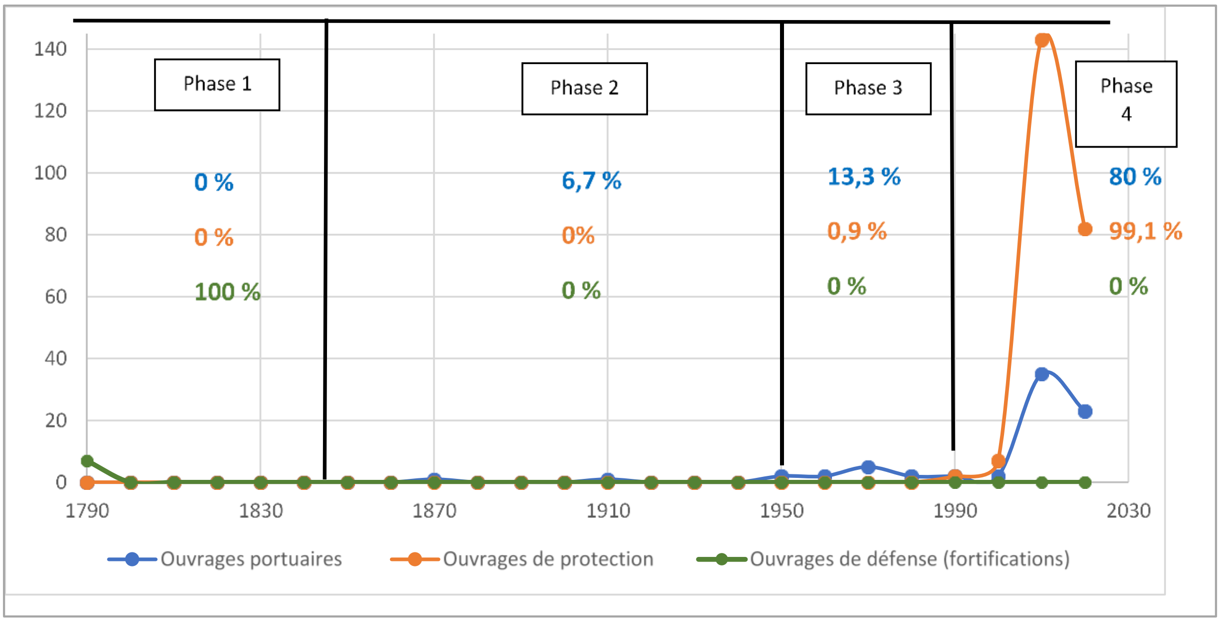


Figure 5 : The four phases of West Africa coastal development since 1790

The post-colonial period is marked by (i) a stage of low development stakes with nevertheless the establishment of several ports on the coastal cities and (ii) a stage with an intensification of development stakes requiring the extension and modernization of port infrastructure.

1.1.3.2 *Characterization and mapping of coastal structures*

Taking into account these coastal protection structures and coastal developments, which affect the transit of sediments along the coast, is essential to the understanding of coastal dynamics and, consequently, to the development of strategies for managing the coastline and adapting to coastal change (Cerema, 2017). Based on the methodology proposed above by Cerema for the six WACA ResIP countries, the database of coastal protection works and coastal developments, from Mauritania to Benin and São Tomé & Príncipe (12 countries), has been developed, mapped and characterized within the framework of the project "Monitoring of coastal risks and soft solutions in Benin, Senegal and Togo" (WACA-FFEM)

MATERIALS AND METHODS

In order to standardize the Database, the coastal protection structures and coastal developments were identified from the images available on "Google Earth". In addition to their location, elements of characterization of structures and developments have been predefined. This identification and characterization work was preceded by a training and awareness workshop on coastal risks, led by Cerema. The purpose of this regional initiative was to allow each of the 12 WARCO countries to geolocate the structures and facilities present on their respective coasts. The structures are surveyed using the computer-assisted visual interpretation technique, where only the structures visible on the 1/2,500th scale images are taken into account. The types of structures considered in this study are classified in the following table.

Type of protection works and coastal developments taken into account. A more detailed description of these protection structures is provided by Cerema (2017)[1]

Category	Class	Type	Orientation
Coastal protection works	Work replacing the coastline	Coastal dike	Longitudinal
		Wall, retaining wall	Longitudinal
		Riprap	Longitudinal
	Erosion control structure	Breakwater	Longitudinal
		Groin	Transversal
Coastal developments	Access	Access, path	Longitudinal or Transversal
		Hold	Longitudinal or Transversal
	Foundation plate	Building	Longitudinal
		Individual protection	Longitudinal
	Port and navigation infrastructure	Pier	Transversal
		Quay	Longitudinal
	Miscellaneous	Hydraulic development (sluice gate, lock, dam...)	Longitudinal or Transversal
		Safety arrangement (first aid station, signalling...)	Longitudinal or Transversal
		Other or undetermined	Longitudinal or Transversal

[1] http://www.geolittoral.developpement-durable.gouv.fr/IMG/pdf/20171107-specif-tech-carto-ouvrages-littoraux.pdf

Overall analysis of the mapping results

The mapping results have enabled us to count 836 protection structures and developments on the West African coast, for a cumulative length of about 209 km, or an overall artificialization rate of the coastline of about 5% (Table 1). This rate varies from country to country. It is higher in Togo with about 20%; followed by Ghana 11%, Guinea-Conakry 10%, Gambia and Senegal 9%, Benin 6%. The other countries have rates below 5% (Figure 6).

Approximately 60% of the structures identified are longitudinal (wall, dike, riprap, buildings, individual protection and dock), i.e. structures replacing the coastline, representing 85% of the mapped linear (on the overall artificialization of the coastline).

Nearly 452 coastal protection structures (54%) were identified, of which 279 (62%) correspond to coastline replacement or coastline fixing structures and 173 (38%) to erosion control structures. The riprap is the most common coastline fixing structure identified in this study, followed by groynes and retaining walls. The piers, followed by docks, are also very present. A significant portion of coastal protection structures and shoreline developments (other or undetermined) could not be identified with certainty from the interpretation of Google Earth images (Figure 7).

Table I : Cumulative structures and developments and rate of coastal artificialization in the 12 countries

Country	Protection structure (units)	Other facilities (units)	Total work (units)	Coverage rate by country (%)	Total length of structures (km)	Length of the coastline (km)	Coastline artificialization rate (%)
Mauritania	24	29	53	6.34	13.37	754	1.77
Senegal	183	114	297	35.53	48.69	531	9.17
The Gambia	7	21	28	3.35	7.36	80	9.20
Guinea Bissau	0	10	10	1.20	1.61	350	0.46
Guinea	21	93	114	13.64	31.38	320	9.81
Sierra Leone	5	47	52	6.22	12.34	402	3.07
Liberia	7	14	21	2.51	8.86	579	1.53
Côte d'Ivoire	22	3	25	2.99	4.12	515	0.80
Ghana	123	23	146	17.46	60.01	539	11.13
Togo	41	6	47	5.62	11.74	56	20.96
Benin	17	9	26	3.11	7.37	121	6.09
São Tomé & Príncipe	2	15	17	2.03	3.02	209	1.44
Total	**452**	**384**	**836**	**100**	**209.87**	**4456**	**4.71**

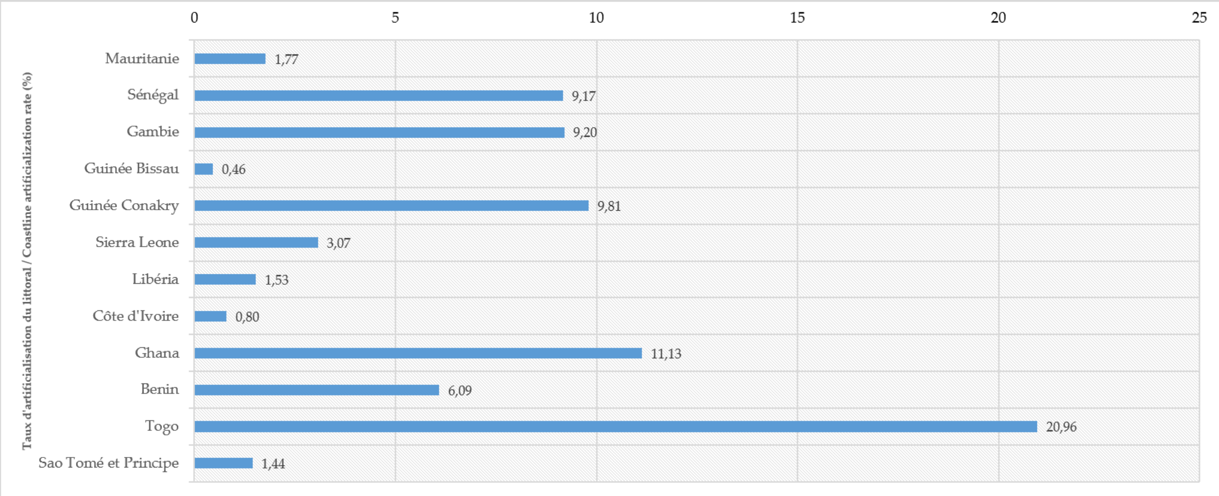


Figure 6 : Artificialization rate (%) of the coastlines of the 12 countries covered by the observatory

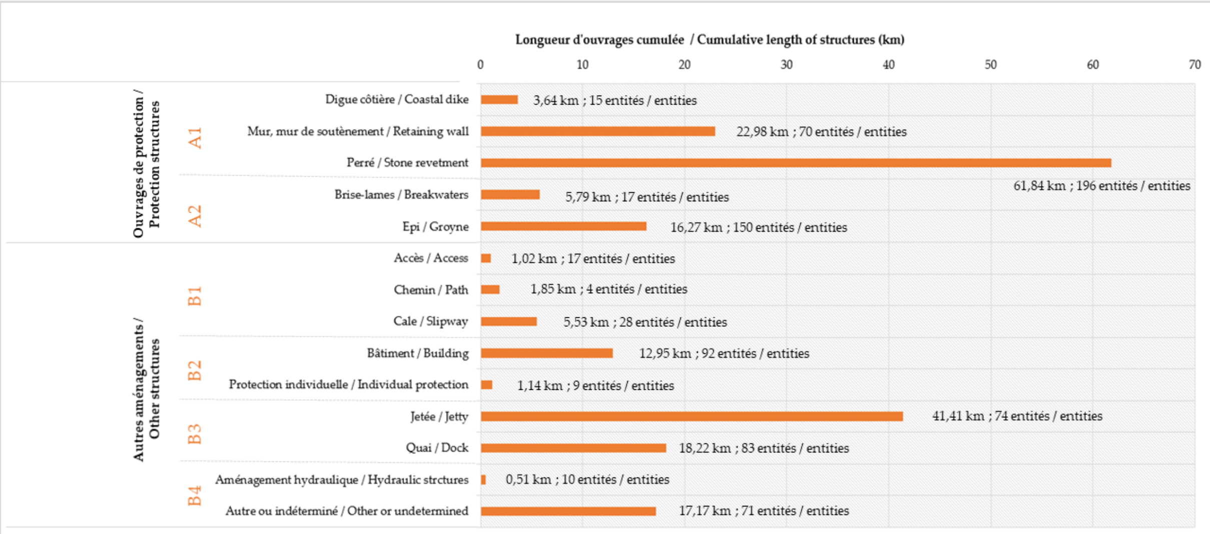


Figure 7 : Cumulative number and length according to the typology of coastal protection works and coastal developments identified in the 12 WARCO countries

Coastal protection works and coastal developments have experienced a strong dynamic between 1999 and 2019 (Table III, Figure 9). A synthesis of this evolution, at a 5-year time span since 1999, shows a clear progression of the coastline fixing structures, from 22% in the 90s until 2000, 18% between 2001 and 2005, 13% between 2006 and 2010, 23% between 2011 and 2015 and finally, 25% between 2016 and 2020. The riprap followed by the protection walls are the most recorded and most dynamic structures over the last 20 years. Erosion control structures, particularly groins, have also experienced a strong dynamic over the last two decades. Approximately 32% of the identified erosion control structures were constructed between 2001 and 2005.

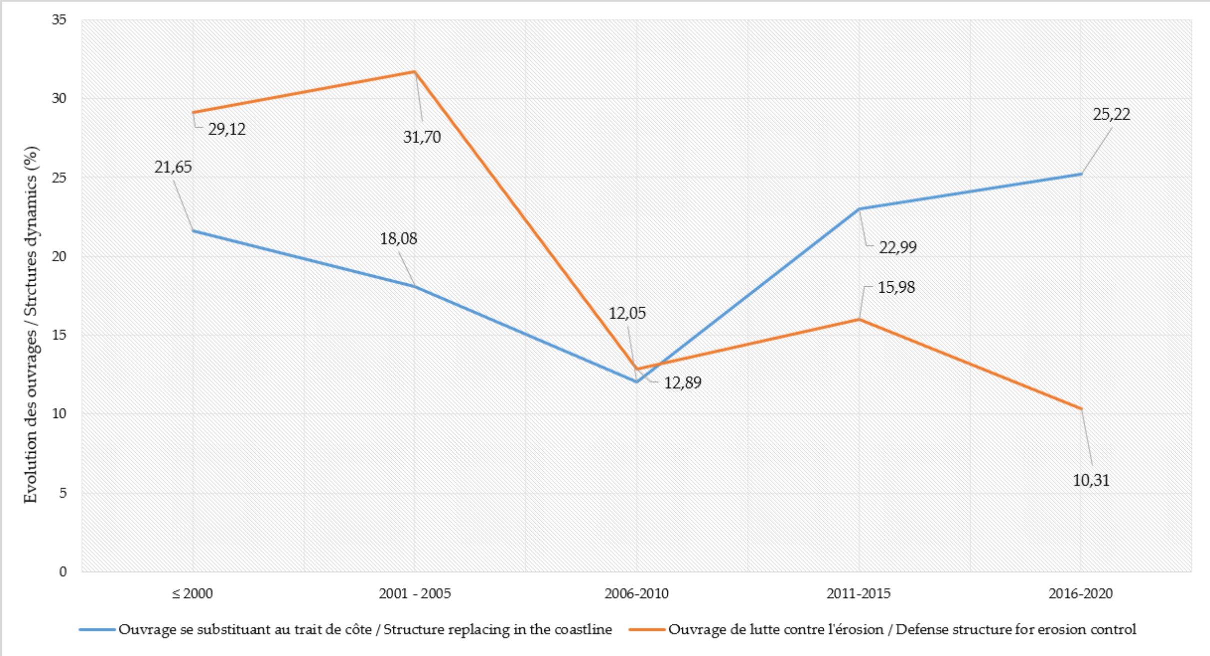


Figure 8 : Evolution of protective structures before the 1990s to 2019

Table II : Dynamics of coastal structures and developments in number by type (A) and class of structure (B)

A		≤ 1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Infrastructure Substituting the Coastline	Coastal Dike	8	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	2	0	0	15
	Wall, Retaining Wall	11	7	1	5	6	6	7	3	0	4	3	2	1	3	1	1	2	5	1	0	2	71
	Riprap	46	6	5	4	11	5	5	1	7	7	11	2	5	7	7	6	5	13	21	7	15	196
Erosion Response Infrastructure	Breakwater	5	0	0	0	1	0	0	2	0	0	1	0	0	0	2	2	1	0	1	0	1	16
	Spur	12	0	1	7	11	1	5	0	1	1	7	2	1	12	23	5	17	21	10	10	3	150
Access	Access	8	1	1	0	2	2	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	17
	Pathway	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	Block	1	1	0	0	0	4	5	0	2	1	5	0	1	0	0	1	1	1	1	3	1	28
Buildings	Building	23	18	4	0	4	4	7	1	2	4	1	0	7	4	2	4	3	1	1	1	1	92
	Individual Protection	2	3	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	9
Port and Sailing Infrastructure	Pier	10	3	3	8	14	5	8	0	4	0	3	0	0	5	3	2	0	2	2	2	0	74
	Wharf	9	1	5	2	4	9	16	0	9	0	1	6	2	1	4	1	4	0	3	5	1	83
Miscellaneous	Hydraulic Development	4	4	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	10
	Other or unspecified	5	18	2	2	3	5	2	0	3	0	2	2	1	4	5	1	4	2	8	0	3	72
Total		146	64	23	28	56	42	55	7	29	17	37	14	20	37	47	23	38	46	52	28	27	836

B	≤ 1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Infrastructure Substituting the Coastline	65	15	6	9	17	11	12	4	7	11	14	4	6	11	8	7	8	19	24	7	17	282
Erosion Response Infrastructure	17	0	1	7	12	1	5	2	1	1	8	2	1	12	25	7	18	21	11	10	4	166
Access	11	2	1	0	2	7	5	0	3	1	5	0	1	0	0	1	1	1	3	3	1	48
Buildings	25	21	4	0	4	4	7	1	2	4	3	0	9	4	2	4	3	1	1	1	1	101
Port and Sailing Infrastructure	19	4	8	10	18	14	24	0	13	0	4	6	2	6	7	3	4	2	5	7	1	157
Miscellaneous	9	22	3	2	3	5	2	0	3	0	3	2	1	4	5	1	4	2	8	0	3	82
Total	146	64	23	28	56	42	55	7	29	17	37	14	20	37	47	23	38	46	52	28	27	836

Low Dynamics | Medium Dynamics | High Dynamics

Analysis of results by country

The coastal protection works and coastal developments identified on the West African coast are unevenly distributed in the 12 countries of the observatory. Overall, Senegal and Ghana have the highest rates of recorded works, with 35% and 17% respectively, for a total of 52%.

Concerning the protection works, Senegal concentrates about 40% of the listed works which are mainly made up of riprap, walls and groynes. Ghana comes in second place with 27% of the protection structures identified in the 12 countries. Apart from Togo, which accounts for about 9% of the protection structures surveyed, the other countries show rates well below 5%. In Guinea-Bissau, however, no protective structures were identified in this study (Figure 9, Table III).

Table III : Distribution of types of coastal protection and development structures (in number) in the 12 WARCO countries

		Mauritanie	Sénégal	Gambie	Guinée B	Guinée C	Libéria	Sierra Leone	Côte d'Ivoire	Ghana	Togo	Benin	STP	Σ
Ouvrage se substituant au trait de côte / Structure replacing in the coastline	Digue côtière / Coastal dike	0	5	1	0	1	0	0	4	1	4	0	0	16
	Mur, mur de soutènement / Retaining wall	4	51	5	0	2	0	1	3	2	0	1	0	69
	Perré / Stone	11	86	0	0	16	7	2	8	56	7	1	0	194
Ouvrage de lutte contre l'érosion / Defense structure for erosion control	Brise-lames / Breakwaters	0	10	0	0	1	0	0	0	2	3	0	0	16
	Epi / Groyne	9	31	1	0	1	0	2	7	62	27	15	2	157
Accès / Access	Accès / Access	0	16	1	0	0	0	0	0	0	0	0	0	17
	Chemin / Path	0	2	1	0	0	1	0	0	0	0	0	0	4
	Cale / Slipway	4	3	3	0	7	2	9	0	0	0	0	0	28
Bâti / Building	Bâtiment / Building	2	31	5	0	35	5	9	0	0	0	0	0	87
	Protection individuelle / Individual protection	0	8	0	0	0	0	0	0	0	0	0	1	9
Infrastructure portuaire et de navigation / Port and navigation infrastructure	Jetée / Jetty	10	25	1	0	3	5	0	3	12	5	8	10	82
	Quai / Dock	11	17	5	10	11	1	23	0	4	1	1	2	86
Divers / Others	Aménagement hydraulique / Hydraulic strctures	0	5	0	0	4	0	0	0	1	0	0	0	10
	Autre ou indéterminé / Other or undetermined	2	7	5	0	33	0	6	0	6	0	0	2	61
Σ		53	297	28	10	114	21	52	25	146	47	26	17	836

Faible / Low — Moyenne / Moderate — Forte / High

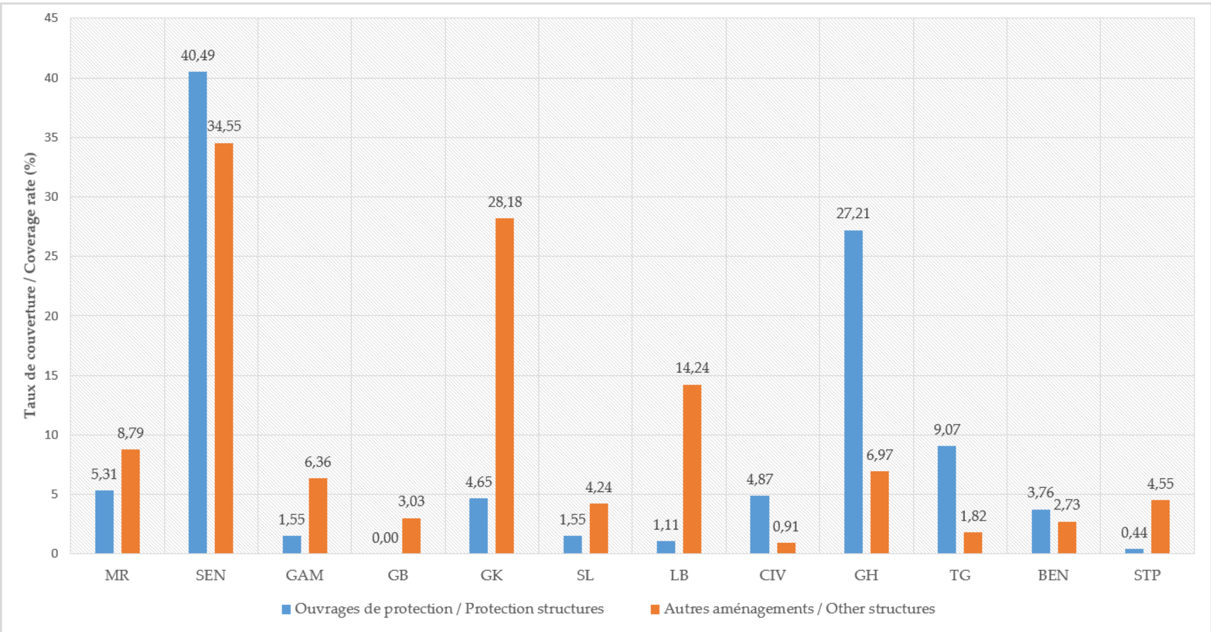


Figure 9 : Distribution of statistics by category of works surveyed and by country

Concerning coastal developments (buildings, piers, quays, hydraulic developments, slips, accesses, roads), the surveys focused on the structures located on the coastline and which can directly or indirectly influence the sediment transit. For this purpose, 384 coastal developments have been identified in the 12 countries of the observatory, and the records also vary from country to country. Guinea Conakry and Senegal have the highest rates of coastal development recorded, with approximately 25% and 30% respectively.

RECONSTITUTION OF THE BEACH THROUGH THE INSTALLATION OF BREAKWATERS IN THE TOURIST AREA OF SALY PORTUDAL

Breakwaters are structures designed at a distance ranging from a few dozen to several hundred meters to mitigate the energy of the incident swell, by reflection, breaking and dissipation (Garcia N et al., 2004), thus contributing to the nourishment and recovery of lost beaches by reducing wave pressure (Miossec A., 1998 ; Bougis J., 2000). The construction of emerged breakwaters for the protection of the tourist area of Saly Portudal started, with the support of the Climate Change Adaptation Fund, with the construction of two breakwaters in 2014. Starting in 2016, with support from the World Bank, 12 additional breakwaters were constructed over a distance of 1.5 km, with a right-of-way of 120m long by 25m wide, spaced 80m apart and positioned 120m from the shore. The spacing between these structures facilitates marine and littoral transfer and is important for beach nourishment as well as for the passage of pirogues (world Bank Group, 2016). The construction of these breakwaters has made it possible to protect houses along the Saly coastline over several kilometers, as well as hotel facilities and installations used to store, process or sell fishery products. They have also allowed the restoration of lost beaches, to the benefit of beach tourism and the local fishing sector.

Installation of breakwaters in the tourist area of Saly Portudal between 2003 and 2020

1.1.4 A diversity of marine and coastal ecosystems and ecosystem services

The West African coastline can appear as cliffs beaten by the sea or, when the depths slowly decrease, as a loose vaso-sandy littoral strip (coastal dunes or dune massifs), then extends into mudflats (deltas, estuaries of rivers) in the more sheltered coastlines where seagrasses and/or mangroves develop. These habitats reach their maximum development towards the south, from the latitude of the Saloum Delta (Senegal).

1.1.4.1 *Marine and coastal ecosystems*

Among the marine and coastal ecosystems found in West Africa, we distinguish:

- Intertidal areas (rocky coasts, barrier beaches);
- Estuaries, deltas and coastal lagoons;
- Mangroves ;
- Seagrass beds.

Rocky coasts

On the rocky coasts (partly in Mauritania, Senegal, Guinea-Bissau [Bijagos archipelago]...), the vegetation does not exceed in most cases the top of the cliff or the level of the highest seas. Also, the slopes of certain hard rock cliffs can sometimes shelter a vegetation of algae whose upper edge materializes the limit of the highest seas. The organisms that live there (algae, mollusks...) have developed particular adaptations that allow them resisting the force of the waves.

Barrier beaches

Under natural conditions, barrier beaches often have coastal dunes. The dune system is located at the top of the beach and most often protects the coastal plains located inland. It consists of dunes that may differ in morphology and vegetation cover. The western dunes are mostly devoid of vegetation, except for a few very sparse stands of shrubby formations (*Tetraena sp.*, *Tamarix sp.*). Further inland, the plant formations on the dune massifs are progressing and the floristic procession is more diversified and abundant; an herbaceous cover may appear (Mauritania).

Estuaries, deltas and coastal lagoons

Estuaries, deltas and lagoons are very original environments, located at the land-sea interface, where freshwater and saltwater mix and where the dynamic actions of rivers and the ocean clash. They are therefore very complex environments, of great fragility, which offer very particular living conditions for the species, due to the salinity and the regular floods. In West Africa, mangroves play an essential role (Sine Saloum in Senegal, Bijagós archipelago in Guinea-Bissau...) behind which, there are sometimes oversalted areas, the tannes (case of Sine Saloum in Senegal).

In addition to mangroves, the vegetation associated with estuaries, deltas and coastal lagoons may include marshy grasslands (Bayeba M.C., 2019).

Mangroves

Mangroves are among the most important ecosystems on the West African coast. They are made up of salt tolerant trees found on sheltered tropical and subtropical coasts.

In the West African region, which extends from the southern border of Mauritania to Nigeria, mangroves are found in a variety of coastal settings, including estuaries, lagoons, along major rivers or continental margins. Their geographical extent is highly variable, with forests being more important in countries where deltas and rivers are important, such as in Nigeria, Guinea, Guinea-Bissau, Senegal and the Gambia. In countries dominated by lagoon systems such as Benin, Togo and Côte d'Ivoire, mangrove areas are smaller and more fragmented.

West African mangroves represent 13% of mangrove forests worldwide and cover more than 2.4 million hectares in 19 countries (source: West African Regional Expert Workshop on Mangroves and Climate Change, Elmina [Ghana], May 2014). Approximately 14% of the West African region's mangroves are found in protected areas and constitute a complex ecosystem with diverse interdependent biodiversity.

West African mangroves are dominated by Rhizophora or "red" mangrove species. In total, there are five native mangroves on the Atlantic coast of West Africa, belonging to three families:

- *Rhizophora harrisonii*,*Rhizophora mangle* et *Rhizophora racemosa* (red mangroves) ;
- *Avicennia germinans* (black mangrove);
- *Laguncularia racemosa* (white mangrove).

There are two mangrove-associated species, *Acrostichum aureum* and *Conocarpus erectus*, as well as an invasive mangrove palm, *Nypa fruticans*, which was introduced from Asia in 1906 (Nwobi et al., 2020; Ukpong, 1991).

In addition to floristic biodiversity, mangroves are also home to a wide range of aquatic and terrestrial fauna that use this ecosystem as a breeding, nursery and feeding ground. Among the vulnerable or threatened species living in the West African mangrove ecosystem are:

- Loggerhead turtles (*Caretta caretta*) and leatherback turtles (*Dermochelys coriacea*), globally vulnerable species[1] ;
- the West African manatee (*Trichechus senegalensis*), a globally vulnerable species;
- the pygmy hippopotamus (*Choeropsis liberiensis*), an globally endangered species;
- the critically endangered globally Pennsylvania red colobus (Piliocolobus pennantii);
- the dwarf crocodile (*Osteolaemus tetraspis*), a globally vulnerable species;
- the thin-nosed crocodile (*Mecistops cataphractus*), critically endangered worldwide species (Dodman et al., 2006).

The total area of mangroves in West Africa is about 20,000 km^2, with the largest area (40%) in Nigeria (8,573 km²), followed by Guinea-Bissau (3,833 km²) and Guinea (2,343 km²) (Liu et al.) The largest mangrove forest is in the Niger Delta region of Nigeria, covering about 80% of the country's mangrove area.

[1] IUCN Red List assessment according to the following categorization with increasing extinction risk: Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, Extinct.

This ecosystem is threatened by population growth, coastal development, resource exploitation and poor governance. In addition, climate change poses a risk to the remaining mangrove areas, primarily due to sea level rise and increased sedimentation from rainfall and coastal artificialization.

Many restoration and protection initiatives are underway, notably in Sierra Leone, Côte d'Ivoire (West Africa Biodiversity and Climate Change (WA BiCC) program), Senegal... The project "Management of mangrove forests from Senegal to Benin", funded by the European Union for a period of 5 years (2019-2024), aims to achieve integrated protection of mangrove ecosystems in West Africa, and enhanced resilience to climate change.

Seagrass beds

In West Africa, the potential of seagrass beds is enormous, but extensive research is needed to determine their distribution and to set up a monitoring system taking into account the needs and means available in the region. With the exception of the Banc d'Arguin in Mauritania, knowledge of these seagrass beds is still rudimentary in the sub-region. Nevertheless, their presence is confirmed in Senegal, Guinea-Bissau and Cape Verde.

Seagrasses are therefore a little known ecosystem, but their known ecological services of reproduction, nursery and spawning grounds impose an urgent need for protection.

The ResilienSEA[2] project funded by the MAVA Foundation (2019-2022) aims to improve knowledge and experience through capacity building in seagrass management in West Africa. The pilot countries selected for this project are Cape Verde, Gambia, Guinea, Guinea-Bissau, Mauritania, Senegal and Sierra Leone. One of the tasks of the ResilienSEA program is the evaluation of available regional data and their use to create regional and national maps of seagrass distribution.

1.1.4.2 *Ecosystem services*

Coastal natural environments in West Africa contribute directly to the production of ecosystem services that are useful, even indispensable to coastal societies, perhaps even more so in the context of climate change, currently discussed (WAEMU, 2017). These ecosystem services provide identifiable benefits at all scales, including global as regards carbon fixation by mangroves, seagrass beds and coastal marshes, which is recognized as important. They can be categorized into:

- support services : habitat and environmental constitution, maintenance of energy flows and nutritional cycles through primary production, inter- and intra-ecosystem services and functions, reproduction, nurseries, etc. ;
- production services (production of material goods directly usable by humans): fisheries, agriculture-rice-growing, wood energy, wood and non-wood food products gathered, aquaculture, handicrafts, construction, pharmacopoeia, genetic resources, etc. ;
- regulatory services (responsible for controlling natural processes): carbon sequestration, coastal protection against marine erosion and extreme weather-sea events, treatment and recycling of terrigenous inputs and anthropogenic effluents, wastewater purification, protection against inland flooding, dune fixation, etc. ; and
- cultural services (non-material services, obtained through spiritual and artistic enrichment and recreation): landscape attractiveness and environmental quality (formation of beaches, islands

[2] http://resiliensea.org/?lang=fr

and coastal landscapes), recreational activities (urban beaches), research and education, tourism and cultural exchanges, cultural and religious heritage (customs, traditional ways of life, artistic expressions), etc.

All of these ecological services are not yet systematically valued economically, with the exception of a few sectors such as fishing. However, concerns about coastal erosion show that deficiencies in the functioning of coastal systems can have significant economic impacts.

Wetland ecosystems provide major goods, services, functions and water resources.

Ecosystem services provided by seagrasses

Seagrasses provide valuable ecosystem services, but they are disappearing at a rapid rate worldwide, mainly due to anthropogenic stressors. The report "General Assessment of Seagrass Ecosystem Services in West Africa (ResilienSEA Program)" presents an assessment of the ecosystem services provided by seagrass beds in seven West African countries: Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, Cape Verde and Sierra Leone (MAVA Foundation, 2020).

The assessment of ecosystem services is based on those identified in a recent study (Nordlund et al. 2016 in MAVA Foundation, 2020), which remains the most comprehensive assessment to date. The seagrass ecosystem services provided by the three major West African species, *Cymodocea nodosa*, *Halodule wrightii*, and *Zostera noltii,* were extracted from the paper and then cross-checked with others (including Dewsbury et al. 2016; Ruiz-Frau et al. 2017; Himes-Cornell et al. 2018 in MAVA Foundation for Nature , 2020) :

- biodiversity habitat ;
- fish, vertebrate and invertebrate habitat;
- role of nurseries ;
- sediment stabilization ;
- carbon sequestration ;
- coastal protection, accumulation or stabilization of sediments;
- water quality regulation ;
- heritage value, cultural and spiritual values ;
- tourism.

Local communities depend, in large part, on the services provided by seagrass beds. These seagrass beds are threatened by multiple factors, both anthropogenic and natural and classified in order of importance as follows:

- disturbances of anthropogenic origins ;
- pollution ;
- threats related to fishing ;
- climate change ;
- lack of information.

Ecosystem services provided by mangroves

Mangrove forests provide a range of ecosystem services such as: supporting unique terrestrial and aquatic biodiversity, providing timber and firewood, protecting coastlines from storm surges and sea level rise, supporting fisheries, tourism and climate regulation through carbon sequestration.

In West Africa, the main services also include the provision of food, wood, firewood and medicinal sources (N. Z. Feka & Ajonina, 2011). Throughout West Africa, mangroves are heavily impacted by human activities such as: small-scale logging for firewood and building materials. The mangrove timber industry is a major source of income for many coastal communities in the region and a direct source of fuel for over 30% of the coastal population (Goldberg et al., 2020). These forests are also heavily impacted by clearing for construction and urban expansion in the coastal zone, as well as clearing for oil extraction and degradation due to pollution (N. Z. Feka & Ajonina, 2011; Goldberg et al., 2020).

Between 2000 and 2016, the largest loss of mangrove extent occurred in Nigeria and Guinea, with Ghana and Guinea recording the highest percentage of loss (Goldberg et al., 2020; Nwobi et al., 2020; Thomas et al., 2018). The main cause of loss in the region was: clearcutting, selective logging, and dieback due to oil pollution, accounting for 56% of mangrove losses in Guinea-Bissau between 2000 and 2016 (Goldberg et al., 2020) (Table IV). Erosion is the main driver of loss in Senegal, The Gambia and Togo, while urban expansion is the main driver in Liberia.

Table IV: Total extent of mangrove loss from 1996 – 2016 and main drivers of loss in West Africa from 2000-2016 (Goldberg et al., 2020)

Country	Loss Area 2000-2005 (km^2)	Loss Area 2005-2010 (km^2)	Loss Area 2010-2016 (km^2)	Total Loss 2000-2016 (km^2)	Percent Loss 2000-2016	Primary Loss Driver
Senegal	0.38	0.34	0.18	0.91	0.05%	Erosion
Gambia	0.17	0.16	0.02	0.35	0.04%	Erosion
Guinea Bissau	2.90	5.39	1.99	10.29	0.26%	NPC
Guinea	16.20	23.16	13.46	52.83	1.97%	NPC *
Sierra Leone	1.13	2.53	1.87	5.53	0.31%	NPC
Liberia	0.00	0.04	0.01	0.05	0.05%	Settlement
Côte d'Ivoire	0.03	0.00	0.01	0.05	0.18%	NPC
Ghana	2.88	1.73	0.17	4.78	2.96%	NPC
Togo	0.00	0.01	0.00	0.01	0.45%	Erosion
Benin	0.11	0.01	0.00	0.12	0.18%	NPC
Nigeria	66.70	17.56	6.50	90.76	1.14%	NPC

* NPC = Non productive conversion

One of the side effects of degradation and non-productive conversion of mangrove forests in the region is the invasion of invasive species that can compete with regenerating mangroves. This is a major problem in eastern Nigeria, for example, where the invasion of Nypa palm competes with overexploited mangroves in the Niger Delta (Nwobi et al., 2020) and the Calabar estuary.

While most countries have experienced a net loss of mangroves, the extent of mangroves is constant or increasing in some areas, due to expansion and regeneration offsetting some of the anthropogenic losses. In Senegal, for example, mangrove cover expanded from 2000 to 2016 by 2.6% (Hakimdavar et al., 2020), offsetting losses caused primarily by erosion.

Table V: Mangrove extent (in km²) comparison for West Africa using data published by the Global Mangrove Watch (Bunting et al., 2018), the United States Geological Survey (USGS, 2016) and the NASA Carbon Monitoring System (Liu et al., n.d.)

Country	2010 Global Mangrove Watch	2014 United States Geological Survey	2017 NASA Carbon Monitoring System
Senegal and Gambia	2,048	3,532	3,044
Guinea-Bissau	2,761	2,900	3,833
Guinea	2,412	2,613	2,344
Sierra Leone	1,333	1,621	1,703
Liberia	196	274	203
Côte d'Ivoire	59	4	35
Ghana	207	115	120
Togo and Benin	1	154	66
Nigeria	7,010	7,473	8,725
Total	16,026	18,684	20,074

Mangrove structure-including canopy height, above- and below-ground biomass, and soil carbon stocks-varies across the region depending on climatology and anthropogenic factors (Simard et al., 2019). The highest mangroves and aerial biomass values are found in Nigeria, Côte d'Ivoire, and Liberia, while the largest total carbon stocks are found in the most extensive countries, namely Nigeria, Guinea, and Guinea-Bissau. The Table VI provides an overview of canopy height, biomass and distribution of mangrove carbon stocks for West Africa.

Table VI: Canopy Height, Biomass and Carbon stock distribution of mangrove for West Africa

Country	Maximum H eight in m (+/- 3.6 m)	Mean height (m)	Max AG* Biomass ($Mg.ha^{-1}$)	Mean AG Biomass ($Mg.ha^{-1}$)	Total AG Biomass (Mg)	Total Carbon (Mg)	Total area (ha)
Mauritania	10.2	8	56.3	39.4	1,028	8,077	26
Senegal	11.9	6.9	71.3	31.9	1,822,351	17,401,914	57,164
Gambia	17	8	123.1	41.1	2,860,292	21,616,022	69,590
Guinea-Bissau	22.1	12.8	183.9	79.5	16,285,202	68,902,599	204,802
Guinea	22.1	10.3	183.9	60.5	14,384,186	76,960,253	237,789
Sierra Leone	27.2	11	252.6	70.2	10,726,951	50,469,666	152,867
Liberia	44.1	19.6	530.8	177.6	2,197,234	4,980,120	12,380
Ghana	30.5	10.7	302.4	69.7	725,915	3,435,676	10,416
Côte d'Ivoire	39	15	440	117.1	209,432	646,749	1,788
Togo	15.3	5.6	104.8	24.6	2,293	27,887	93
Benin	8.5	3.6	42.6	12.5	46,057	1,074,325	3,687
Nigeria	33.9	13.9	355.3	99.6	68,016,334	238,906,942	682,688

* AG = Above-Ground

1.1.5 Need for fine and updated data such as bathymetry

The knowledge of the bathymetry of the continental shelf is useful to understand both its future evolution and its current use (resources and navigation). However, our knowledge is not very advanced, as **most of the surveys done in this region date back an average of 30 years**. This gap has led to uncertainties in coastal wave and flooding models and resulting risk assessments and predictions, and currently limits the best regional coastal management strategies (Ndour et al., 2018 ; Almar et al., 2020).

High resolution bathymetric data of the West African continental margin are currently not available for scientific use. Most high-resolution bathymetric studies are very localized. The recent development of satellite altimetry has had a great influence on the bathymetric mapping of the deep seabed. New technologies such as video imagery and X-band radar have made it possible to estimate depths and coastal positions continuously and at a regular frequency (Angnuureng et al., 2020; Bergsma et al., 2019, 2020).

Most studies of beach morphology variability remain limited to the coastline. For example, to establish the long-term relationship between wave forcing, littoral drift and the morphological evolution of beach profiles, *in situ* measurement campaigns have been conducted and video cameras have been installed in West Africa (Almar et al., 2014). The oldest video acquisition system in this sub-region was installed in Grand Popo (Benin) in 2013, as part of the INSU LEFE-EC2CO project (Almar et al., 2014). Subsequently, as part of the COASTVAR project, an intensive international field experiment conducted in St. Louis, Senegal, in 2016, numerous instruments were deployed to measure waves, currents, bathymetry, and topography to quantify the natural protective role played by the sandbank, coastal currents, and transient exchanges with the inland shelf (Ndour et al., 2020).

Recently, Almar et al. (2020) to quantify robust regional bathymetry, spatiotemporal cross-correlation has been used, gathering information on sparse surrounding time waves while retaining their spatial information at high resolution. This method was then implemented on a regional scale by Daly et al. (2020) their "S2Shores" project. They produced a regional scale coastal bathymetry with an unprecedented fine resolution (0-100 m) along 4,000 km of coastline and over nearly 70% of the coastal area of the West African Atlantic continental shelf (Figure 10). These data cover the contiguous coastal zone (12 nautical miles) of West African coastal states. The method detects depths of up to 40 m and has the potential to monitor the dynamics of shallow coastal features such as deltas, shoals and underwater dunes. At this scale, the width of the shallow West African coastal zone varies considerably, with the widest (> 25 km) being in the deltaic region covering The Gambia, Guinea-Bissau, Guinea and Sierra Leone, and along the Niger Delta, and slightly sloping in Senegal (10-20 km wide), in the Bay of Benin and in Bonny, and the narrowest (> 5 km) along the coast of Liberia, immediately north of Dakar and around Bioko Island, Equatorial Guinea. Although at this scale it is not easy to distinguish deep features (> 30 m depth, such as submarine trenches), shallower features, such as the channels around the Bijagós Islands (Guinea-Bissau) and the St. Anne's Shoal in Sierra Leone, are well represented. As shown in the figure Figure 10, the hotspots (Senegal, Guinea-Bissau, Cameroon, Equatorial Guinea, Sierra Leone, and Guinea) at a resolution of 200 m depth and at least up to 30 km from the shoreline highlight the ability of the model to discern depths at a local scale. It also captured the bathymetric characteristics of the Volta and Niger deltas better than GEBCO.

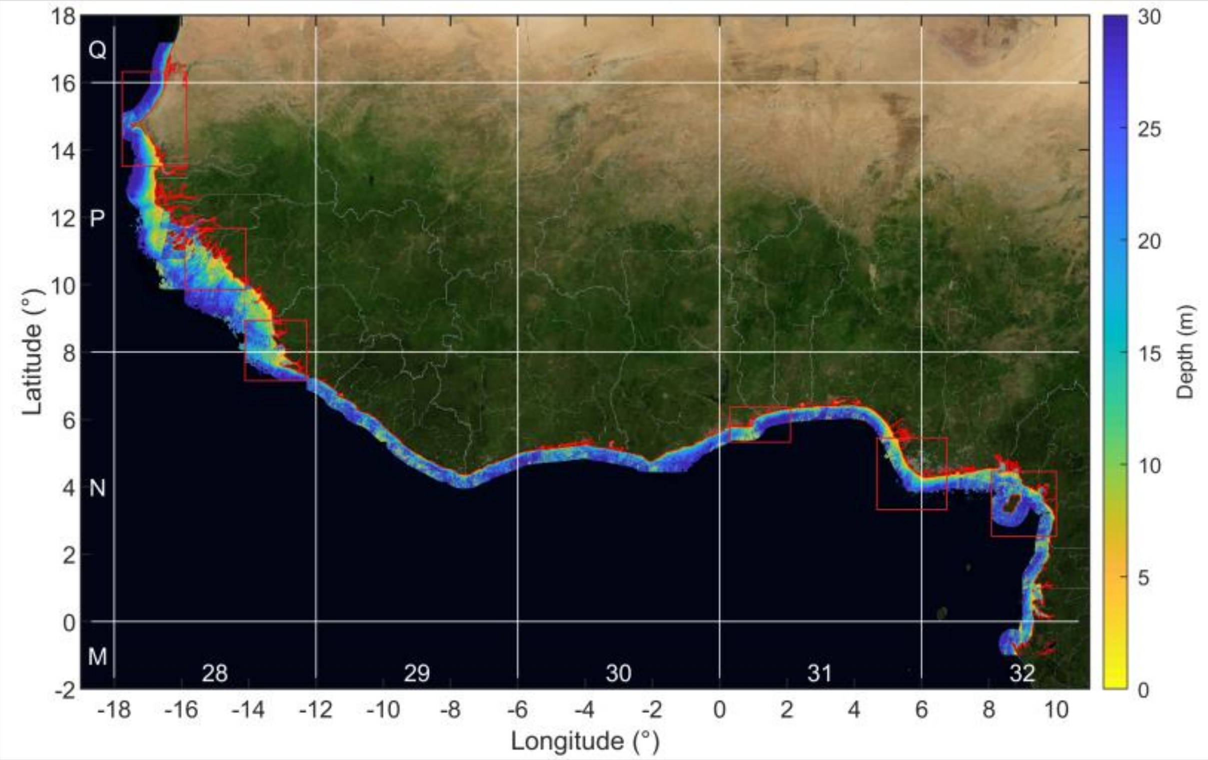


Figure 10: Mosaic of S2Shores bathymetry composites for the WA Region (after Daly et al., 2020).

Colour scale shows depths between 0-30 m, the red line shows the shoreline and UTM zones shown in white. Red boxes outline the area of the six hotspots

This new West African coastal atlas will undoubtedly enhance research and planning capabilities for the region and expand the ability to frequently and accurately monitor large-scale bathymetric changes and the understanding of dynamic coastal processes and their coupling to large-scale forcing conditions. In addition, this new development offers the ability to create unique time series of bathymetry over shorter periods of time, and thus observe dynamic changes in shallow water features, such as deltaic formations or underwater dune migration; and the ability to produce models of weekly to seasonal bathymetric changes, both on a local and regional scale.

1.2 Vulnerability of coastal areas and coastal risks

In West Africa, the problem of coastal risks is becoming more and more prevalent with the increase in the frequency of exceptional weather and marine events and their corollaries which are coastal erosion and marine and river submersion.

1.2.1 Sea level rise in low elevation coastal zones

Sea level is predicted to rise between 14-36 cm by 2050 with an intermediate climate scenario (Representative Concentration Pathway RCP 4.5) or 21-52 cm by 2050 with a worst-case climate scenario (RCP 8.5) (Vousdoukas et al., 2018).

LIDAR derived Digital Elevation Models (DEMs), along with current, bathymetric and storm surge data, is widely acknowledged to be the most accurate way of modeling fine-scale Sea Level Rise (SLR)

(Gesch, 2018; Gunduz & Tulger Kara, 2015; Kulp & Strauss, 2015). Although this is largely recognized as the most accurate approach, LiDAR data is expensive to obtain, often unavailable in many parts of the world, and would require a large amount of processing power to analyze at the scale of the West African Coastline. DEMs are also commonly used to map SLR vulnerability, although it has been shown that global DEMs are not suitable for mapping fine scale Sea level rise over relatively short time horizons with any acceptable amount of accuracy (Leon et al., 2014).

Given these accuracy and data availability issues, it is hardly possible to precisely model sea level rise (Figure 11). However, it is possible to model 10-meter Low Elevation Coastal Zones (LECZs) for the entire west coast of Africa (Senegal to Nigeria).

Sea level rise is not uniform in the Niger Delta coastal area and other coastal areas because: storm surges show patterns of spatial differentiation based on wind patterns and because of differences in scale and spatial resolution in the original data sets. These results highlight that a number of areas appear to have high vulnerability and risk, but also have some limitations due to a combination of mapping scale, data gaps and uncertainties. Nevertheless, in terms of natural systems, coastal mangroves, marshes, estuaries and lagoons in West Africa are all highly vulnerable to marine stressors (coastal maps of Senegal/Gambia/Guinea-Bissau/Guinea/Sierra Leone from PRCM WebGIS, 2021), while providing a buffer capacity against storm surges. These systems are currently under-protected (USAID, 2014a (NASA Earth data, 2019[3])

Figure 11: Map of West Africa 10-meter Low Elevation Coastal Zones (USAID, ND)

3 https://earthdata.nasa.gov/

While this analysis was largely geared to produce such map for communications purposes, more work is necessary for planning at a local level (other maps at country scale are available in appendixes). This data can be used to further identify areas at risk within this 10-m LECZ if additional analyses were conducted to create a risk index for the prioritization of climate mitigation efforts by aggregating much of this information. Even so, this still only allows for planning at a large scale. A more detailed analysis should be conducted for local level planning, utilizing higher resolution DEM datasets or other SLR modeling methods, and including more information about storm surges and ocean dynamics in the specific area of interest.

SEA LEVEL RISE ANALYSIS

This analysis was conducted using MERIT DEM data, which was created by removing multiple error types from SRTM3 v2.1 and AW3D-30m v1 to reduce vertical height bias (Yamazaki et al., 2017). Given this increased vertical accuracy, MERIT DEM can map 10-meter LECZs with an 89% accuracy (Gesch, 2018).

To determine the 10-meter LECZ, the goal was to identify pixels that had a value less than 10 and were adjacent to the coast or a coastal water body. Once this zone was determined, several key factors were also added on the maps :

- Global Mangrove Watch **mangrove** data from 2016 (because mangroves are an important ecosystem for mitigating the impacts of rising sea levels and more frequent storm surges (Bunting et al., 2018) and are also at risk to be degraded in the face of rising sea levels and should be protected (Gramling, 2020) ;
- High Resolution Settlement Layer **population** data for each country (in order to determine the extent and density of vulnerable populations (Facebook Connectivity Lab & Center for International Earth Science Information Network - CIESIN - Columbia University., 2016)) ;
- **Water bodies** within this zone (coastal waterbodies are likely to contain key ecosystems such as lagoons, estuaries and deltas, and should be identified as at-risk ecosystems so efforts can be made to protect from climate related impacts) (Hansen et al., 2013) ;
- **Main roads** (to show how infrastructure may be impacted by sea level rise or climate related events).

1.2.2 “Erosion” and “Flood” hazards characterization, which regional tools?

The Detailed Master Plan - textual and cartographic document - aims at characterizing a territory and highlighting its major issues, including in particular the impact of climate change on the coastline. Much data is analyzed and combined (bathymetry data, coastline data, climatic and oceanographic events) to establish indicators and projections.

Producing reliable and updated data and information is necessary to achieve the goal of reducing coastal hazards and improving the resilience of communities living in the coastal zone. Various methodologies and approaches - with a goal of regionalizing their uses - are used to assess coastal risks and manage coastal vulnerability to climate change. These include:

- The Coastal Hazard Wheel - CHW

  The CHW methodology is a universal coastal hazard classification system that can be used in areas with limited data availability.

- The Coastal Multi-Hazard Risk Assessment;

  The coastal multi-hazard risk assessment enables to identify the areas of highest risk and specifies/locates additional detailed studies to be conducted.

- using the Coupled Model Intercomparison Project 5 (CMIP5);

This project aims at performing climate simulations in a coordinated manner between different research groups, enabling to better estimate and understand the differences between climate models. Phase 5 (CMIP5) simulations include historical simulations from 1850 to 2005, climate projections simulating future climate change over the 21st century, and climate projections initializing models by estimating the observed state.

These three methods and their results are described in the following sub-chapters:

1.2.2.1 *The Coastal Hazard Wheel, a Coastal Hazard Measuring Tool*

A capacity building request on risk assessment techniques using the Coastal Hazard Wheel (CHW) method was initiated by CSE within the Climate Technology Centre and Network (CTCN). Training was provided and a regional workshop held in 2019.The Coastal Hazard Wheel methodology was used for the West African zone (Senegal, Gambia, Guinea, Côte d'Ivoire, Ghana, Togo, Benin) and Cameroon, following a process supported by CTCN and the consortium formed by GlobalCAD (lead), WE&B, Meteosim and WASCAL.

The Coastal Hazard Wheel is identified as a universal coastal hazard classification system. It mainly fulfills three functions:

- multi-hazard assessment at local, regional, and national scales;
- identifying possible management options at a specific coastal site; and
- disseminating coastal data through a standardized coastal language.

The results obtained from the coastal hazard mapping showed that the main hazards identified and the associated risk level for the eight West African countries are:

- Flooding (class 4: very high risk);
- Erosion (class 4: very high risk);
- Progressive flooding (class 3: high risk);
- Saline intrusion (class 3: high risk) (see box "Hazard Wheel Method").

The mapping confirmed that the most important risks at regional level are erosion and flooding, with more than 50% of the coastline classified at a very high erosive risk level. Progressive flooding and saline intrusion risks are also notable, with more than 60% of the coastline classified at a high risk level. The risk of ecosystem disruption was rated moderate for all eight countries surveyed (Figure 12).

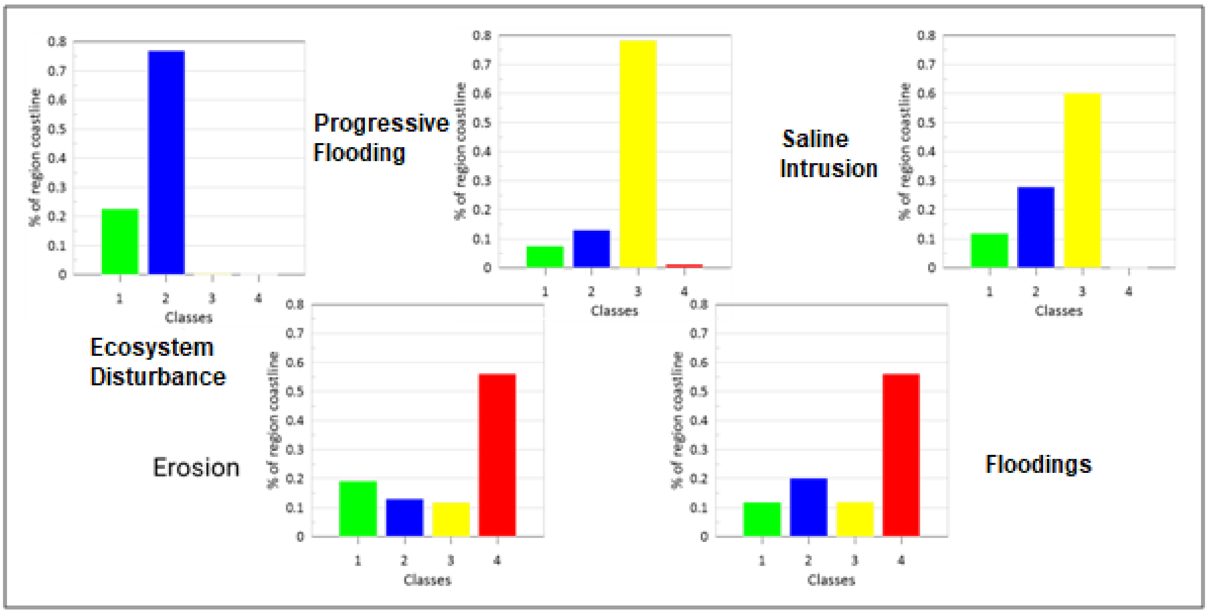


Figure 12: West Africa Region - CHW Bio-geophysical Classification Method (Global CAD et al., 2019)

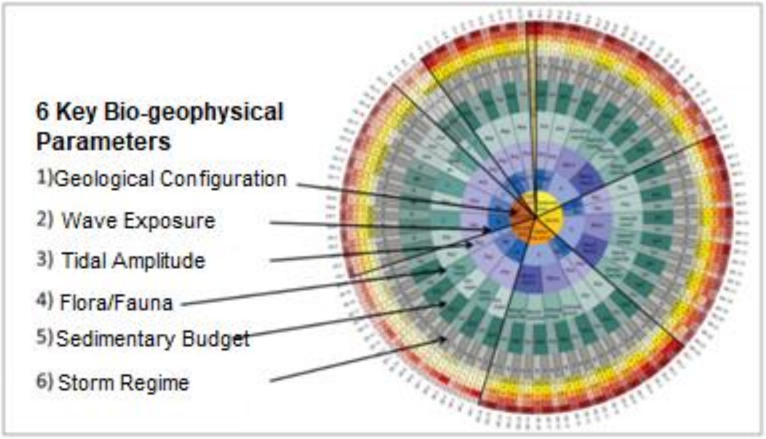
Regarding ecosystem disturbance, although the results show moderate disturbance; the recent 2019 regional workshop shared that the scope of the other hazards would eventually undermine the integrity of the ecosystem where hazards occur. As such, the current outcome should not be underestimated.

It is essential to always consider coastal areas as a system with many other subsystems, whose functions are highly interconnected. Selecting management options must be done holistically, including the socio-economic aspect integration.

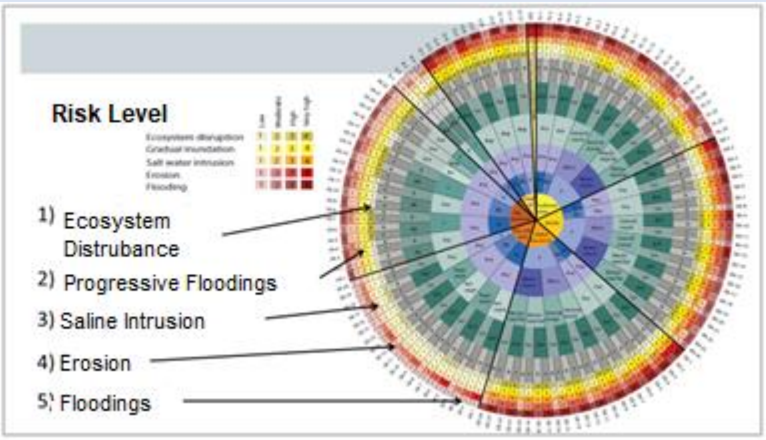
COASTAL HAZARD WHEEL METHOD

The assessment system of this method is based on the consideration of the following six bio-geophysical parameters, which are considered as the most important for a given coastal environment (see Figure "Bio-geophysical Classification"): geological layout; wave exposure; tidal range; biodiversity; sediment balance; storm climate.

The nature of these parameters enables assessing the intrinsic vulnerability of the coast. They are integrated in a kind of wheel to classify the level of 5 coastal hazards: ecosystem disturbance, progressive flooding, saline intrusion, erosion, and flooding (see Figure "Hazard classification").



CHW Bio-geophysical Classification



CHW Risk Classification

For each hazard, 4 levels of risk were considered: low, moderate, high and very high.

These hazards are respectively: the potential disturbance of the current state of coastal ecosystems; the potential progressive submersion of a coastal environment; the potential saline intrusion into coastal surface waters and groundwater; the potential erosion of a coastal environment; the potential sudden and abrupt flooding of a coastal environment caused by short-term water level rise due to storm surges and extreme tides.

1.2.2.2 *The coastal multi-hazard risk assessment*

Coastal communities in **Côte d'Ivoire**, **Ghana**, **Togo** and **Benin** face various threats, from flooding and coastal erosion to environmental degradation and sea level rise. Given a massive concentration of population along the coastline, disasters can take an important toll in lost lives and damaged livelihoods.

The development of coastal multi-hazard mapping, vulnerability and risk assessments, at spatial and temporal scales most relevant to specific needs and context, is pivotal to build a better understanding of impacts and cascading effects and strengthen resilience of coastal communities. The assessments provide insight on the vulnerability of the most important community infrastructure, both built and natural assets, whereupon governments can take risk-informed decision-making of coastal interventions.

From the assessments, coastal communities are ranked according to their level of vulnerability to erosion and flooding risk, under both present and future predicted climate conditions, and the hotspots are sorted out from the less vulnerable areas. The prioritisation and ranking methodology as detailed in the paragraphs hereinafter had been developed in ways that it can be applied elsewhere in West African coastal regions.

The coastal multi-hazard mapping, vulnerability and risk assessments are informed by local knowledge of historical events and coastal trends (WAEMU, 2017; UICN & WAEMU, 2011) and the specific context of exposure of social, economic and natural systems (USAID, 2014b), as well as the outputs of numerical modelling and GIS analysis (IMDC, 2017e, 2017d, 2017c, 2017b, 2017a). The assessments include the consideration of underlying climate change, environmental degradation and economic development-related risk drivers.

The coastal multi-hazard risk assessment is based on computing a Coastal Index which aggregates the (multi-)hazard intensity index and a vulnerability index, which is built by a combination of vulnerability categories (or proxy indicators) to measure characteristics of vulnerability within the overarching social, economic and natural systems (Table VII). For Social Vulnerability, examples of vulnerability characteristics are population density, population growth and subnational poverty and extreme poverty. Vulnerability characteristics in the Economic Systems Indicator are for example tourism activities, fisheries, transport infrastructure and commercial crops. The Natural Systems Indicator ranks existing coastal ecosystems – e.g. Ramsar sites, national parks, mangrove forests – by importance.

Vulnerability assessments are a key component of any coastal (multi-)hazard risk estimation as they support the design of mid- and long-term adaptation options to target economic sector or more sensitive populations or ecosystems.

In this Coastal Risk Assessment Framework, vulnerability to erosion and/or flooding risks is represented by a multidimensional index composed of social, economic and natural factors that considers the spatial distributions of several physical elements (categories or proxy indicators) reflecting the individual and collective characteristics – e.g. human population, economic and infrastructural factors, ecosystems – of a specific coastal sector. The assessment is targeted to give equal weight to the (multi-)hazard intensity index and the vulnerability index, which itself is targeted to give equal weight to the different analysed proxy indicators for vulnerability characteristics. However, the methodology can be expanded and re-calibrated for analysing the risk taking into consideration the myriad of dimension vulnerability can have.

Table VII : Summary of hotspot sectors in the four countries, as determined in the study by IMDC, 2017a – based on the multi-hazard Coastal Index under future projected climate conditions, benchmarked against the WAEMU/IUCN studies (WAEMU, 2017; UICN & WAEMU, 2011)

Country	Sector	Name	Coastal Index	WAEMU and UICN, 2011	WAEMU and MOLOA, 2016
Benin	BJ1-b	Grand Popo – West Cotonou			
	BJ1-a	Togo Border - Grand-Popo			
	BJ2-d	Cotonou			
Côte d'Ivoire	CI6-b	East Abdijan Suburban Zone - Grand Bassam			
	CI7-b	Sandy terrace and coconut grove in eastern			
	CI3-c	Fresco – Assigny			
	CI5-a	Abidjan – West Port Bouët			
	CI5-b	Abidjan – East Port Bouët			
Ghana	GH10-b	Left Bank Volta Delta			
	GH9-a	New Ningo – Lekpoguno			
	GH10-a	Left Bank Volta Delta			
	GH8-a	East Accra Urban and Suburban Area			
	GH9-b	Right Bank Volta Delta Ada Foah - Ningo			
Togo	TG1-c	Togo			
	TG1-d	Togo			
	TG1-e	Togoville – Agbodrafo – Aného			

Such proxy indicators for vulnerability characteristics may be viewed as the foundation on which plans to strengthen the resilience of coastal communities and facilitate climate adaptation is built. By looking into more, less or different proxy indicators can make different issues of vulnerability/disaster become more salient – e.g. vulnerability of the built environment – or more unimportant – e.g. coastal environmental degradation – in coastal (multi-)hazard risk assessments and ensuing development of disaster risk reduction strategies and climate adaptation options. In the present Coastal Risk Assessment Framework, the vulnerability of social, economic and environmental systems to coastal erosion and flooding hazards are attributed the same importance, adding to a greater store of understanding and analysis of the breadth of exposure and vulnerability in risk.

1.2.2.3 *The Coupled Model Intercomparison Project 5, including climate forecasts*

The world Bank Group undertook a study (world Bank & WACA, 2020) focusing on five countries in the region: **Mauritania, Senegal, Côte d'Ivoire, Togo and Benin**, to explore how climate change will affect the coastal zones and specifically identify the exposed and vulnerable areas of the five countries.

Historical trends of three key climate parameters (temperature, precipitation, and SLR) were analysed to assess how climate has been changing in recent decades.

Future projections of the three parameters were modelled for three time horizons (2030, 2050, and 2100)[4] and compared to the baseline period 1986-2005[5]. Two Representative Concentration Pathways (RCPs) scenarios (RCP 4.5 and RCP 8.5) were considered for each parameter and time horizon to illustrate the degree of change between the most commonly referenced pathways. The Coupled Model Intercomparison Project 5 (CMIP5) data from the World Bank Climate Change Knowledge Portal (CCKP) was used to estimate potential changes in the three main parameters under the two major RCPs.

Finally, an evaluation of how climate change will affect the coastline was presented through the analysis of two natural hazards: coastal erosion and coastal flooding. These are the two most common phenomena occurring along the countries' coastlines and will be exacerbated due to the effects of climate change. Coastline position in the 1984-2015 period was evaluated using Landsat and Sentinel images and projected to the three-time horizons to estimate potential future coastal erosion. To evaluate coastal flooding, maps of coastal areas exposed to floods were generated through simulations based on SLR projection data, combined with 90-meter spatial resolution Shuttle Radar Topographic Mission (SRTM) digital elevation data. The main exposed areas were identified for each country and analysed through the generation of spatial maps.

The main results of the study are the following:

- A general warming is expected in all five countries ;
- A general decrease in future precipitation in all countries, except in Côte d'Ivoire ;
- By the end of the century in all countries, over 1m increase in the sea levels was projected ;
- The area expected to be most affected by erosion are the areas south of the port of Nouakchott (likely to lose 40.6 km² by 2100), east of Lomé (17.4 km² loss in the same year), and the east of Cotonou (12.9 km²). Other areas at risk include Jreida in Mauritania, Abidjan and Lagoon of Popo in Côte d'Ivoire, the Togolese coastline close to Benin and Grand Popo in Benin.
- The locations most exposed to flooding include the lagoons of Mono and Kouffo in Benin; the area between Abidjan and the border with Ghana in Côte d'Ivoire; the urban areas of the capital Nouakchott and city of Nouadhibou in Mauritania; the cities of Saint-Louis, Dakar, and Casamance region in Senegal; and the coastal neighbourhoods of Lomé in Togo.

The synthesis highlights the need for local level studies and data collection on SLR, precipitation, and extreme events such as storm surges […] complemented with an in-depth analysis of socio-economic impacts that would provide a more reliable quantitative assessment of projected losses along the coast in the future. See Table VIII for a summary of key findings by country and Table IX for detailed identification of gaps and recommendations.

[4] Time horizons: 2020-2039, 2040-2059, and 2080-2099.

[5] Exact periods vary slightly based on data availability.

Table VIII : Summary of key findings

	Observed Climate Change			Future Climate Change Projections			Climate Change related Hazards	
	Temperature	**Precipitation**	**Sea Level Rise**	**Temperature**	**Precipitation**	**Sea Level Rise**	**Érosion**	**Flooding**
Mauritania	Mean annual temperature increased by almost +0.9°C in 1979-2016 period.	No clear precipitation trend observed. While a decrease of -0.04 mm/year is registered in 1950-2016 period, a positive trend of +0.5 mm/year is observed in 1979-2016 period.	According to ESA data, an increase of +0.32 cm/year in1992-2007 period is measured.	Temperatures are projected to increase by +2.3°C by 2050 and +4.6°C by 2100 under RCP 8.5.	Precipitation is expected to fall by -2 mm in 2050 under RCP 8.5.	Sea level rise is expected to increase up to +60 cm at mid-century under RCP 8.5.	Sandy and low-lying coastline is expected to be severely affected, mainly area in south of port of Nouakchott, area of Jreida, and coastline of Nouadhibou.	Coast is constantly at risk of inundation as extreme weather events will occur more frequently. Urban areas like Nouakchott and Nouadhibou are exposed to coastal flooding.
Senegal	Mean annual temperature increased by almost +0.8°C in 1979-2016 period.	A general decrease from the Dakar station observed in 1950-2016 period (-0.8 mm/year). From 1979, an increase of +0.9 mm/year registered.	An increase of +0.25 cm/year registered by ESA satellites in 1992-2017 period.	Temperatures are projected to increase by +1.3/+2.7°C by 2050s and up to +4.3°C by 2100 under RCP 8.5.	A general decreasing trend in precipitation is likely. However, robust conclusions are difficult to make.	Projections for Sea level rise show an increase of more than +1 m by the end of the 21st century.	Most exposed areas are N'Dar Toute-Saint-Louis, Fas Boye, Boro Deunde, Kayar, M'Bour-Saly Portudal, Kafoutine-Casamance, Ngalou Sam Sam, Palmarin, and Dijffer.	Relatively low altitude areas. The most exposed areas are cities of Saint-Louis, Dakar, and Casamance region.
Côte d'Ivoire	Mean annual temperature increased by almost +0.7°C in 1979-2016 period.	A decrease of -0.5 mm/year in 1950-2016 period in Abidjan airport station. The 1979-2016 period shows a decrease by -0.1 mm/year. This data shows higher trend variability and uncertainty.	Increased about +0.32 cm/year in 1992-2017 period measured by ESA satellites.	Mean annual temperature projected to rise +1.9°C by 2050 in high emission under RCP 8.5.	Mean annual precipitation could decrease by -1.38 to -3.57mm in 2050 under RCP 4.5 and -0.5 to -0.7mm under RCP 8.5.	Sea level is expected to increase to +30 cm in 2070 and +95 cm in 2100 for RCP 4.5. Sea level is expected to increase to +115 cm in 2100 under RCP 8.5.	From west to east, the first section of coastline is stable. From Sassandra to Abidjan, coastline is significantly exposed to erosion. Other areas exposed to erosion are Grand Lahou, Lagune of Popo, and San Pedro.	Heavy precipitation along coastline and Sea level rise generate frequent flooding events especially between Abidjan and border with Ghana.

	OBSERVED CLIMATE CHANGE			FUTURE CLIMATE CHANGE PROJECTIONS			CLIMATE CHANGE RELATED HAZARDS	
	Temperature	Precipitation	Sea Level Rise	Temperature	Precipitation	Sea Level Rise	Érosion	Flooding
Togo	Mean annual temperature increased by about +0.5°C in 1979-2016 period.	A decrease of -0.1 mm/year in 1950-2016 period. Positive trends in 1979-2016 period, registering a +0.3 mm/year increase.	Sea level increased by about +0.25 cm/year in 1992-2017 period as measured by ESA satellites.	Temperatures projected to increase by +1.1/+2.8°C by end of 2050 and by +2.5°C/+5.6°C by end of century under RCP 8.5.	Projections of change in rainfall present high variability and uncertainty. An increase during winter months and decrease during summer month is shown.	Sea level is estimated to increase about +31 cm by 2050 under RCP 8.5.	Coastline is almost entirely affected by erosion. Most vulnerable areas include sector TG1-c, TG1-d, and TG1-e. Main affected areas identified in south of Lomé and at the border with Benin.	Risk of flooding is high along whole coastline, mainly in the lower region of city of Lomé and in sector TG1-c.
Benin	Mean annual temperature increased by almost +0.5°C between 1979-2016.	General decrease in precipitation of -0.2 mm/year in 1950-2016 period in Porto-Novo station. In 1979, a +0.2 mm/year increase with strong uncertainty of ±0.3 mm/year was observed.	A +0.25 cm/year increase in 1992-2017 period as registered by ESA satellites.	Mean annual temperature expected to rise +1.3° C under RCP 4.5 and +2.1° C under RCP 8.5 by mid-century. Warming in winter months is higher than summer months.	Future projections show decrease over the century in summer months. In winter months, a slight increase is expected.	By the end of the century, sea level is expected to increase to +81 cm in a range between +75 and +152 cm.	Areas identified to be most affected are the western area of the coastline, especially cities of Hillacondji and Grand-Popo. The section of Azizacoue-Abouta, Djomehountin, Cotonoú, and border area with Nigeria are also at risk.	More frequent and intense floods expected. Most exposed sections of coastline are the western and the central western areas. In this report, the surrounding area of Cotonoú has been analysed.

Table IX : Gaps and recommendations

	Key Findings	Gaps and Limitations	Main Contribution	Recommendations for Future Studies
General Climate Characteristics	Mauritania and Senegal have a long dry season (Nov-May) with mild and high temperatures (22-32°C) and a short, wet season in summer (Jul-Sep). Waves of 1.2 to 1.7 m come mostly from Northwest. The other three countries have a long rainy season (Apr-Oct) with hot temperatures the entire year (24-32°C) and waves of 1.2 m coming mostly from the south.	Information about wind and swell directions and magnitude, tides, and currents were usually poorly detailed so was information on storm surge and extreme precipitation events.	A description of the main climate characteristics, e.g., temperature and precipitation patterns, coastal geomorphology, winds regime, and oceanic conditions, are provided at a regional level and analysed for each country. Directional waves rose were generated for each country to show the frequency and significant height of waves coming from various directions using ERA interim dataset.	Further studies on extreme climatic events such as storm surges and extreme precipitation rainfall is needed.
Observed Climate Change	A general increase of temperature and Sea level rise has been observed at a regional level and for each country. With higher data variability, a general decrease of precipitation was also detected in the area of study.	The high variability observed in historical data for rainfall precipitation represents a significant limitation when analysing evolution of rainfall over the decades. Studies on storm surges and precipitation extreme events were also missing.	Observed data on temperature and precipitation were collected and processed from ERA Interim data series and main coastal city weather stations. Sea level data were obtained from CCKP, and transformed to yearly trends, and analysed. Return periods and Sea level anomalies related to storm surges and precipitation extremes were collected from risk data platforms.	Future studies on past extreme climate events and interpretation of high variability of precipitation and wave events are needed.
Future Climate Change	Temperature and Sea level rise are expected to increase, while future projections of precipitation that are expected to decrease in the future show high variability. This does not allow the drawing of accurate conclusions.	Although many studies are available on Sea level rise at a global level, a significant data gap has been detected at the regional and at national levels. Information is missing for various time horizons and scenarios (especially RCP4.5). Research on projections of extreme events like storm surges and precipitation are getting initiated. Therefore, reliable results for specific places are difficult to find.	Projection data of main climate parameters were gathered mostly from the World Bank CCKP Portal, but also from scientific reports and national and international documents. The information was summarised in tables and the results were analysed for each climate parameter.	To understand how sea level rise, storm surges, and extreme climate events will change in the future, further studies will have to be undertaken at regional and national levels.

	Key Findings	Gaps and Limitations	Main Contribution	Recommendations for Future Studies
Climate Change Natural Hazards	Sea level rise, temperature increase, and increase in frequency and intensity of extreme climate events will amplify the phenomenon of erosion and generate more flooding events along the coastline of all countries analysed. Human intervention in coastal areas will intensify these effects.	Lack of updated studies on the influence of extreme climate events such as storm surges, extreme winds, and rainfall precipitations on erosion and coastal flooding in the region.	Description of erosion and coastal flooding issues at a regional level and their further analysis at the national level was completed. For each country, the most exposed areas were identified, and an analysis of the effects were provided. Maps of erosion (for Mauritania and Senegal) and coastal flooding (for each country) were generated to show the effects of erosion and flooding over the three-time horizons and two climate scenarios.	More studies will be useful to assess the effects that extreme climate hazard may have on coastal erosion and flooding.

1.2.3 Characterization of the "Marine Oil Pollution" Hazard

Among the pollution frequently encountered, particularly near urban areas, we can cite pollution linked to the discharge of untreated urban and industrial effluents, to agricultural activities, to the exploitation of oil and gas, etc. " marine pollution by hydrocarbons' hazard for which data are available on a regional scale.

The marine oil pollution hazard is a reality for the region's countries (see Chapters 2.2.2 and 2.2.3 on offshore oil and gas activities and maritime traffic).The International Tanker Owners Pollution Federation (ITOPF) publishes data[6] on maritime incidents, including spills of 7 tons or more of oil. Between 2007-2019, the data indicates that the majority of oil spills in the GI WACAF[7] region were due to the maritime traffic of vessels other than tankers as listed in the table below. However, note that a large number of spills, particularly those below 7 tons, are not necessarily reported and therefore not recorded.

Table X : Pollution Events Related to Maritime Transport Listed by ITOPF

YEAR	COUNTRY	VOLUME (IF KNOWN)	VESSEL TYPES
2000	South Africa	-	Vessel other than a tanker
2001	Cameroon	7-700 tons	Tanker
2002	South Africa	7-700 tons	Vessel other than a tanker
2005	Namibia	-	Vessel other than a tanker
2009	Nigeria	> 700 tons	Tanker
2009	Nigeria	-	Tanker
2011	Nigeria	-	Tanker
2013	South Africa	-	Vessel other than a tanker
2013	South Africa	-	Vessel other than a tanker
2016	Ghana	-	Vessel other than a tanker
2017	Côte d'Ivoire	-	Vessel other than a tanker
2017	South Africa	-	Vessel other than a tanker
2018	Togo	7-700 tons	Tanker
2018	Cameroon	7-700 tons	Tanker
2019	South Africa	-	Vessel other than a tanker

Note that the potential externalities of a spill depends on many factors, including the type and quantity of oil shipped, whether it is bunker oil (fuel) for all vessels, or cargo oil in the case of tankers. Regarding pollution events related to the oil industry, data is difficult to access. The few data available, such as those availed by the International Oil and Gas Producers (IOGP) Association, provides little detail and covers overall Africa. Nevertheless, they show that in Africa, on average 6.9 tons of crude oil are accidentally spilled for every million tons of crude oil produced[8], onshore and offshore combined. These hazard drivers are measured against the resilience degree of the relevant countries. Although the state of preparedness and response to oil spills varies significantly between countries in the region, progress has been made since 2006 (see chapter "3.3.1.5. Management of oil pollution").

[6]ITOPF's data disclaimer: "Please note that there is considerable annual variation in the frequency of oil spills and the quantities of oil spilled. Although we strive to provide accurate reports on each event, we cannot guarantee that the information received from the specialized press and other sources is complete and accurate. The number of events, volumes of oil spilled and all other data are based on the most recent information. Therefore, the information provided should be carefully considered. "

[7]The GI WACAF region covers 22 countries located on the Atlantic coast of Western, Central and Southern Africa from Mauritania to South Africa inclusive. The WACOM area countries are thus included in this region.

[8]https://www.iogp.org/bookstore/product/2017e-environmental-performance-indicators-2017-data/

2. West Africa Coastal Areas: Strong and Diverse Pressures

West African coasts concentrate a large part of the urban population and economic activities such as fisheries, tourism and offshore mining, oil and gas activities. This situation caused the occurrence of strong pressure and increased hazards on the coastal area.

2.1 Demographic and Urban Dynamics

Africa has the fastest urban growth in the world. The continent's population is expected to double by 2050.Two-thirds of this growth will be absorbed by urban areas and, over the next 30 years, cities will host an additional 950 million people. The countries covered by the SDLAO are home to 114 million people in 2015, 130 million people in 2020 and are not exempt from this trend (2015 data sets).West Africa is one of the most mobile regions in the world due to a long history of trade, nomadic pastoralism, seasonal migration, labor expropriation during colonialism, and economic relations with former colonial powers.

The West African urban space is increasingly dynamic, particularly in the economic and administrative capital cities located less than one kilometer from the coast. The development intensity and form of the large West African cities result from three key factors: economic development, housing supply and the extended transport networks. This rapid artificialization of the coastline of large West African cities (particularly between 1992-2020) has worrying consequences for land use, natural resource use and waste management (pollution).

2.1.1 Coastal Urbanization

2.1.1.1 *Administrative and Economic Capital Cities Are Predominantly Coastal*

29.2 million persons (25.5% of the population in the 11 countries covered by the SDLAO 2O11) live in coastal cities, while only 24.1 million (21%) live in non-coastal cities, the rest of the population being rural (Figure 13).

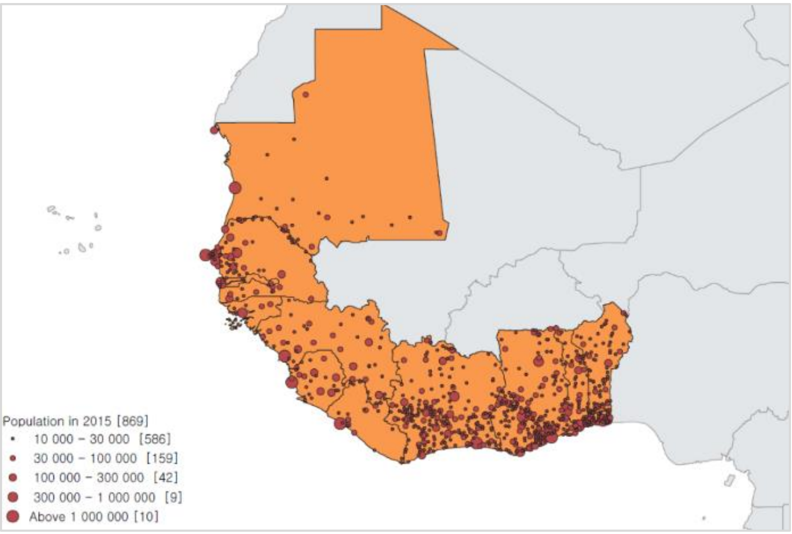


Figure 13 : Urban Agglomerations with More than 10,000 Inhabitants (2015 figures).

There are 206 coastal cities in the region with an average population of 142,000. The average population size of the 195 coastal cities that are not national capital cities is 34,000 inhabitants. The average population size of coastal cities is mainly due to national administrative and/or economic capitals. Nine of the ten cities with more than one million inhabitants in the study area are coastal cities (Figure 14). The largest coastal city (Abidjan) has 4.7 million inhabitants, while the largest non-coastal city (Kumasi) has 2.8 million inhabitants.

The number of inland cities is significantly higher (663) than the number of coastal cities. The average population size of inland cities (36,000 inhabitants) is similar to that of coastal cities excluding national capital cities.

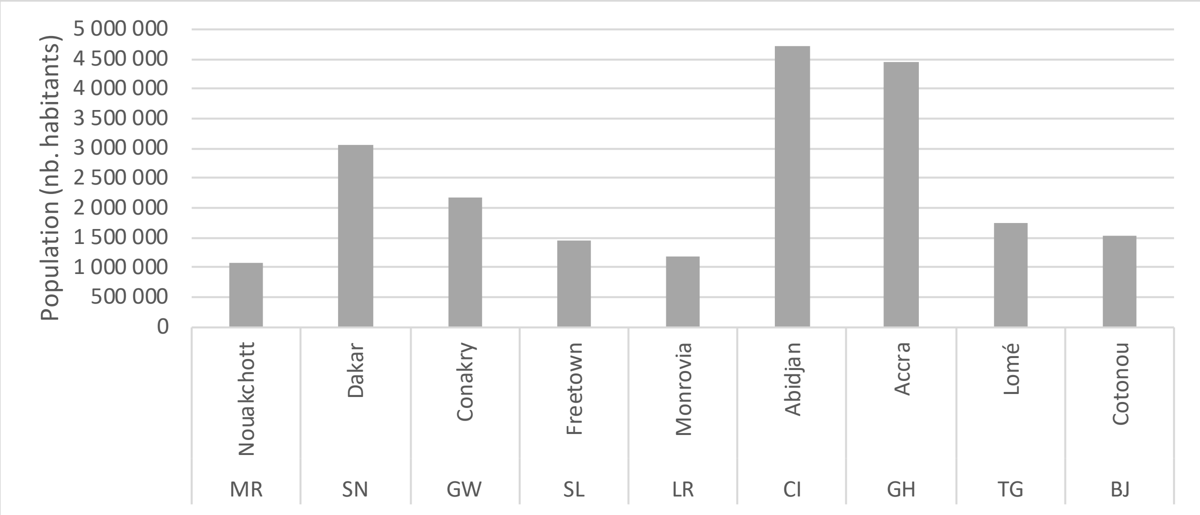


Figure 14 : Population of coastal cities with more than one million inhabitants

2.1.1.2 *The Population Growth of Coastal Cities Ensures their Primacy*

Between 2000-2015, the population of coastal cities increased by 81%, while the population of inland cities increased by 102% (Figure 15). This results from strong urban growth including not only the development of small agglomerations, but also the emergence of new spontaneous mega-agglomerations. In addition, despite the decline of trade routes, driven out by colonization and then globalization, in favor of coastlines, highlands continue to concentrate the major historical settlement centers in sub-Saharan Africa with high urban growth potential. Political balances are influenced by urban development, particularly in the inland. Some of the medium-sized agglomerations within the country, such as Kumasi in Ghana, Touba in Senegal and Bouaké in Côte d'Ivoire, are the second largest cities competing with national metropolises. **Apart from capital cities, whose primacy is still confirmed, the rest of the development of medium-sized cities remains relatively homogeneous, with an average size comprised between 34 and 36,000 inhabitants.**

The growth trends of the nine urban agglomerations with more than one million inhabitants also differ. While Abidjan (in Côte d'Ivoire) and Accra (in Ghana) confirm their numerical superiority at around 4.5 million inhabitants, four coastal cities remain below 1.5 million (Figure 16). However, the urban population of these four coastal capital cities is highly polarized (with a share of the coastal urban population against the total urban population exceeding 50% and reaching 81% in Liberia) (Table XI).

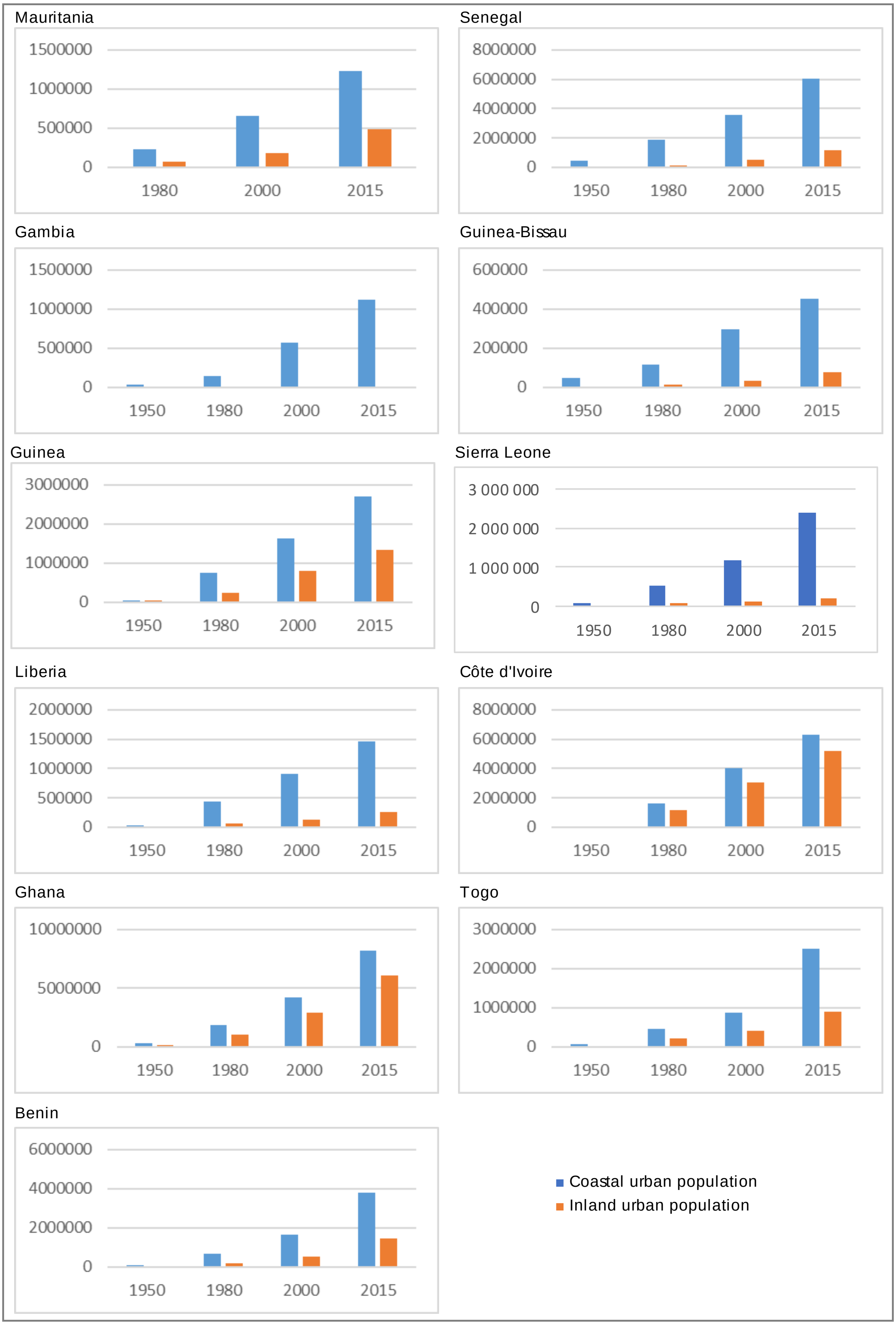


Figure 15 : Urban Population Distribution (Coastal Population and Inland Population)

Table XI : Share of coastal urban population as % of total urban population

Year	MR	SN	GM	GW	GN	SL	LR	CI	GH	TG	BJ
1950	-	78%	100%	100%	41%	81%	100%	60%	64%	100%	81%
1980	70%	69%	100%	89%	64%	59%	81%	51%	53%	63%	70%
2000	75%	65%	100%	91%	56%	60%	84%	50%	48%	60%	64%
2015	69%	62%	100%	84%	58%	63%	81%	46%	44%	64%	54%

MR : Mauritanie, SN : Sénégal, GM : Gambie, GW : Guinée-Bissau, SL : Sierra Leone, LR : Liberia, CI : Côte d'Ivoire, GH : Ghana, TG : Togo, BJ : Bénin, NG : Nigéria, STP : São Tomé & Príncipe

The share of the coastal urban population compared to the overall population of the country is also heterogeneous and varies from 20.4% (Guinea) to 54.0% (Gambia). The coastal urban population of Côte d'Ivoire accounts for 22.9% of its total population, and the coastal urban population of Benin accounts for 27% of its total population.

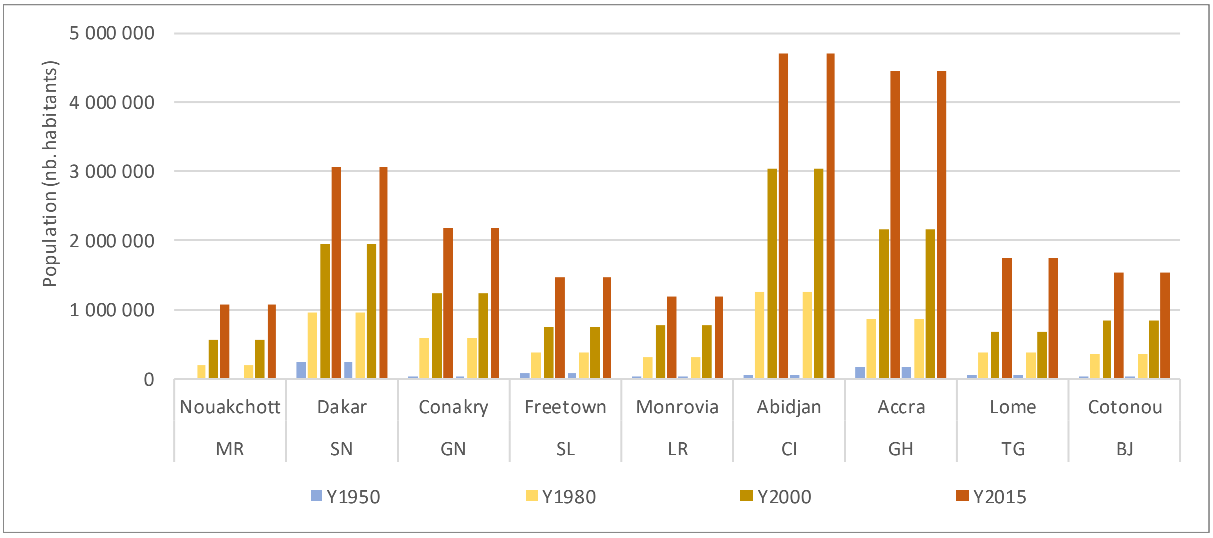


Figure 16 : Population Growth in Coastal Urban Areas with More than One Million Inhabitants

2.1.1.3 *The Spatial and Temporal Growth of the Coastline is Heterogeneous at Regional Level*

A large discontinuity can be observed from Mauritania to Côte d'Ivoire, while the coasts of Ghana, Togo and Benin show a quasi-continuous urban density which continues towards Nigeria forming transnational metropolitan areas that require a shared and coordinated coastal development policy. However, on a smaller scale along the Great Ibadan (Nigeria) - Lagos (Nigeria) - Accra (Ghana) (GILA) urban corridor, urban agglomerations only casually follow the coastline; the main routes of the corridor avoid the coastal edges of the lagoon regions and bypass the Volta Delta.

The Ghanaian and Ivorian cities are the largest and most dynamic in West Africa. Their urban footprints have grown considerably in less than 30 years. In Ghana, between 1992 and 2019, the urban area more than doubled from about 1,000 km² to 2,500 km². The same applies to Côte d'Ivoire, where the urban area has increased from about 800 km² to 1,800 km², and in Senegal and Guinea, where urban areas have increased from about 300 km² to 800 km² in less than 30 years. In the other West African countries, the urban growth is also characterized by an increased area of coastal cities, but their spatial coverage is much smaller than that of the cities mentioned above.

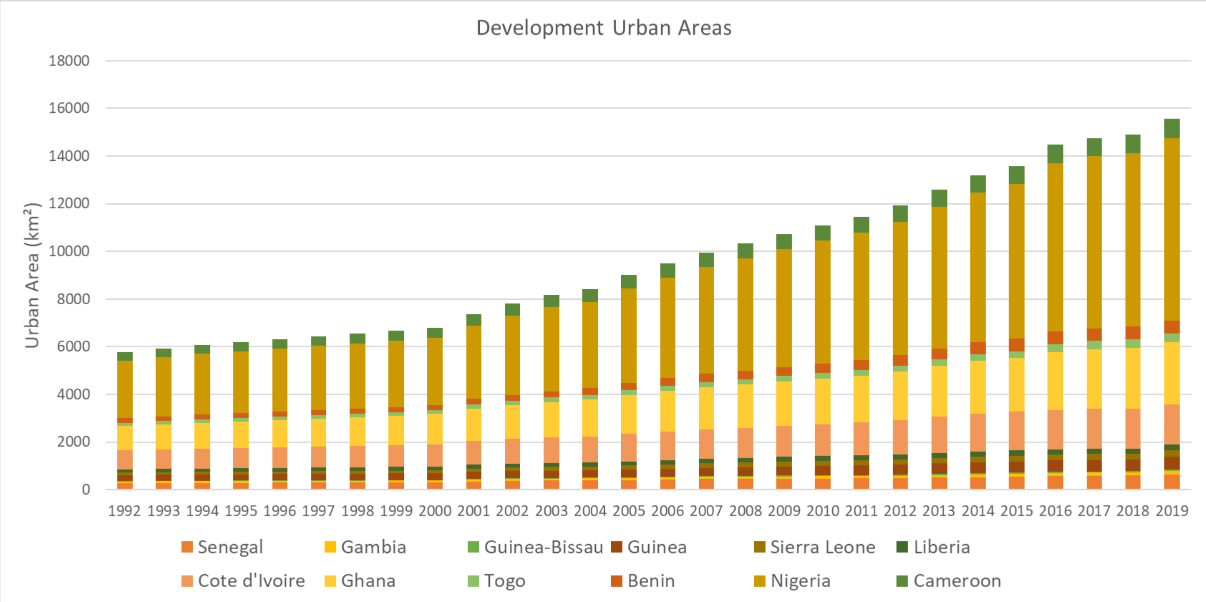


Figure 17: Urban area per year per country derived from LC-CCI and Climate Service data sets.

Each bar represents the extracted urban area for one year and each colour represents one country. A clear increase of urban areas is visible over the years. It has to be noted that due to the resolution of the data only larger urban regions are detected (see box "Materials and methods : LC-CCI et Climate Service data processing").

Comparing land coverage in 2010, 2016 and 2020 reveals some notable changes:

- peri-urban expansion progress in a spillover effect, mainly in the agglomerations inland. This kind of urban expansion is noted in almost all national capital cities (Figure 18). Some secondary cities are developing so rapidly that they merge with the main city. This is the case of the city of Dubreka in Guinea, which in some places merges with the Conakry city;
- an expansion along the seafront in the cities of Nouakchott (MR), Freetown (SL), Monrovia (LR) and Abidjan (CI);
- a progress of residential extensions along coastal roads, generally towards new urban development poles. For instance, the Nouakchott city (MR) is expanding increasingly northward towards the new international airport of Oumtounsy, located 25 km north of the Nouakchott city;
- a sometimes rapid development of a few core centers and secondary cities far from the coastline and likely to some extent to polarize future developments away from the coast.

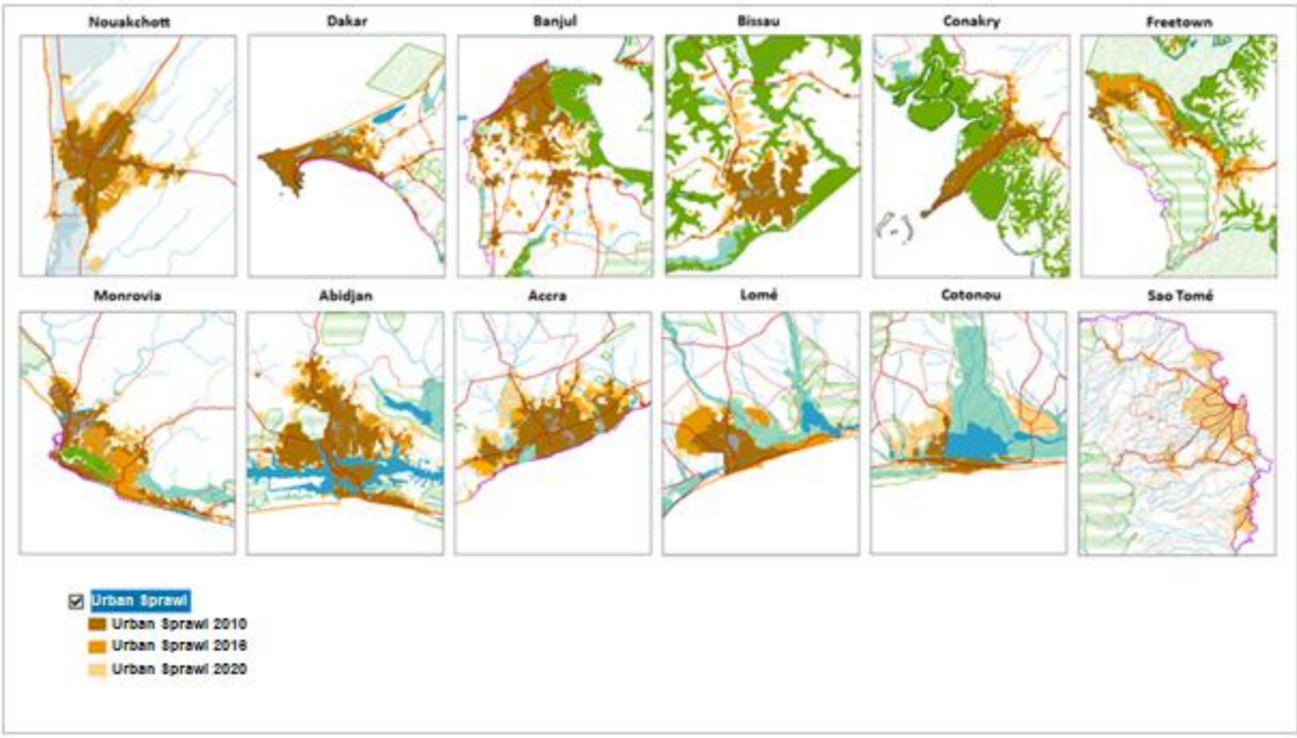
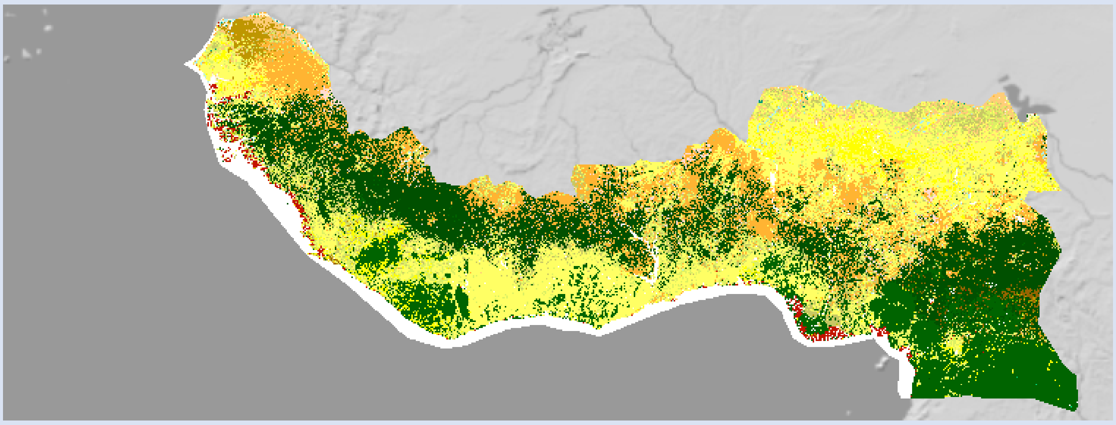


Figure 18 : Evolution of the Urban Spot of West African Coastal Cities Between 2010 and 2020

LC-CCI DATA PROCESSING AND CLIMATE SERVICE

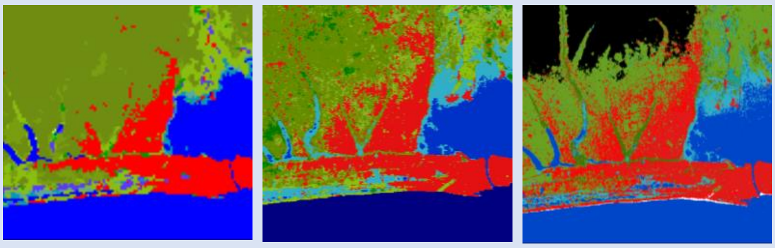
Several data sets derived from satellite remote sensing are available for land cover/land use classification. Two sources have been used here for retrieving statistics for the development of urban areas on a larger scale. The first one is a combination of a time series of yearly data sets provided by ESA within the ESA CCI Landcover data ("LC-CCI", CCI = Climate Change Initiative) and the Copernicus Climate Change Service ("C3S") land cover products (Defourny et al. 2017, 2019). They cover the years 1992 - 2019, the land cover information is available for 21 classes. There is one class representing urban/built up areas which has been used to calculate the percentage per total area for providing an indicator for the development of urban areas. The information is available in 300m spatial resolution. A second data set that provide several years of land cover information is provided by Copernicus Global Land Service (CGLOPS). It covers the period 2015 – 2019 and provides information in 100m spatial resolution. It has been used for analysing the influence of the spatial resolution to the results.



VALUE	LABEL	COLOR	VALUE	LABEL	COLOR
0	No Data		120	Shrubland	
10	Cropland, rainfed		130	Grassland	
20	Cropland, irrigated or post-flooding		140	Lichens and mosses	
30	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)		150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	
40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)		160	Tree cover, flooded, fresh or brackish water	
50	Tree cover, broadleaved, evergreen, closed to open (>15%)		170	Tree cover, flooded, saline water	
60	Tree cover, broadleaved, deciduous, closed to open (>15%)		180	Shrub or herbaceous cover, flooded, fresh/saline/brackish water	
70	Tree cover, needleleaved, evergreen, closed to open (>15%)		190	Urban areas	
80	Tree cover, needleleaved, deciduous, closed to open (>15%)		200	Bare areas	
90	Tree cover, mixed leaf type (broadleaved and needleleaved)		210	Water bodies	
100	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)		220	Permanent snow and ice	
110	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)				

LC-CCI land use classification of West African countries in 2019

The first step was to investigate the influence of the resolution on the detection of urban areas and thus the extraction of percentage of urban areas per country. The following figure shows three data sets with different spatial resolutions from 300m – 100m – 10m. The coarsest resolution detects the large urban areas, but not the small-scale structures.



Resolution	km² urban	km² whole area
300m	309.7	4141.4
100m	538.7	4145.2
10m	576.0	4143.1

Example of urban area comparison for three different resolution of data (arbitrary area around Lagos)

Low resolution data (left: Copernicus Climate Change Service, 300m), medium resolution data (middle: Copernicus Global Land Service, 100m) and high resolution data (right: EO4SD classification 10m, Sentinel-2)

Following table shows the area of the urban class in the three datasets. While the whole area is the same for all three data sets (last column), the area for the urban class is the smallest for the coarse data set because the small scale built-up areas are not captured. As we have the long time series only for the coarse data set, we decided to use that data set despite this limitation.

2.1.1.4 *Urbanization Against Natural Coastal and Littoral Areas*

Any area urbanizing process is highly disruptive of environments and ecosystems. Indeed, coastal cities have characteristics common to all urban agglomerations, and thus create identical disturbances in the environments and landscapes where they are established. (Robert S., 2019). In West Africa, coastal environments and ecosystems are weakened by coastal urban development, through port, seaside and residential facilities that have an impact on the evolution of the coastline. The ports of Nouakchott (MR), Monrovia (LR) and Lomé (TG) caused very pronounced coastal erosion downstream regarding the littoral drift. The extraction of beach materials is a situation prevailing in many cities such as Nouakchott (MR), Dakar (SN), Freetown (SL), Monrovia (LR) and São Tomé (STP). All these actions contribute in changing the sedimentary dynamics of the coast, creating risky situations.

Regarding biodiversity, the wetlands of West African coasts are among the environments most affected by urban developments. In Nouakchott (MR), the extension of residential areas in the wet depressions around the Sebkha and Ryad districts, located in the north-west of the city, has been noted. The same situation is noted in cities such as Bissau (GW), Conakry (GN), Monrovia (LR) and São Tomé & Príncipe (STP).

Furthermore, a degraded protective vegetation cover of the coastal dune is observed along the overall length of the Nouakchott city, due to high attendance (fishery sites, tourism, motor sports, etc.). Similarly, a drastic mangrove vegetation reduction is noted north of the city of Freetown (SL), due to urban development.

Urbanization does not exclude marine protected areas either. In Dakar (SN), it is noted that an area of 78 hectares on the northern strip of filaos has been released for housing purposes. The city of Freetown (SL) is also whittling away the Western Area Peninsula National Park land, in the east of the city.

Coastal cities are also growing to the detriment of urban agricultural areas, leading to their conversion to residential or tourist purposes. Examples of progressive and anarchic urbanization are noted in the *Niayes* area, located north-east of the city of Dakar (SN) and around the mangrove rice-fields in the city of Bissau (GW).

The urbanization ecological footprint also includes the pollution of beaches by solid and liquid waste. In many beaches in West African coastal cities, the landscape is the same, with solid waste dumping sites and urban effluent discharge. The industrial sector also contributes in this pollution process through discharges into the sea, the consequences of which are harmful to the environment and coastal ecosystems.

Note: Based on current data, it does not seem possible to define the area of natural zones that has disappeared in favor of the development of coastal urban megapolises. Indeed, the various versions of the SDLAO and the associated mapping do not enable this analysis because of the evolution of the definition of the terms used[9] and the unavailability of satellite images for the updating period of the assessments.

2.1.2 Climate migration in coastal regions

The region has also experienced some of the worst impacts of climate change, including rising temperatures, erratic rainfall, increasingly intense rainfall events, flooding, and coastal erosion owing to heightened storms and sea level rise. These trends are expected to continue. West Africa's coastal area

[9] The mapping of the "mangrove" housing under the SDLAO 2010 is generated from an interpretation of Landsat images and the MNT-ASTER (30m). In addition to the vegetation cover, it also includes more or less important areas of open water and mudflats depleted of vegetation, as well as many islands more or less sandy. Conversely, in 2016, the mapping is based on Global Mangrove Watch (GMW) data, and includes only the mangroves above-ground biomass portion.

is home to a third of the region's population and generates 56 percent of the GDP (IUCN & WAEMU, 2010). Given a high dependence of most coastal countries on the agriculture and fisheries sectors, a growing coastal tourism sector, as well as the high concentration of people and assets along the coast, the economy and livelihoods of West African countries are highly vulnerable to climate variability and change. This raises the question whether these impacts may spur even higher rates of migration over the coming decades, be it as a successful adaptation to climate change stabilizing livelihoods and increasing incomes or as distress migration from intolerable situations that leave the migrants impoverished and with few options.

To help respond to this question, the World Bank launched the flagship report groundswell - Preparing for Internal Climate Migration (Rigaud et al., 2018). The groundswell report took a scenario-based approach and applied a modified form of gravity model to isolate the projected portion of future changes in the spatial population distribution that could be attributed to slow-onset climate factors – over the longer term and across scale. The model looked at the impacts of water stress and drops in agriculture productivity using the database of state-of-the-art computer model simulations of biophysical climate impacts, coupled with sea level rise and compounded by storm surge[10]. The groundswell report found that West Africa could have up to 54.4 million internal climate migrants by 2050 under a pessimistic scenario[11]. Importantly, the study underscored how concrete climate and development action could reduce significantly the scale of climate-induced migration.

To better inform policy dialogue and action, work is currently underway to provide a more granular analysis of climate migration in West Africa, with a focus on the coastal countries. This includes an advancement of the model which encompasses, among other changes, a higher spatial resolution, additional climate impact variables (that is, inclusion of ecosystem impacts through net primary productivity and flood risk projections). The results provide plausible climate migration scenarios from 2020-2050 for the six coastal countries of West Africa Coastal Areas Resilience Investment Project (WACA ResIP), namely Mauritania, Senegal, Côte d'Ivoire, Togo, Benin and São Tomé & Príncipe as well as Nigeria and Ghana as additional countries that have been participating in a dialogue with the WACA Program[12].

While all coastal countries will witness some level of climate-induced migration, the pattern of this mobility will depend on the demographic, economic and climate trends in each country. Supporting the overarching conclusion of the Groundswell study that climate change is becoming a potent driver of migration within countries, the preliminary findings of this regional assessment for West Africa indicate the following:

- The trajectories of climate-induced migration across the countries in the region will ramp up in the face of climate impacts. The scale and trajectory of climate migration will depend on the specific demographic, economic, and climate trends in each country.
- The countries will see the emergence of climate in-migration and climate outmigration hotspots. Generally, people will move from less viable areas with lower water availability, crop productivity and/or pasturage and from areas affected by rising sea level and storm surge to more attractive and viable places.

10 The full methodology is available in Appendix 1 of the Groundswell report.

11 The original Groundswell report included the following 17 countries: Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, São Tomé & Príncipe, Senegal, Sierra Leone, Togo

12 While the focus of the new report is on the listed WACA countries, the enhanced model was applied to all 17 West African countries included in the original Groundswell report.

- Climate-friendly and inclusive development scenarios will see significantly lower levels of climate migration compared to the pessimistic scenario of continued high emissions and unequal development.
- The relative scale of climate versus development migrants varies across countries depending on the climate vulnerability context and reliance of the population on climate-sensitive livelihoods.
- Changes in water availability are emerging as a major driver of climate migration in West Africa, alongside Sea level rise and storm surge impacts, which will contribute to significant climate outmigration due to impacts on livelihoods and habitat losses.
- Coastal countries are likely to see some level of displacement from the coastal zone and a dampening in terms of population growth, but the scale will vary depending on the country context.
- While some level of climate migration is a reality, the scale of climate migration and hotspots are not set-in stone. Coordinated action on reducing greenhouse gases (at the global level) combined with more inclusive development can help reduce significantly the intensity and scale of migration.

2.1.3 Territory development policies

An initially inward coastalization

Most major colonial cities were port cities and are the foundation of many of today's most populated West African agglomerations. Nevertheless, some inland agglomerations have grown and emerged rebalancing social, economic and political equilibrium. However, most of these coastal capital cities still have only limited contact with the seafront; Nouakchott's urban area barely touches the coast. The centre of Abidjan is located on a lagoon and not at the edge of the ocean, just like Cotonou, Porto-Novo, or Saint-Louis. Thus, at the local level, many buildings and sites along the coastline are more inward than seaward impacting future land planning design and perspectives.

These specificities have several roots:

Historical. The colonisation of sub-Saharan Africa was carried out by sea by the Portuguese navigators from the 15th century onwards, later by the other European powers, who established coastal trading posts.

Economic and sociocultural. The low development of tertiary activities and in particular of infrastructures related to the development of seaside tourism undoubtedly contributes to limiting the coastal development of the sub-Saharan coasts. As in Central America, West Africa gathers mainly agrarian and pastoral societies. Coastal areas are less attractive because of the poor agrarian quality of soils and sea fishing is poorly developed. African societies have often tended to turn their backs on wetlands (source of contagious diseases), which by extension also includes the coastal areas, often swampy, poorly drained, and with sandy and saline soils of poor agricultural quality. Most of the movement of goods and people is done by land, and at a good distance from a coastline with many bays that are difficult to cross.

Geographical. Sub-Saharan Africa has been relatively isolated from the rest of the world by the presence of the largest desert in the world, conditioning its history and territorial development, notably with a weak exchange interface (very present for example in the Mediterranean Basin).

In contrast to northern and southern Africa, the coastalisation in the eleven studied countries is recent but should not be neglected, as illustrated by the recent appropriation of the seafront by construction near major urban centres (Lagos, Dakar, Abidjan…). These developments are still domestic and marginal for a limited but growing segment of the population - emerging middle classes. This new attraction for the coastline signals a significant societal change, thus linked with new environmental challenges in terms of land planning and respect of environmental standards.

Towards more place-based and dynamics analysis for multi-scalar sustainable policy options

Urban transition offers great development opportunities, but it also poses significant environmental challenges, in particular for cities developing along the coasts. Urban agglomerations are developing most often without the benefit of policies or investments able to meet these challenges. This is particularly challenging for cities facing environmental risks such as coastal erosion. One of the most crucial pieces of information for these cities and the institutions that manage them is to anticipate their growth and understand their spatial development beyond the administrative boundaries of the initial agglomeration.

Observed urban landscape transformation underlines the heterogeneity of local contexts, highlighting the importance of multidisciplinary contextual awareness and the need for designing multi-scalar territorial policies and coordinated transnational and regional responses.

Facing the challenge of environmental externalities, policymakers and local actors will benefit from updated, homogeneous and spatial data on urban agglomeration and its territorial footprint. SIG capacities and new interactive tools allow understanding and better anticipate how climatic and geographical factors influence the spatial configurations of urban settlements and their temporal evolution. It highlights the need for data production & sharing and training in order to ensure that cities can fully play their role as change driver in the perspective of a more respectful environment.

2.2 Dynamics of Economic Activities in Coastal Areas

2.2.1 The Importance of Fisheries in the Coastal Countries Economy

Due to the existence of favorable weather and oceanic conditions, the countries' coasts in the West African zone, from Mauritania to Nigeria, are a favorable region for the activity of fishing vessel fleets and fishermen. The 14 countries of this region (Mauritania, Senegal, Cape Verde, Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, Nigeria and Sao Tome & Principe) aggregate approximately 2.85 million tons of annual catches of products fished at sea, or 2.37 million excluding Nigeria (FAO data, Table XII). This is 37% of African production and 3% of global production (excluding aquaculture). Within this region, the share of fisheries in the Gross Domestic Product (GDP) varies between 0.5 and 5% depending on the country. However, no analysis of these fisheries and their dynamics can be made without describing first the components of these West African fisheries. These include, respectively, industrial fishing, small-scale fishing in its different varieties, and finally fish processing and marketing activities. All these segments of the fishery sector leave their footprint on the coastal environment, either by the catches or the damage inflicted on the environment that they generate, or more simply by leading to land coverage under their activities. But inversely, all these fishing activities segments, as well as their actors, are friendly to the environmental changes that affect the coastline and all of them can therefore be impacted, in a more or less acute way, by these changes. These different aspects are addressed successively in the rest of this chapter.

Industrial fishing

The industrial segment of West African fisheries is, on the one hand, made up of fishing vessel fleets belonging to companies under national law (but whose capital is often held by foreigners), based in the major ports of the region (Nouadhibou, Dakar, Abidjan, Lomé, Cotonou, Lagos). On the other hand, these include foreign-flag fleets and working under license in their Exclusive Economic Zone (EEZ), under negotiated agreements. Indeed, many States in the region have granted foreign States, groups of States (such as the EU) or private companies the right to fish under license in their waters, while prohibiting these same industrial vessels from entering a coastal strip (varying from 1 to 6 nautical miles depending on the country) which is mainly reserved for national small-scale fishing or for the conservation of ecosystems (Marine Protected Areas). Industrial fishing, both national and foreign, must basically register and land their products in the ports of the countries where they take their licenses, in order to supply domestic markets (contributing to a certain food security for populations) or, on the contrary, in the packaging and processing factories for a transparent export (and generating foreign currency) to the global market (demersal fish, shrimps, fish meal). However, this requirement is not always met, part of the products being transshipped offshore to buyer freezer vessels for clandestine export toward other continents, so much that the industrial fishing statistics established at the level of the States of the region are questioned.

Even more seriously, industrial fleets sometimes operate without a license or using environmentally damaging fishing practices, such as trawling in the coastal strip, with major negative impacts on coastal ecosystems and fish populations, as well as on small-scale fishing activities themselves, as the trawls frequently damage the nets set by the pirogues. This is referred as IUU fishing, i.e. illegal, unreported and unregulated fishing. West Africa is recognized as one of the most affected regions in the world by this environmental and economic plague of industrial IUU fishing (Greenpeace report). However, the professional organizations of small-scale fishermen know how to fight to obtain from governments the banning of the most destructive forms of industrial fishing, and they are beginning to gain ground (e.g.: Senegal)

Marine Small-Scale Fishing, Its Multiple Components and Trends

In most West African countries, domestic fishing is essentially by nature small-scale fishing. This means that fishermen use small or medium-sized boats, generally made locally (in wood) and which are the result of local/national investment dynamics. Pirogues and small-scale fishermen are then organized into “Fishing Units” which are basically part of the informal economy, but which are increasingly registered and recognized administratively (paying annual fishing licenses, registration, construction approval), although they are not real companies in a tax perspective.

Marine small-scale fishing is very developed in West Africa, with more than 56,000 boats, around 235,000 persons directly involved in the fishing business, and a regional production probably exceeding 1.3 million tons (excluding Nigeria from all these figures). This shows an overall trend increase as the production was only estimated at 620,000 tons 35 years ago, if the same countries are extracted from the Chaboud and Charles-Dominique summary (1991).

Table XII : Main Figures of Industrial Fishing and Marine Small-Scale Fishing in West Africa

	Overall Prod.* (tons/year)	Marine Small-Scale Fishing			
		Annual Prod.* (tons/year)	Nb. of Boats	Nb. of Fishermen	Nb. of Landing Sites
Mauritania	952,707	183,000	7,440	21,000	38
Senegal	453,633	450,000 to 490,000)	13,240 to 14,000)	68,000	142
Gambia	48,268	10,000	497	3,150	11
Guinea-Bissau	6,550	28,500	2,407	6,475	132
Guinea	256,675	205,377	7,538	28,000	200
Sierra Leone	200,000	100,000	7,600	30,000	641
Liberia	13,810	9,000	500	3,000	
Côte d'Ivoire	73,687	40,000	1,608	11,000	105
Ghana	286,777	225,000	12,000	50,000	304
Togo	18,260	7,520	370	2,640	23

	Overall Prod.* (tons/year)	Marine Small-Scale Fishing			
		Annual Prod.* (tons/year)	Nb. of Boats	Nb. of Fishermen	Nb. of Landing Sites
Benin	26,059	11,000	728	4,305	47
Sao Tome & Principe	9,730	8,000	400	3,000	
Cape Verde	26,586	20,000	900	5,000	77
W.A. Set	2,858,799	1,298,000 to 1,338,000)	55,228 to 55,988)	235,570	

*Industrial and small-scale fishing (Figures from FAO-FIGIS, 2018).

Blue cells: uncertain or estimated data. Pink cells: data from the 2014-2015 WAEMU survey. White cells: data from FAO.

However, these small-scale fisheries are not homogeneous or uniformly distributed along the West African regional coastline. Broadly speaking, we can recognize two historical anchors and three current dynamics that structure and drive the evolution of West African marine small-scale fisheries. The two historical anchors are the following:

- In most of the West Africa Coastal Areas, human communities were mainly made up, until the middle of the 20th century, of farmers and cattle-breeders who only practiced fishing in a low-intensity form, with modest investments (non-motorized boats), a moderate fishing effort concentrated on certain favorable seasons, and aiming only at providing livelihoods or generating income supplement in addition to their agricultural activities. These small-scale fishermen were reluctant to clear the bar and did not go to the high seas; they were often limited to estuary areas and regions with a lagoon system or the like (Imraguen on the Banc d'Arguin, Nyominka in Sine-Saloum, Bijagos in Guinea-Bissau, Soussou in Guinea, Kru in Liberia, Ebrie in the Ivorian lagoons). Deeply rooted to their coastal land, these peasant fishing communities did not deploy distant migration strategies, and therefore did not conquer new fishing areas. These types of communities still exist, at least in a relict state, in coastal regions, even if some of their members have seen their behavior change resulting from recent developments (see below).
- On some segments of particular coasts, open to the sea, some communities played the role of historical “hotbeds” to develop modern, intensive and commercial small-scale fishing. These are mainly the Wolof and Saint-Louisian people of the northern and central Senegalese coasts and the Fanti people of the Ghanaian coasts. Since the 1950s, they have adopted the use of motors, with increasingly large and powerful pirogues (25 HP and more), and crews of more than 5 people, and integrating numerous technological innovations in their fishing method. These innovations include adopting fishing trips of several days in high seas using iceboxes to preserve the fish, using GPS, developing the large pelagic revolving net (seine), and migrating to other coasts (sometimes other countries) according to the seasons, in search of the most fishy waters. These fishermen have sometimes been qualified as “migrants”, sometimes as “large-scale professional fishermen”. They are not afraid of the sea and prefer fishing to any other form of business, abandoning agriculture.

From these two forms of historical roots, three evolution dynamics can be identified, very different, but all contributing to an unceasing increase in human numbers and fishing capacities (boats and nets) engaged in small-scale fishing along the West African coast:

- The first dynamic is that of the space extension of professional and migrant communities (described in Item 2 above). The large-scale Senegalese fishermen (Saint-Louisian) are largely settled in Mauritania, where they have been the pioneers of the strong development of artisanal fishing since the 2000s. They are also largely present in Guinea, with the same outcomes. On the Gulf of Guinea, large-scale Ghanaian fishermen have long spread westwards (Côte d'Ivoire, Liberia) and eastwards (Togo, Benin) where they have sometimes settled permanently and now are a large part of the marine small-scale fishermen population in these countries. However, within their settlements, and although they have made a significant contribution to the growth of fishery production in the host areas, large-scale fishermen have generally remained "foreigners" in the social perspective, preventing them from having real access to land and land ownership.

- The scattering and the geographical extension of large-scale fishermen from their Senegalese and Ghanaian original hotbeds have caused a knock-on effect on local (indigenous) communities in their adoptive areas, as these local communities have been tempted to imitate them in intensifying and professionalizing fishing activities, in search of cash income. The phenomenon is particularly noticeable among young people from indigenous communities who abandon their parents' poorly remunerative agriculture (often traditional rice farming) to become full-time fishermen by learning from the large-scale migrant fishermen. Over the years, they reach the level of competence of the large-scale fishermen, and also begin to make long fishing trips (the case of the Soussou in Guinea), or even migrate far away (the case of the Nyominka, who in turn become "large-scale fishermen" and go fishing around the islands of Guinea-Bissau). All of these fishermen, whether they were originally large-scale migrants or local and more recently professionalized, now mingle in the same social life within large professional fishing villages/camps, which have sometimes emerged like mushrooms (the case of Katchek in Guinea), where Islam serves as a melting pot for the integration of these people of different origins. And they all share the same practices of intensive investment and permanent work in fisheries.
- In addition, the West Africa Coastal Areas, which are already populated by local communities of peasant fishermen and the large-scale fishing camps that have been established everywhere, are receiving more and more young rural people from the hinterland. In the 1970s and 1990s, they were fleeing from the great drought in the Sahel; today, they are fleeing from insecurity in Mali, Niger and Burkina Faso, or simply from the devaluation of traditional agricultural systems that yield little cash income (millet is increasingly abandoned by urban dwellers). These young people go to the large coastal landing stations where they are hired as fish crate carriers, and then sometimes embark on seine boats (which are always looking for people to pull their big net). For them, fishing is an "adventure" business, just like small-scale gold mining. From certain large cities (Abidjan, Dakar), young urban dwellers who have dropped the school system without any real qualification come to join them. Some of these young people will use their earnings to finance new "adventures" far away (emigration), but others will remain in the fish landing stations where they will gradually become integrated into the professional fishing communities. According to surveys conducted by WAEMU in 2014-2015, these neo-fishermen (identified by the fact of declaring no ancestors - neither father nor uncle - in fishing) would represent at a given time 14.6% of the number of fishermen in the 5 countries of the WAEMU zone (Table XIII). In the next generation, once they merge into the fishermen communities, they can no longer be spotted. As such, the 14.6% figure is an inflow index, on a generational scale.

Table XIII : Number of Fishermen and Neo-Fishermen, by WAEMU Country (WAEMU Survey) for Fishermen Filling in the "Ancestors in Fishing" Variable

Country	Fishermen descendants	Nb. of Neo-fishermen*	% of Neo-fishermen
Senegal	57,906	10,663	15.6%
Guinée Nissau	5,218	1,529	22.7%
Côte d'Ivoire	9,967	692	6.5%
Togo	2,012	364	15.3%

Country	Fishermen descendants	Nb. of Neo-fishermen*	% of Neo-fishermen
Benin	4,018	285	6.6%
WAEMU Set	79,121	13,532	14.6%

*No ancestors in fishing

These three phenomena contribute to an unceasing growth in the number of fishermen and fishing vessels in the West African region. The annual increase rate has been estimated at 5.4% by the end of the 20th century (Chavance P., 2002 ; Morand et al., 2005), a value that is much higher than the natural demographic growth rate. This numerical increase in the number of fishermen and boats has led in some cases to overexploitation, at least in the economic sense of the term (strong decrease in fishing yields, expressed per effort or investment unit). Indeed, the annual tonnages landed by small-scale fishing in the old centers of professional fishing seem to have for long reached their potential maximums: we now observe either a quasi-plateau situation, as in Senegal, with an average of 450,000 t/year since the mid-2000s, or a downward trend, as in Ghana, which has gone from 300,000 t/year in the early 1990s to 225,000 t/year today. Increased small-scale fishing catches are now only noticed in countries with a recent extension of intensive professional fishing, such as Guinea (from 60,000 t in 2000 to 205,000 t in 2018) and Mauritania (from 80,000 t in 2000 - Chavance et al., 2006 - to 183,000 t in 2019). In the Gulf of Guinea countries that hosted the extension of the Ghanaian small-scale fishing in the 20th century (i.e., Côte d'Ivoire, Togo, Benin), the number of small-scale fishermen is no longer increasing, and production has also stopped, notably due to unfavorable environmental factors (IUU fishing by Asian industrial fleets, industrial pollution, or coastal erosion in certain sites).

SMALL-SCALE FISHING IN MAURITANIA

In Mauritania, by the end of 2019, there were 7,440 small-scale fishing boats, defined by the regulations as decked or not decked boats of less than 14 m. The majority of these boats are non-decked pirogues made of fiberglass (63%) or wood (31%) propelled by outboard motors, most often of low power. There are still about one hundred traditional boats (lanches) sailing in the Banc d'Arguin area. The numbers of the national pirogue fleet are not precisely known, and may vary from one year to another depending on the conditions of other economic sectors such as agriculture. Controlling the fishing capacity of the small-scalesector is part of the priorities of the Government which established a registration system coupled with a licensing system supported by the World Bank's PRAO program.

The Mauritanian artisanal fishing focuses on the use of three main fishing drivers: octopus pots targeting this species (69% of the pirogues for which the motors was identified), nets to catch fish species such as sardinella, mullet or croaker (16%), and hand lines to catch fish or squid (15%).

The Mauritanian coastline is mainly an open coastline with a bar phenomenon close to the shore which makes boarding and landing operations difficult and hazardous. The Nouadhibou Bay in the north of the country is an exception with a protected landing station which alone hosts more than 54% of the number of small-scale pirogues, with the disadvantage of a high degree of congestion in the port of Baie du Repos dedicated to this business. After several years of work, the Government has just opened a second site in Tanit, near the Nouakchott capital city, which should eventually help to relieve congestion in the northern zone while providing better conditions for the pirogues based in Nouakchott. There are currently relatively few small-scale pirogues in the areas south of Nouakchott (about 260, or 4% of the total) due to the lack of facilities and connections to the national road network. Developing the landing points on the southern coast is part of the Government's priorities.

Small-scale fish landings have been estimated at around 183,000 tons in 2019.The main species landed is mullet (30,000 tons), whose flesh and eggs are highly demanded for the production of bottarga, ahead of sardinella (22,300 tons) and octopus (12,000 tons), which are targeted by the majority of boats in the north due to their high value on international markets. The other important species in the landings are the croaker and the sea-breams.

The Mauritanian small-scale fishing products largely supply an export sector, especially for the boats based in Nouadhibou, which can benefit from adequate logistics to preserve the products after landing and to transport them fresh (fish) to the target markets or after freezing on land (octopus). Fresh (fish) sales are the unique method of selling the products to the Mauritanian population. There is not enough wood in Mauritania to enable preservation by smoking, and salting remains relatively unknown. The products are most often sold directly on landing, as in Nouakchott, where the fish market is being extensively renovated through the PRAO program assistance. Women fishmongers supply the interior of the country by buying the fish at the landing, and then transporting it to the regions, often in rudimentary conditions. Compared to neighboring countries such as Senegal, where fish consumption is around 28 kg/inhabitant per year, Mauritania is a country where fish consumption is relatively low, around 12 kg/inhabitant per year. However, national consumption tends to increase in recent years under the impetus given by the Government.

Small-scale fishing enables the employment of about 21,000 fishermen, almost all of them Mauritanians, with a predominance of fishermen from N'Diago, a village near the Senegalese border. The small-scale fishing sector provides livelihoods to a group of people providing services to the vessels (supply, unloading) or in the marketing channels in which the majority is made up of women. The number of these jobs is not well known, particularly due to the informal nature of the sector, but current estimates suggest that artisanal fishing generates income for at least 60,000 persons.

An Important Segment of Post-Capture Businesses and Actors

The fish landed by small-scale fishermen is, in some extent, consumed at the family level, but most of it is for sale. The buyers are local micro-fishmongers (who resell the fish in the coastline locality), actors and particularly actresses in the product processing (who smoke, salt or dry the fish before reselling it), and finally large-scale fishmongers who take the fish to the city or to the packaging factories, where it will be prepared for export to Europe or Asia. It is generally considered that one fisherman's job corresponds to two or three jobs in the post-capture and marketing activities chain. Therefore, these activities account for the majority of jobs in the sector.

It is important to highlight that the separation between the industrial and artisanal fishing segments does not exist beyond the fish landing: on the one hand, some products caught by industrial fishing reach the stalls and smoking boards of retailers and processors (this is the case, for example, of the by-catches of tuna fishing), but on the other hand, some small-scale fishing products reach the packaging factories working for export (high-value fish, shellfish) or the flour processing factories which also work for export. This situation has given rise to competition between local and industrial actors for access to products. This is, for example, what has been observed over the last ten years with the development of fishmeal factories (about fifteen now installed in Mauritania and Senegal) that are increasingly capturing quantities of small pelagic fish landed by small-scale fishermen, depriving local women processors from access to the raw material. This leads to an acute social problem in Senegal.

Fishing as a business and occupation dynamics

Industrial fishing activities, including the use of trawls (targeting demersal fish and shrimp) or dredgers (targeting shellfish), are reputed to significantly disturb the sea floor. In contrast, marine small-scale fishing activities have little impact on the environment, except, of course, the significant and sometimes excessive harvesting of fish populations. However, it is worth mentioning the old lost nets that may remain in the waters and perform a “ghost fishing” after fishing campaigns or the few discharges of polluting products from the use of outboard motors (oils, fuels).

Meanwhile, the landing environmental footprint of small-scale fishing is very important and is expressed in many ways: land occupation by the landing stations and their facilities, which are sometimes made of concrete, parking lots for the fishmongers' vehicles, beach occupation by hundreds of pirogues at rest, occupation of vast areas by the drying and smoking activities, which often generate adverse effects (smoke, odors, flies). Furthermore, the fish processing by smoking causes a significant consumption of wood, often taken from the mangroves and neighboring forests without complying with any regulations. Finally, the large fishing camps, which have often emerged without any control, like “mushroom cities”, without any urban planning or any effort to build a sanitation system, generate significant environmental pollution regarding plastic waste and untreated wastewater.

West African small-scale fishing can be considered to be primarily affected by specific fisheries problems, which may have environmental causes, such as certain climate impacts on the more or less good renewal of fish populations (see summary in FAO, 2018), or human, economic and institutional causes (market fluctuations, direct and indirect damage caused by industrial IUU vessels). Here we examine how often small-scale fishing are confronted with aspects that are specifically related to the coastal environment, such as coastal erosion, industrial and effluent (wastewater) pollution. For this purpose, we use data collected by WAEMU on the 5 countries concerned by this economic zone (Benin, Côte d'Ivoire, Guinea-Bissau, Senegal and Togo).

Coastal erosion is a phenomenon that can be observed on all the WAEMU countries’ coasts. Altogether, the landing stations affected by coastal erosion (or at least by its declared perception) aggregate a share of fishermen reaching 89% (on the scale of all the coasts of WAEMU countries), and even more in the northern part of Senegal (96%).

Wastewater pollution events are reported by sites aggregating 45.3% of the fishermen at the WAMU level, especially in central Senegal where the rate of fishermen concerned reaches 68.1% (Dakar and Petite Côte areas), and to a lesser extent in Côte d'Ivoire and in southern Senegal (Sine-Saloum and Casamance). This phenomenon is not reported in any site in Guinea-Bissau.

Industrial pollution events are a little less widespread. They only concern a total of 26.3% coastal fishermen in the five WAEMU countries. This rate reaches 57.2% for the middle part of Senegal (Cape Verde peninsula and Petite Côte, i.e., around Dakar), 27% in Benin and 23.8% in Togo (phosphate terminal) and finally 13% in Côte d'Ivoire. The perceived prevalence of industrial pollution is nil in southern Senegal (Sine-Saloum and Casamance) and in Guinea-Bissau.

The phenomena of “degraded mangroves” due to excessive logging are declared by sites gathering 13.2% of fishermen at the WAEMU level. The rate of fishermen living in the sites affected by this issue reaches 43.9% in southern Senegal (Sine-Saloum and Casamance), 37.0% in Côte d'Ivoire and 28.6% in Guinea-Bissau. The other countries (Togo, Benin) and the central and northern regions of Senegal have almost not experienced this phenomenon (mangroves are very little present there).

Regarding the most widespread phenomenon relating to coastal erosion, it is important to examine the relative position of indigenous fishermen, often peasant-fishermen and inhabitants of old villages, by comparing it to that of fishermen settled as migrants or foreigners, who generally reside on more recent settlement sites. It can be assumed that the former are relatively less exposed, on the one hand, because the old village sites are generally less close to the sea, but also because, being settled on their customary land, they have an easier possibility of moving their settlement, for example by retreating inland in the event of a shift in the coastline. The second group, which is composed “foreigners” and generally more numerous, is often confronted with situations of strangulation between the sea, on the one hand, and the land further back, which is certainly safer, but on which they have no right of access and settlement. This issue has been well documented in Côte d'Ivoire (Konan et al, 2018) where it is considered as the second most important issue according to fishermen, just after IUU fishing. In some regions, migrating fishermen are settled on a coastal spit or cordon between the river and the sea (in Guet Ndar, Saint-Louis), or between lagoon and sea (in Lahou-Kpanda, former site of Grand-Lahou in Côte d'Ivoire). In this type of setting, the possibilities of repositioning the fishing settlement are extremely limited.

SMALL-SCALE FISHING IN GUINEA

In Guinea, the number of active small-scale fishing boats was estimated at 7,538 in 2018 (CNSHB, 2019).The main types of boats are *Salan* (73% of the fleet), which are boats with ribs of about 10 m propelled by outboard motors, *Ghankényi* (27% of the fleet), which are monoxyle boats of about 6 meters mostly non-motorized, and *Flimbotine* (2% of the fleet, which are boats with ribs that can exceed 20m propelled by outboard motors). The Guinean authorities are pursuing an ambitious objective to control the capacity of the small-scale fleet, starting by implementing a registration program for all pirogues supported by the World Bank's PRAO program.

The vast majority of small-scale fishing boats in Guinea use gillnets, most often monofilament nets imported into the country. Gillnets are used through techniques such as drawing, drifting or encircling. A minority of vessels (about 13%) use hooks (handline or longline). The Guinean authorities wish to eliminate the use of monofilament nets due to their negative impacts on the marine environment, but the initiative is currently hampered by the lack of alternative options offering the same cost/efficiency ratio.

Small-scale fishing boats are deployed along the entire Guinean coastline. They operate from about 200 landing stations, which often provide relatively poor conditions to protect the vessels and to unload and process catches, with challenging access conditions to the distribution networks due to the lack of roads. The upgrading of the main landing stations is a priority for the coming years, with the PRAO currently upgrading the Koukoudé landing station and connecting the village to the main road network by asphalting the access track.

The small-scale fishing boats' landings were estimated at 205,377 tons in 2018, with about half pelagic species and half demersal species. Among the pelagic species, Ethmalosa species is clearly the main species exploited (72,645 tons landed in 2018) ahead of Sardinella (27,235 tons). Regarding demersal species, Captains (Galeoides decadactylus - small captain and king captain - 39,497 tons), Machoirons (Arius latisculatus, 24,687 tons) and Cobo (Ethmalosa fimbriata, 7,012 tons) are the main species landed. The yields observed by the fishermen tend to increase, particularly since the strengthened control of the compliance with the limits imposed on industrial trawlers thanks to the PRAO support.

Due to the difficulties encountered in selling catches and the cold storage at landing sites, fishery products are processed through small-scale smoking at landing sites by women organized in associations. Smoking techniques are often rudimentary, requiring large quantities of mangrove wood and with potentially negative impacts on the health of communities exposed to the smoke. New types of smoking ovens using less wood and with better control of smoke emissions are currently being tested in Koukoudé with the support of the PRAO, before generalizing the modernization of the village's facilities under the project. In addition to smoking, there are some freezing facilities used particularly to stabilize products that will be exported to Asian markets where certain species such as Cobo are highly preferred.

The small-scale fishing sector in Guinea makes a significant socio-economic contribution. Regarding employment, small-scale fishing is estimated to employ more than 28,000 fishermen whose activities directly support the activities of more than 25,000 women processors and fishmongers. The processing/marketing activities are estimated to support more than 135,000 indirect jobs for fish preparation, product packaging and distribution. Globally, nearly 200,000 actors draw their livelihoods from small-scale fishing activities in Guinea. This sector is also an important contributor to the food security of the population by providing a source of protein sold at affordable prices to the poorest segments of the population, notably with the Ethmalosa and Sardinella species.

2.2.2 The Coastal Mining Sector and Oil and Gas Activities Offshore

The Coastal Mining Sector

The raw materials-related wealth in the coastlines of many West African countries offers great potential to increase government revenues and sustainably strengthen the region's economy. At the same time, extracting raw materials has considerable social and ecological consequences (a strong coastal dynamic prevails) and put the administration in front of important challenges. “States are under great pressure to conclude unfair mining contracts and markets, and to give mining companies tax incentives that they will suffer from in the long run” (OXFAM, 2017).

Various actions are being undertaken in many countries to control this mining business: developing production techniques [Guinea]; planning local development [Sierra Leone]; developing roadmaps [Liberia]; preparing strategies [Mauritania...], legislation, local development procedures, gender… [Sierra Leone], sustainable management procedures [Côte d'Ivoire]…) under the Regional Governance of the Extractive Sector in West Africa (GRSE) project (GIZ, 2019). Many coastal mining developments and extraction of sandy material for construction exist (2016-2020 period) in the countries of the West Africa region (according to the Detailed Plan 2020):

Mauritania: many prospecting (and mining) operations to extract metalliferous minerals (ilmenite) contained in the coastal sand (mainly at the level of the dune cordon) ongoing or planned along the entire coastline;

Senegal: metalliferous sand extraction sites exist in Casamance;

Gambia: material extraction sites (Kololi Point - Bald Cape sector);

Guinea-Bissau: the deposit of metalliferous sands (ilmenite, rutile and zirconium) located on the coastal dune at Nhiquim/Varela;

Sierra Leone: beach sand extraction around Freetown;

Liberia: sand extraction for construction (sectors: Manba Point - Sinkor, Sinkor - Paynesville, Paynesville - Margibi, Sopwe Town Dolota), sand mining (Greenville and Greenville-Grancess areas);

Côte d'Ivoire: sand extraction on the beach in the right of the Digboué lagoon (San Pedro urban area and western periphery), and on the beach in the Sassandra Bay, around Port Bouet;

Ghana: extraction of sandy material for construction (Bonyere-Eikwe sector);

Togo: the majority of coastal communities live mainly on sand/gravel extraction and sea fishing.

Offshore Oil and Gas Activities

In 2018, Africa accounted for 8.7% of the global oil production and holds 7.5% of the world's known reserves13. Although oil and gas activities have long been concentrated in the Gulf of Guinea and further south (with the historical producers namely Nigeria, Gabon and Angola), oil-producing areas since the 1950s, exploration and production now also involve West Africa. If all the states covered by the current "coastal assessment" are not oil-producing countries, all the coastal states of West Africa, except Cape Verde, have undertaken exploration activities over the recent 30 to 20 years on a more or less large scale. As a result of these exploration campaigns, four coastal countries have reached the production stage: Côte d'Ivoire, Ghana, Mauritania, and Benin. According to the U.S. Energy Information Administration (EIA), production in Ghana exceeded 175,000 barrels per day in 2018. The port of Tema is a major oil terminal.

Mauritania and Benin are no longer producing today, but are still subject to spill risk due to the ongoing exploration offshore on the Mauritania-Senegal border, or due to the abandoned platforms in Benin. Several drilling platforms in the Seme oil field were abandoned after the end of production and oil leaks have been observed14.

Technology developments in exploration and production techniques, such as the ability to drill deeper offshore, and soaring raw materials prices in the first decade of the 21st century, have contributed in expanding the geographic areas covered by oil and gas prospecting and production activities. Resources located in the isolated and landlocked basins, previously inaccessible, are no longer so.

As such, over the recent ten years, several major oil and gas deposits have been discovered between Mauritania and Guinea, an area known as the MSGBC basin (Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea Conakry). The recent discovery of the Grand Tortue Ahmeyim gas field, between Mauritania and Senegal, with an estimated total gas volume of 425 billion cubic meters, is a good example of this progress15.

Moreover, producing countries in the region or neighboring countries (such as Nigeria, Gabon, Congo or Angola) export more than 50% of the oil produced (Augé B., 2018), meaning that in addition to exploration and production activities, activities such as the loading and unloading of crude and refined oil, as well as increased maritime traffic also are potential risks of oil spills.

2.2.3 Marine Traffic and Port Facilities

Since the 1970s, maritime trade has gradually increased and now is between 80 and 90% of international trade. It goes on accelerating, showing a 4% increase in transported volumes in 2017 (UNCTAD, 2018b).

Developing countries have become major exporting and importing countries at global level. Although this progress highlights the strategic importance of developing countries in general as drivers of maritime trade, and reveals their growing participation in the global value chain, Africa still stands out. The relative importance of traditional African exporters of liquid and dry bulk commodities is decreasing and has only been partially offset by other sources of raw materials in Africa. African developing countries have been less successful in participating in the global value chain, but still rely heavily on raw materials exports.

13 BP 2018 statistical study based on data for 2017.

14Environmental audit of the dismantled abandoned facilities in the oil field of Seme, Benin, Environmental, technical, and financial study, V/Ref.:349/MEF/MERPMEDER/DNCMP/SP of 09/09/13 N/Réf.:101405-001, September 2015

15https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-announces-final-investment-decision-for-phase-1-of-the-greater-tortue-ahmeyim-lng-development.html

However, according to UNCTAD (UNCTAD, 2018a), although Africa's global shipping share is lower (in particular due to lack of port facilities and administrative barriers), the gap is gradually closing. Combined with increased oil production, this progress may allow the region, if sustained, to become strategically more important and to experience an increase in maritime traffic, with vessels using offshore shipping routes or berthing at African ports.

More specifically, global tanker traffic has been steadily increasing in absolute terms since the 1970s. In 2017, crude oil trade accounted for 17.5% of the growth in maritime traffic in ton-miles (UNCTAD, 2018b). However, tankers currently weigh less than they used to in total maritime traffic. In 1970, for instance, oil and gas accounted for about 55% of total maritime trade, compared to about 30% in 2017.

All the ports in this region are showing an overall increase in their traffic (Deiss H., 2019). Numerous port expansion, modernization and creation projects (trade, fishing) punctuate the coasts of West African countries, reflecting the national and international maritime transport development dynamics. Indeed, some ports are considered as hub ports that contribute to the regional trade with landlocked bordering countries. Information from the 2020 Detailed Master Plan does not provide very accurate data on the status of each project, but for the SDLAO countries over the period 2016-2020, the following 40 port projects can be cited (according to the Detailed Master Plan 2020):

- Mauritania: (i) extending the fishing port and the mineral port of Nouadhibou (ii) building the fishing port of Tanit (iii) building the port of N'Diago;
- Senegal: (i) the future river-sea mineral port (ii), extending the Autonomous Port of Dakar (iii) the future mineral port in Bargny (iv) implementing the mineral and bulk port project of Sendou and the port of Ndayane;
- Gambia: the Banjul port expansion project and port facilities;
- Guinea: (i) developing the port of Katougouma, the river ports of Dapilon, Taressaport and Kokaya (ii) extending the port of Kamsar and Conakry (iii) creating the port of Taigbé (iv) the deep water port projects on Taigbé Island, Gonzalez Island, Cap Verga, Matakang peninsula;
- Guinea-Bissau: building a fishing port in Bandim;
- Sierra Leone: the country has just started to develop a master plan for the development of its ports. Expanding the small port of Tagrin is planned;
- Liberia: (i) improving the port of Buchanan (ii) developing the port of Greenville;
- Côte d'Ivoire: (i) extending and modernizing the Port of San Pedro (ii) extending and optimizing the port space in Abidjan;
- Ghana: (i) building a free port (Bonyera-Eikwe sector) (ii) developing the Axim fishing port (iii) extending the port of Takoradi (iv) building a breakwater for the port of Sekondi (v) as part of the "Ghana Coastal Fishing Port and Fish Landing Site Project" the port projects: Moree, Gomoah Fete, Mumford (vi) building a second container port in Tema (vii) building a port in Keta;
- Togo: (i) completing the extension of the Port of Lome (ii) building and commissioning a fishing port (east urban Lomé port sector);
- Benin: extending the Autonomous Port of Cotonou and an extension on the beach (ii) creating a deep water port project (east Cotonou sector).

2.2.4 Tourism, a Major Pillar of Economic and Social Development

Tourism is a powerful factor in economic development and is considered as a driver of growth for many West African countries. Aware of these stakes, WAEMU and ECOWAS Member States are committed to making tourism a major pillar of the economic and social development. The will of developing the tourism sector was materialized in establishing in 2010 a Common Tourism Policy (PCT) and the adoption of the Regional Tourism Development Program (PRDTOUR) within WAEMU. This program aimed at strengthening the sector by 2020 through a series of incentives. By 2020, the average contribution of tourism to GDP in the WAEMU should exceed 7%, enabling to achieve 800,000 jobs in the sector. All these objectives should beef up tourism receipts to CFAF 4,070 billion (AfDB et al., 2015). The following national projects and stakes are identified in the 2020 Detailed Master Plan, although it does not give any further details on their progress:

- Mauritania: i) developing ecotourism in the Banc d'Arguin sector ii) developing discovery tourism related to the proximity of the Senegal River Biosphere Reserve (South Tiguent - Chott Boul sector);
- Guinea-Bissau: aggressive tourism in the Bijagos Islands sector is a concern;
- Sierra Leone: potential developments for tourism (Banana island sector);
- Guinea: Ecotourism developments in the marine and coastal protected area network;
- Liberia: developing tourist hotels (Robertsport sector) and tourist urbanization (North of Saint-Paul River - Right bank and Interior lagoon - Newkru town sectors);
- Côte d'Ivoire: (i) developing tourism and beach leisure (Cavally Estuary sectors - Liberia border and west Tabou sectors), (ii) the flagship project of the “Sublime Côte d'Ivoire" tourism development plan (Grand Bereby, San Pedro west sectors, San Pedro urban area and western periphery, Sassandra right bank, Sassandra left bank - Dagbego, and East Port Bouet), iii) some islands of the primary forest interesting for green tourism (San Pedro east sector), iv) a challenge for the Sassandra city (Sassandra right bank sector);
- Ghana: i) developing tourism in West Elmina (urban areas and extensions Elmina - Cape Coast - Saltpond sector), ii) the “Marine Drive Tourism Investment Project” (Accra center sector, and Wetland break Tema west Sakumo);
- Benin: building tourist camps and unauthorized fishing (Togo border sector - Grand Popo);
- São Tomé & Príncipe: the coastal strip concentrates very important economic sectors such as ecological tourism (Ribeira afonso - Lo grande and Yo Grande - Rio Lemba sectors).

2.2.5 A Road Network under Construction

Road transport remains the leading travelling mode in West Africa accounting for nearly 80-90% of interurban and interstate freight traffic (AfDB, 2012 in NEPAD et al., 2017). But this road network is deficient in most countries. The poor state of facilities hinders notably the growing and developing capacity of the African private sector, and in particular impedes the labor-intensive industry growth, which is one of the keys to promoting inclusive growth in the continent (NEPAD et al., 2017).

Today, transport costs are thirty times higher than in developed countries, and the delivery of goods on the corridors is very long with a timeframe of three to fifteen days (Coulibaly N., 2019).

Africa's economic integration is hampered by major deficiencies in its transport infrastructure. An investment of $32 billion to improve and maintain the African road network would reflect increased trade flows up to $250 billion over a 15-year period, and the main beneficiaries will be the most isolated areas

(Program on Services and Assistance Provision in Preparing and Managing the Abidjan-Lagos Road Corridor Development Project, 2017). Excerpt from the detailed Master Plans, the main national road projects and stakes are as follows:

- Mauritania: (i) building a road connecting Mamghar to the Nouakchott - Nouadhibou road; the major part of this road crosses the Banc d'Arguin National Park (PNBA)-sector MR2-a (area of high biodiversity) which may be a source of pollution and resource degradation; (ii) an all-season road from Keur Macène (Chott Boul - Ghara sector); this presence in the MR4-c sector, which encompasses several outstanding natural areas, may constitute a potential threat to biodiversity.
- The Gambia: rehabilitating the Banjul road network and building a road on a dike (Banjul Center sector). Its presence in the GM1-b sector, where Outstanding Natural Areas are noted, may be a source of degradation for biodiversity.
- Guinea: building a bypass connecting the container terminal to the highway at the entrance to the Kaloum city (Mangroves and peri-urban edges Conakry - Coyah sector). This 4 km long road, only for heavy vehicles, is located in the GN3-b sector, which may be affected by this specific traffic.
- Côte d'Ivoire: advanced degradation of the coastal highway and other roads (Grand Bereby sector). On the coastline, erosion threatens the road infrastructure (San Pedro sector, urban area and western periphery). The road connecting the bay to the Abidjan-San Pedro highway is impassable (San Pedro - Sassandra - Fresco sector). The road that runs along the beach is often cut off by marine flooding (Bassam Estuary left bank sector).
- Ghana: building the Takoradi-Agona road (urban and peri-urban sector of Sekondi-Takoradi).
- Togo: the Benin-Togo multinational project to rehabilitate the Lomé-Cotonou road (Lomé urban east port, Lomé east and Togoville-Agbodrafo-Aneho sectors). Implementing this road in the TG1-c, TG1-d and TG1-e sectors, which contain several Outstanding Natural Areas, may affect ecosystems and biological diversity.
- Benin: i) the project to develop the Fishery Road, the Slave Road, and building the Cotonou-Ouidah coastal road with bypasses in Togbin and Djègbadji (West Ouidah-Cotonou sector), ii) rehabilitating the coastal road (West Ouidah-Cotonou and West Airport to Port sectors), ii) the asphalting project of some secondary roads (Ambassadors sector) These different roads may constitute sources of degradation for the Outstanding Natural Areas noted in sectors BJ2-a and BJ2-b.
- São Tomé & Príncipe: developing a road of more than a hundred kilometers (sector Rio Lemba - Diogo nunes). It may constitute a source of threats for the Outstanding Natural Areas biodiversity of the STP2-a sector.

2.3 Economic valuation of the coastal environment

2.3.1 Cost Assessment of Degradation Related to Coastal Erosion, Marine Submersion, Flooding, and Pollution

Developing a consistent approach for estimating the impacts of environmental degradation in coastal communities is key to better understand the impacts and cascading effects, and build resilience in coastal communities. Analyzing environmental degradation provides an overview on how coastal erosion and flooding risks are intensified by this risk layer, after which governments can make informed risk decisions for coastal responses.

Figure 19 : Coastal Areas of the Four Countries Covered by the World Bank Study.

The objective of the CoCED (Cost of Coastal Environmental Degradation) analysis framework is to generate systematic and comparable evidence on the damage and economic losses related to environmental degradation at the country and pilot site levels.

The cost of coastal degradation was assessed for some West African countries in 2015 by the IMDC and in 2017 by the world Bank:

- In 2015, at the national and pilot site level for Côte d'Ivoire, Ghana, Togo, and Benin.
- In 2017, at the national level for Senegal, Côte d'Ivoire, Togo and Benin, with an overall population of 56 million and a coastline of 1,223 km (Figure 19). The coastal areas of these countries - which have been defined here as all coastal districts-are home to 36% of the countries' total population.

The IMDC work is based on the CoCED methodology for assessing the cost of environmental degradation at the pilot site or national level. The work conducted at the scale of Côte d'Ivoire, Togo, and Benin by IMDC has been repeated by the world Bank for updating with more recent costs (2017) and adding variables.

This method is a combination of more detailed methods used in OECD (Organisation for Economic Co-operation and Development) countries (using detailed information on the number of houses, buildings, or m² of area at risk) and very general models used for the analysis (using GDP/ha as a proxy).

This pooling enables a better understanding of all damages to buildings, road infrastructure, crop loss in fields, loss of farmland, loss of irrigation facilities, formal and less formal economic activities...

The coastal degradation cost assessed by the IMDC includes costs associated with:

- Coastal erosion (loss of assets over the year, loss of production over the year);
- Coastal flooding (marine submersion);
- Water pollution (waterborne diseases and untreated wastewater).

The cost of coastal zone degradation assessed by the world Bank includes costs related to:

- Coastal erosion (assets lost within a year, production lost over the next 30 years, bare land permanently lost);

- River flooding (damage to assets and economic output and mortality);
- Rainfall flooding (damage to assets and economic output and mortality);
- Air pollution (health costs, related to ambient PM2.5 pollution, in the capital cities of the four countries);
- water pollution (waterborne diseases and untreated wastewater);
- waste pollution (cost of sub-optimal municipal waste management).

Coastal flooding from seawater is not included in the analysis due to limited data. The available modeling results are mainly relevant to long-term planning.

THE COCED ANALYZING METHOD

The CoCED analyzing method consists of two consecutive steps.

At first, a coastal (multi-hazard) risk assessment is performed. The four-step risk assessment process is explained below. The risk assessment in this study considers:

1. The vulnerability of certain assets to projected sea level rise in order to exclude less vulnerable assets;
2. The probability of coastal flooding due to future climate projections;
3. The consequences of the impacts, not only in terms of what the impact would do to a particular asset, but also how it would affect the surrounding community and beyond; and
4. The risk rating of the consequence and its probability of occurrence. Risk is reflected in absolute terms (in US dollars, USD) as well as in relative terms - that is, as a percentage of countries' GDP.

1 **Hazard Assessment**	2 **Exposure Assessment**	3 **Damage Assessment**	4 **Risk Assessment**
Coastal erosion and flooding. Events with a 10, 50 and 100 year return period.	People, assets, economic productivity and critical ecosystem.	Loss of life, coastal restoration, asset-related damage, loss of assets, land, and economic productivity.	Damage aggregation: different events, types of risks, and current and projected future risks.

Four-Step Coastal (multi-hazard) Risk Assessment Process (IMDC, ND)

Second, the cost analysis of the coastal environment degradation itself, which is based on the categories of land use - namely rural, urban, economic, and natural - affected by erosion or flood hazards if considered individually or collectively as well as impacts on people and livelihoods, including loss of assets (e.g., houses, facilities) and damage to critical ecosystems (e.g., mangroves, marine habitat).

The CoCED Analyzing Method provides an accounting framework that integrates different types of information - e.g., risk profiles - and combines generic steps - e.g., damage functions - with country-specific data and information. The risk levels in the CoCED analyzing framework are able to consider context-specific vulnerabilities in the overall social, economic and natural systems. Uncertainty in the estimates can be reduced by specifying exposure and vulnerability characteristics.

The tables below present the values of the two approaches. They therefore differ naturally given the difference in the different parameters considered.

Table XIV : Cost of Coastal Degradation in USD 1 million for 2015 at the Coastal Districts of Côte d'Ivoire, Ghana, Togo and Benin Associated with Coastal Flooding and Coastal Erosion

	Ghana	Côte d'Ivoire	Togo	Benin
Estimated COED to coastal erosion and inundation				
Total (USD million/year)	47	2.1	3.6	10
Total (% of National's GDP)	0.04	0.006	0.04	0.10
Estimated COED to water pollution				
Water pollution	*	*	*	*

*Data not available

Table XV : Cost of Coastal Degradation in USD for 2017 at the Coastal Districts of Senegal, Côte d'Ivoire, Togo and Benin Associated with the Vagaries of Fluvial and Pluvial Floods, Coastal Erosion and Pollution

	Senegal	Côte d'Ivoire	Togo	Benin
TOTAL (USD million/year)				
Fluvial and pluvial floods	230	1183	10	29
Coastal erosion	537	97	213	117
Water pollution	375	485	36	53
Air pollution	17	166	23	10
Waste	90	53	28	20
Total	**1250**	**1985**	**310**	**229**
Estimated COED to coastal inundation				
Pluvial floods	77	760	4	9
Fluvial floods	134	398	5	18
Mortality due to pluvial and fluvial floods	20	25	2	3
Total (USD million/year)	*230*	*1183*	*10*	*29*
Total (% of each country's GDP)	*1.4*	*2.9*	*0.2*	*0.3*
Estimated COED to coastal erosion				
Assets lost	1	1	0.2	1
Production lost	103	16	25	35
Land lost	432	80	188	81
Total (USD million/year)	*537*	*97*	*213*	*117*
Total (% of each country's GDP)	*3.3*	*0.2*	*4.4*	*1.3*
Estimated COED to pollution				
Water	375	485	36	53

	Senegal	Côte d'Ivoire	Togo	Benin
Air	17	166	23	10
Waste	90	53	28	20
Total (USD million/year)	*482*	*705*	*87*	*83*
Total (% of each country's GDP)	*3.0*	*1.7*	*1.8*	*0.9*

At regional level, the cost of environmental degradation is estimated at around USD 3.8 billion[16], i.e. 5.3% of the GDP of the four countries in 2017. Flooding and erosion are the main forms of degradation, accounting for over 60% of the total cost. Moreover, coastal degradation causes more than 13,000 deaths per year, mainly due to water and air pollution and flooding. At national level, coastal areas degradation imposes costs ranging from 2.5% of GDP in Benin to 7.6% of GDP in Senegal in 2017.

These estimates result from three major factors affecting the coastal zone:

- Flooding due to heavy rainfall (pluvial flooding) and river overflows (fluvial flooding) causes casualties and significant damage to houses, infrastructure, and critical ecosystems, such as beaches and mangroves. Flooding is extremely damaging in Côte d'Ivoire, with an estimated cost of US$1.2 billion per year, mainly due to large areas affected by pluvial flooding. In other countries, the flooded areas and associated water depths are smaller, resulting in comparatively lower flooding costs.
- Erosion is the result of both natural and human factors with diverse situations depending on the site: in contrast to areas affected by erosion (land loss), some areas are stable while others are accreting (land gain). In Benin, Côte d'Ivoire, Senegal and Togo, about 56% of the coastline is subject to an average erosion of 1.8 meters per year. Erosion is the most damaging factor in Benin, Senegal and Togo, mainly due to the loss of valuable urban land. The highest cost, estimated at 0.5 billion USD, is related to Senegal. In all countries, the cost of erosion is expected to increase significantly in the coming years, as the phenomenon is likely to affect larger urban areas.
- Air, water and waste pollution have a significant impact on people's health and quality of life. Its cost can reach 0.7 billion USD in Côte d'Ivoire. In the four countries covered by the study, inadequate water supply, sanitation and hygiene are particularly harmful factors, causing more than 10,000 deaths per year; they mainly affect Côte d'Ivoire and Senegal, where they generate more than 4,000 deaths per country. Air pollution and suboptimal waste management are also important forms of degradation, but are considerably underestimated: the cost of air pollution (2,500 deaths) concerns only the impacts of fine particles in the countries' capital cities, while the cost of waste covers only the impacts of insufficient collection and inappropriate disposal of municipal waste.

The study shows that flooding, erosion and pollution are major challenges for West Africa's coastal zones. They cause death, reduce the quality of life of citizens, and result in considerable economic damage accounting for more than 5.3% of the GDP of the four countries. Building coastal resilience will allow reducing these damages and save billions of USD in the future for damage repair.

[16] If we adjust this figure to country purchasing power parities, we get a total loss of USD 10 billion, adjusted to PPA, year 2017.

2.3.2 Cost Assessment through Natural Capital

The overall coastal degradation cost is not necessarily quantifiable from a financial perspective. This is the case, for example, of natural capital and in particular of mangroves.

Indeed, mangrove forests are globally recognized as highly carbon-rich tropical ecosystems that provide a range of essential economic and ecological services to surrounding coastal populations. However, mangroves have been heavily affected by degradation and deforestation, with 20-35% of the global mangrove area lost in the recent 50 years. Mangrove losses in the 20th century were largely dominated by forest clearing and logging for timber and raw material production, as well as rapid coastal population growth and urban expansion.

Two mangrove-specific studies are ongoing with the support of the PROBLUE Program[17] and focus on:

- The economic assessment of ecosystem services (nurseries, carbon sequestration, flood protection) in Guinea (study carried out by the world Bank).
- The study of mangroves in Guinea and Ghana as protection against erosion and coastal flooding in Guinea and Ghana (study carried out by Deltares).

The results of these studies could be used in the next update of the Master Plan.

[17] Multi-donor trust fund within the world Bank. The objective of the fund is to safeguard healthy and sustainable oceans. The fund's activities include fisheries management, marine pollution control, sustainable development of marine industries, and integrated coastal and marine management.

3. Responses Provided: Actions Taken in Favor of the Coastline by States and Stakeholders

Considering a mainly sedimentary coastline (nearly 50% of mangrove mudflats, less than 3% of rocky coastline), confronted with climate change, marked by a strong dynamic of sediment transit, which concentrates more than 25% of the population in coastal cities, and has significant diversity of coastal ecosystems, the stakes for preserving goods, people and resources are high. The actions taken in favor of the coastline by countries, regional groupings and management organizations take several forms: institutional, regulatory, governance and protection (on-site investments).

3.1 Policy, Legal and Institutional Framework Review

The policy, institutional and governance framework for coastal risks in West Africa may be understood at different levels: national, sub-regional, regional and international.

At national level, environmental management in general, even if it is mainly the responsibility of a ministry responsible, is a cross-cutting area involving local authorities in the framework of decentralization policies. At legal level, many countries have initiated or already adopted regulations on the coast.

At regional and sub-regional levels, the Abidjan Convention covers all the countries of the Assessment, which are very concerned by Articles 10 (on coastal erosion), 11 (on specifically protected areas), 12 (on pollution) as well as its additional protocols (pollution from land-based sources and activities; environmental norms and standards related to offshore oil and gas activities; Integrated Coastal Zone Management - ICZM; Sustainable Management of Mangroves)

Also at regional level, ECOWAS has developed an environmental policy whose objective is to reverse the state of degradation of natural resources, improve the quality of the environment and living environment, and conserve biological diversity in order to ensure a healthy, productive environment, improve the balance of ecosystems, and the well-being of populations. The WAEMU Regional Coastal Erosion Control Program (PRLEC) has enabled developing the West African Coastal Master Plan (SDLAO), a basic tool for coastal risk management in the sub region and a receptacle for the WACA ResIP project, through its governance bodies, which have evolved to this end.

3.1.1 Coastal Management Policies and Projects Evolution

Evolution at Regional Level, at the West African Economic and Monetary Union Level

The community land development policy is prescribed by the Treaty of the Union, which in Articles 5 and 6 of the Additional Protocol No. II, provides for "establishing, by means of an additional act, the guiding principles of a land development policy for the Union, with a view to balancing the various components of the community territory. This policy was adopted in 2004 and has been broken down into four main lines of action, which include establishing:

- programs,
- response planning and management tools;
- a Regional Development Atlas,
- a WAEMU Regional Area Development Plan (SDER);

The objectives of the SDER are to ensure optimal development of the WAEMU area, including complementarity between the Sahel and the coast; to guide the Union's approach in the functions falling within its competence; and to serve as a reference framework to prepare and/or update, and harmonize national planning documents. It was approved by the Ministers in charge of the Regional Planning of the WAEMU Member States on 25 October 2019 in Abidjan. It constitutes the baseline for the next 20 years (Horizon 2040).

- a Regional Observatory for Space Analysis of Community Territory (ORASTEC);

  This platform will allow improving the knowledge of the territory, following its evolution and producing synthetic information which can facilitate defining, guiding, planning the actions and following-up the sectoral policies of land development and planning. ORASTEC is currently being operationalized (Annual Report 2019 on the functioning and evolution of the Union, December 2019).

The WAEMU Council of Ministers has also adopted various instruments (regulations and directives) that support these programs. Some of the instruments are listed below and relate to developing the territory, protecting its land and maritime environment and its resources, including:

- Regulation No. 05/2007/CM/UEMOA on the adoption of the coordinated development plan for fisheries and aquaculture within UEMOA - Adopted in April 2007;
- Regulation n°002/2007/CM/UEMOA on the implementation of the WAEMU regional coastal erosion control program (PRLEC/UEMOA) - Adopted in April 2007;
- Guideline n°02/2008/CM/UEMOA on search and rescue at sea and protection of the marine environment within WAEMU - Adopted in March 2008.

National Level Evolution

The projects undertaken vary from one country to another, according to the non-exhaustive information escalated by the correspondents, and can be divided into three categories since 2016 (the year of the last Coastal Assessment) for the countries in the MOLOA network and in some cases before 2016 for São Tomé & Príncipe, which has joined the process: projects contributing to sustainable coastal management, coastal development and/or defense projects, and institutional and legal reforms.

Projects Contributing to Sustainable Coastal Management

Projects related to sanitation are being carried out, such as:

- Installing a large wastewater treatment unit in Mauritania;
- the "*project to restructure the wastewater collection and treatment network of the western coast road of Dakar*" (building the wastewater treatment station) in Senegal;
- the "*Hann Bay Depollution Project*" with (i) an "infrastructure" component for the construction of a 13 km interceptor along the bay, a treatment plant with primary treatment and a 3 km sea outfall; (ii) a "supporting measures" component intended for capacity building at both the National Sanitation Office (ONAS) and the two relevant directorates: the Sanitation Directorate, which pilots the sector, and the Department of Environment and Classified Establishments (DEEC), in charge of relations with industrialists;
- Rainwater management is also addressed under the Rainwater Management and Climate Change Adaptation Project (PROGEP) with, among others, the development of the Rainwater Drainage Master Plan for Saint-Louis, Senegal;

- the "*Eni Ghana Green Beach Project"* in Ghana, aimed at improving waste collection and management;
- building a new large public waste treatment center in Guinea-Bissau;
- actions, carried out under the WACA ResIP project in Togo, to combat pollution, and manage waste in order to support the collection of household waste (with the Aného Municipality), the Lomé beach sanitation (with ANASAP) and wastewater management.

Voluntary resettlement projects are also being carried out in several areas, such as:

- in Saint-Louis, Senegal, under the Emergency Recovery and Resilience Project (SERRP);
- in the coastal area of the Sundy Praia community in the Autonomous Region of Príncipe (São Tomé & Príncipe), involving 40 family homes.

Furthermore, in São Tomé & Príncipe, the dynamics underway anticipate the extension of urbanization to safer sites, thus contributing to the reduction of the vulnerability of coastal communities and cities to extreme events related to climate change under the "*Coastal Protection, Planning and Resilient Urban Construction*" project.

Some projects are more focused on the sustainable management of coastal ecosystems such as:

- ecological restoration projects of mangroves;
- Hydraulic development and hydrological monitoring of estuarine or deltaic areas (i.e. dredging project of the Somone lagoon in Senegal for the conservation of lagoon-estuarine ecosystems; opening of the mouth of the Comoé River in Grand-Bassam in Côte d'Ivoire in order to (i) improve the renewal of the waters of the Ebrié lagoon by promoting the exchange between the sea and the lagoon (ii) assess the flows and inputs of the river to the sea during floods; protect the sandy cordon and develop the mouth of the Bandama River in Côte d'Ivoire).
- The integrated management of Marine Protected Areas, the use of Nature-based Solutions, associated with Income Generating Activities. This is the case:
    - in Mauritania, Senegal, Guinea and Guinea Bissau under the "*project for reducing the impact of infrastructural development on coastal and marine ecosystems"* (PRISE) aimed at filling technical gaps to develop sustainable infrastructure in coastal areas;
    - in Mauritania under the "Management and Conservation of Banc d'Arguin Ecosystems" project;
    - in Senegal under the Strategic Environmental Assessment of the offshore oil and gas sector in order to anticipate the cumulative impact of offshore activities and their interference with other sectors (fishing, navigation, tourism, etc.). This may include the project to establish a terminal for unloading and loading petroleum products on shores of the Mbao coast (Dakar, Senegal) by building (i) a Conventional Buoy Mooring (CBM) (ii) a Pipeline-End Manifold (PLEM) (iii) a pipeline or sea-line and (iv) a storage unit.

      Also noteworthy is the mapping of coastal and fluvial erosion in Senegal, and the coast and inland pollution mapping; as well as the second phase of the ICZM (Integrated Coastal Zone Management)/Climate Change and project which aims at strengthening the integrated climate action in Senegal and the consistency of socio-economic issues with natural hazards present in the coastal zone (Petite Côte, Saloum delta and Casamance). This can be associated with the project to support the implementation of the national strategy of "*Integrated Coastal Zone Management in Senegal"* to strengthen the application of ICZM and contribute to reducing the vulnerability of communities in coastal areas. In Benin, this also include implementing the management plans of the ACCB (Actions for Climate Change and Biodiversity): (i) Vodountô, (ii) Togbin-Adounko, (iii) Chenal Gbaga, (iv) Djegbadji-Avlekete, (v) Bouche du Roy, (vi) Lac Toho, (vii) Naglanou Forest and (viii) Adjame.The operational plan for the Nouadhibou free zone in Mauritania also falls within this framework.

- In the Gambia, the "*Enhancing Resilience To Vulnerable Coastal Areas And Communities To Climate Change Project*", which initiates mangrove studies, also aims at strengthening the livelihoods of threatened coastal communities through, among others, the provision of fishing boats.
- In Guinea Bissau, the "*Strengthening the Resilience of Vulnerable Coastal Areas and Communities to Climate Change in Guinea Bissau*" and "*Managing Mangroves and Production Landscapes for Climate Change Mitigation*" projects are being implemented.
- in Guinea, under the "*Rehabilitation of Mangrove Ecosystems and Support to the Management of the Alcatraz and Tristao Outstanding Natural Areas*" project as well as the Natural Resource Management project to develop and strengthen the management of the Rio Kapatchez, Rio Pongo, Konkouré and Loos Islands Outstanding Natural Areas protected areas.
- In Sierra Leone under the *WABICC program* for restoring degraded mangrove areas, the Western Zone Peninsula Sustainable Integrated Landscape Management project, the sustainable use of mangroves through innovative fish smoking systems.
- In Benin through investments in the Mono Biosphere Reserve for coastal risk reduction: restoring, rehabilitating and developing the Gbaga Channel, restoring and developing specific sites, managing invasive plants, revegetating riverbanks and restoring degraded mangrove formations. We can also mention the "*Integrated Marine and Coastal Zone Management*" (GIZMaC) project - Identification of ecologically or biologically significant marine areas in Donat with a view to classify the site as a Marine Protected Area.

- Completing the studies on the design of national observatories and establishing Early Warning Systems on coastal risks in Senegal, Côte d'Ivoire and Togo, The early warning project "*Strengthening climate information and early warning systems in the RDSTP by developing resilience and adaptation to climate change*" in São Tomé & Príncipe, which includes (i) transferring technologies for climate and environmental monitoring infrastructures and (ii) integrating climate data in development plans and early warning systems. This is also the case for the "Adaptation to Climate Change in the Coastal Zone Project" (PAMZC) for (i) strengthening coastal early warning systems and marine safety and (ii) coastal protection for vulnerable communities.

Coastal Development and/or Defense Projects (worksites)

- Various actions to protect the coast:
  - in Mauritania, reflected in warping breaches, fixing dunes, developing crossing structures and rehabilitating, extending the existing dike in the Chott Boul-Ghara sector;
  - in Senegal through various projects:
    - (i) A coastal cell protection project on the Mermoz coastline by installing a heavy riprap in the form of a breakwater, reinforcing the coastal part of the lower terrace with a retaining wall protected by rubble stones of 0.5 to 1.5 T, installing a drainage channel for runoff water, embanking the 40,000 m3 plateau, installing a stop wall, regrading and reinforcing the slope;
    - (ii) The "*Saint-Louis Coastal Protection Project*" (PPCS), which is a longitudinal rip rap protection along a 2,150 m linear;

- in The Gambia under the “Enhancing Resilience To Vulnerable Coastal Areas And Communities To Climate Change Project": building a 1 km revetment to secure the beach and protect the shoreline, replenishing the beach to recover part of the lost area and reduce additional sand loss;
- in Sierra Leone by building coastal defense facilities (huge stones, concrete walls, worn tires, etc.) in the Tombo-Cape Shilling area, and building a seawall to protect the island in the Sherbro-main island area;
- in Liberia under the “coastal add-on project”, completed in 2018-2019, which focuses on the protection of the coastal city of New Kru by building revetments and protective walls along approximately 1,025 m of the coast. This project also included a capacity building component for the technicians from the Ministry of Mines and Energy;
- in Ghana by implementing multiple projects:
    (i) the "*New Takoradi Emergency Coastal Protection Project*" (Phase II completed between 2016 and 2019) which consisted in installing a system of embankment groynes, rocky retaining walls with beach stabilization, for protecting approximately 4,000 m of coastal linear including the Elmina Castle;
    (ii) The “Blekusu Sea Defence Project” which enabled building 22 armored rocky groin systems aimed at protecting a 4300m coastal segment; the groin field serves as a landing site for the fishing boats, each groin measuring about 80m long with a spacing of 200m;
    (iii) The “*Komenda Coastal Protection Works*”, which enabled the installation of 3 embankment groynes;
    (iv) The “*Adjoa Coastal Protection Works*” which enabled building a rocky breakwater with two arms of about 950 meters each, building a 300m detached breakwater to protect the bay between Funko and Amanful Kumah on a linear of about 2 500m;
    (v) The “*Axim Sea Defence Project*” which enabled building an armored rocky revetment structure to protect a coastal segment of about 1500m with laterite embankment, an armored rocky groynes field system extending over about 1000m to protect the Fort Axim (Forte of Santo Antonio) and the cove behind Fort Axim;
    (vi) the “*Amanful Kumah Sea Defence Project*" by building a rip rap revetment wall that protects land and property along a coastaline of about 1,500m.
- in Togo by rehabilitating the Gbaga Channel - Dredging, rehabilitating the banks, flood control - Lake Togo/Lagoon of Aného and implementing watershed co-management plans.
- in Benin by developing:
    (i) emergency works to stabilize the beach at Gbèkon;
    (ii) works to open the mouth of the Mono River (Bouche du Roy) under the WACA ResIP project;
    (iii) building a 4 km long submerged dike and beach nourishment project at Avlekete;
    (iv) the Cotonou lagoon shoreline development and enhancement project and the East Cotonou Coast Protection Project, Phase II.

Institutional and Legal Reforms

Regarding legal aspects, implementing some coastal resilience projects such as the "*Enhancing Resilience To Vulnerable Coastal Areas And Communities To Climate Change Project*" in the Gambia also takes into account the regulatory and institutional aspects for climate risk management in coastal areas. In this country, actions are recommended to strengthen the policy framework for the integrated management of coastal zones and the protection against maritime and river risks. This is the case for Mauritania with the Nouadhibou Coastal Planning Guideline planned for 2020, the Nouakchott Coastal Planning Guideline - northern and southern sectors and the N'Diago Coastal Planning Guideline under the WACA ResIP project.

Under the Abidjan Convention, laws relating to the development, protection and integrated management of the coastline/additional protocols have been signed; the ratification process is ongoing. The laws address the (i) integrated marine and coastal zone management (ii) sustainable mangroves management (iii) environmental norms and standards for offshore oil and gas exploration and exploitation activities and (iv) pollution from land-based activities.

In Côte d'Ivoire, Law n°2017-442 of June 30, 2017 on the maritime code is enacted and addresses, among others, the following related issues: maritime, lagoon and river public domains and other maritime zones under national jurisdiction; maritime safety and security; protection of the marine and river-lagoon environment; maritime insurance and marine and lagoon fishing. Under the Sustainable Coastal Zone Management measures, the Law on Sustainable Use and Management of Sands in Coastal Zones defines and regulates the mining conditions of aggregates in coastal areas and in rivers of São Tomé & Príncipe. Some regulatory instruments are being updated in Senegal such as the Environment Code and its application decrees, the regulation on offshore oil and gas activities/Petroleum Code in order to monitor the development of oil and gas activities. The same applies to the new Policy Letter for the Fisheries and Aquaculture Development Sector (LPSD/PA 2016-2023) in order to strengthen food security, economic growth and local development.

Regarding institutional aspects, implementing some projects such as the AMCC_STP Project - Reducing Climate Vulnerability in São Tomé & Príncipe, also addresses the strengthened institutional framework and skills based on an analysis of the legislation and institutional framework of climate change in São Tomé & Príncipe and existing policies, strategies, action plans and other instruments. This is also the case for the Accelerated Adaptation in Africa Project (AAAP) - Support for Integrated and Comprehensive Approaches to Climate Change Adaptation in Africa, between 2009 and 2012, which aimed at strengthening individual and institutional capacities to address climate change hazards and opportunities by (i) building the government's technical and leadership capacities to address climate change hazards and opportunities (ii) responding at the production infrastructure level in the Lobata district (irrigation systems, sustainable agroforestry program, construction of eco-houses, etc.) and (iii) creating the Environmental Observatory. In Senegal, creating the Coastline Management Department (DGL) within the Department of Environment and Classified Establishments, whose main missions are to manage, prevent and combat all forms of coastal degradation, particularly coastal erosion, and to define appropriate action plans for sustainable coastal management.

3.1.2 Regional Protocols and Agreements of the Abidjan Coastal Management Convention

The different member countries of the Abidjan Convention made a series of commitments during COP12 in March 2017 including the signing, ratification and transposition of the additional protocols of the Convention into national laws as well as the development of action plans to implement the said protocols, namely:

- the Protocol on Environmental Norms and Standards for Offshore Oil and Gas Exploration and Production ;
- the Sustainable Mangrove Management Protocol

- the Integrated Coastal Zone Management Protocol;
- and, the Pollution Protocol due to Land-based Sources and Activities.

A summary of these protocols is presented below.

Protocol on "Environmental Norms and Standards for Offshore Oil and Gas Exploration and Production"

Exploring and exploiting offshore oil and gas resources, located on the seabed and subsoil, are activities presenting pollution hazards of the marine environment and coastal areas. During these recent decades, several States of the Gulf of Guinea have made heavy investments to develop oil and gas resources on their continental shelves.

This Protocol appears as the regional legal act that can fill these national gaps and whose purpose is to define the actions aimed at preventing and overcoming incidents, to specify the obligations of the States Parties and private operators and to assign responsibilities in order to provide appropriate, prompt and adequate compensation[18] to the victims of coastal degradation and pollution of maritime areas.

The regional integration elements in this field consist, among others, of mutual assistance in case of oil spills[19], cooperation while implementing regular monitoring programs of the facilities and the consequences of the activities on the environment[20], the implementation of collective research programs on the monitoring and continuous assessment of the marine and coastal environment[21], scientific and technical cooperation[22], mutual information sharing[23], cooperation in case of cross-border pollution[24], etc. To this Protocol are appended several Technical Appendices which are equally legally binding as the Protocol.

However, although the Protocol defined the guidelines for liability and compensation for damage to the marine and coastal environment, it has not included specific provisions on dispute settlement mechanisms.

"Sustainable Mangrove Management" Protocol

Mangrove ecosystems, accounting nearly for 50% of the West African coastline, enable to increase biological productivity, particularly in terms of animal and plant resources, providing services to the neighboring populations and serving as a natural protection of the coastline against coastal erosion. To sustainably manage these ecosystems, these States have identified the need to strengthen watershed organizations and regional networks of Marine Protected Areas under the transboundary management of shared resources[25], in addition to adopting appropriate legislation and regulations for their protection by applying principles[26] such as:

- the precautionary principle;
- the prevention principle;

[18]Protocol Offshore, Article 28
[19]Protocol Offshore, Article 20
[20]Protocol Offshore, Article 21, paragraph 2
[21]Protocol Offshore, Article 21, paragraph 3
[22]Protocol Offshore, Article 24
[23]Protocol Offshore, Article 26
[24]Protocol Offshore, Article 27
[25]Mangrove Protocol, Preamble, paragraph 16
[26]Mangrove Protocol, Article 4

- the polluter-pays principle
- the cooperation principle;
- the ecosystem approach principle;
- the right to information principle;
- the participation principle;
- the access to justice principle;
- and the information sharing on activities affecting the coastline, settlements along the coastline, and related watersheds[27], etc.

The sustainable management of mangrove ecosystems requires a strengthened legal and institutional framework[28] that takes into account multilateral and regional legal instruments, namely relevant international conventions, general principles of international law applicable to the environment in general and to the marine and coastal environment in particular, rules and principles of customary international law, decisions of international judicial bodies, etc.

To this Protocol are appended several technical appendices that are equally legally binding as the Protocol. Although the Protocol has defined the guidelines relating to the sustainable management of mangrove ecosystems, it has not planned specific provisions on dispute settlement mechanisms.

"Integrated Coastal Zone Management" Protocol

The Integrated Coastal Zone Management is a tool, mechanism, or approach to coastal or littoral management that takes into account the interface between land and sea and whose objective is to promote cooperation between the various local, regional, sub-regional, national and international institutions involved in managing and protecting coasts and the marine resources found there. This mechanism must ensure harmonizing national legislation which will take into account the transboundary nature of coastal and marine resources, preserving marine biodiversity based on the ecosystem-based management principle and structured around the general principles of integrated coastal management[29], such as:

- the complementarity and interdependence principle between marine and coastal areas, estuaries, floodplains, riverbeds and watersheds;
- the inter-sectoral coordination principle at all governance levels;
- the participation and accountability principle in the decision-making process;
- the compliance principle with the limited carrying capacity of coastal ecosystems;
- the public sea access principle, etc.

The coastline integrated approach derives its very essence from the basic principle of institutional coordination and cooperation in the actions or activities to be undertaken, through common consultation bodies and common decision-making institutions.

To this Protocol are appended several technical appendices that are equally legally binding as the Protocol. No specific provisions on dispute settlement mechanisms has been enacted.

[27] Mangrove Protocol, Article 18, paragraph 2, xv
[28] Mangrove Protocol, Article 6
[29] Integrated Coastal Zone Management Protocol, Article 6

"Land-Based Pollution" Protocol

Land-Based Pollution originates from the continents and is observed in marine and coastal environments. Generally, this source of pollution is described as all "activities and sources within the territory of the Contracting Parties which may directly or indirectly have an adverse effect on the marine and coastal environment [...], including developments which physically alter the natural habitat or otherwise result in physical alteration or destruction of habitat, emissions, discharges and releases from land-based point and non-point sources and activities [...] that originate from the territory [...] and end in the marine and coastal environment after being transported by wind, watercourses, groundwater and runoff, or buried on the seabed ..."[30].

The Protocol thus places a general obligation on States Parties to cooperate in combating this source of pollution, by adopting appropriate national laws and regulations and in accordance with their obligations within regional, sub-regional and international organizations.

To this Protocol are attached several technical appendices that are equally legally binding as the Protocol, in addition to including a specific provision on litigation by reference to Article 24 of the Abidjan Convention on Dispute Settlement.

3.1.3 Evolution of the Regional Coastal Erosion Control Program (PRLEC) bodies

WAEMU's will to combat coastal erosion and hazards led, in 2007, to the adoption by its Council of Ministers of Regulation N°02/2007/CM/UEMOA on the establishment of the Regional Coastal Erosion Control Program (PRLEC). This program is in line with the implementation of strategic focus area 1 "contributing to sustainable natural resources management for the response to poverty and food insecurity" of the Common Environmental Improvement Policy (PCAE) and aims at effectively controlling erosion in WAEMU states to preserve socio economic potentialities.

WAEMU built on IUCN and the Ecological Monitoring Center of Dakar (CSE) for the implementation of the PRLEC which covers eleven West African countries (from Mauritania to Benin). The governance system established revolves around advisory and coordination bodies including:

- **at regional level** :
  - the WAEMU Commission coordinates the PRLEC-UEMOA at regional level;
  - PRLEC-UEMOA Regional Steering Committee presided over by the State chairing WAEMU's Council of Ministers, to implement the Program's orientations and their diligent as well as effective execution;
  - PRLEC-UEMOA Regional Scientific Committee, in charge of providing a scientific and technical support to the WAEMU Commission, in the program's execution.
- **at national level** :
  - **PRLEC-UEMOA national coordination**, under the supervision of the Ministry in charge of coastal erosion, responsible for the program's execution;
  - PRLEC-UEMOA National Steering Committee, chaired by the Minister in charge of coastal erosion of each relevant State, with as mission to better define national projects and the validation of results from services and works under the program.

[30] Land-Based Pollution Protocol, Article 4 (Scope).

The governance bodies of the West Africa coastal areas resilience investment project (WACA ResIP) are largely inspired by PRLEC bodies. The WACA ResIP project is funded by the world Bank under the WACA program, built on PRLEC achievements. This program is divided into several elements:

- The WACA ResIP project, in its current phase, covers six West and Central Africa [31] countries ;
- a programmatic technical assistance (TA WACA);
- interactions with side projects financed by the Nordic Development Fund, the Global Environment Facility (GEF), the French Facility for Global Environment (FFEM), the Green Climate Fund (GCF), and others;
- the WACA platform, currently under the form of a program technical assistance of the world Bank, for a scaling-up and strengthening of the financing level, knowledge and regional dialogue.

Under the WACA ResIP project, the progress below may be noted in adapting PRLEC governance organs:

- **At regional level**, the Regional Steering Committee steers the project with the support of the Regional Scientific Committee, while WAEMU's Regional Management Unit (RMU) and IUCN's Regional Support Office (BAR) are the coordinating entities.
    - **the Regional Steering Committee** is the overarching strategic guidance and support body to policy dialogue with countries for regional integration, coordination of transboundary interventions, facilitation of resource mobilization and results assessment. It gathers representatives of regional institutions (WAEMU, IUCN, Abidjan Convention [AbC], CSE), ministers or representatives of ministers in charge of the littoral issue in countries and representatives of technical and financial partners (World Bank) involved in the WACA ResIP project. Open to the Economic Community of West African States (ECOWAS) and the Economic Community of Central African States (ECCAS), they meet at least twice a year, or more if needed.
    - **The Regional Scientific Committee** revitalized to move towards a network of national and/or regional institutions (universities, research centers, agencies, etc.) working on the coastal hazards issue with statutory and alternative representatives. It also gathers experts from West Africa littoral countries and representatives of technical partners (IGOs, NGOs, CSOs, etc.). The regional scientific committee's mandate is mainly focused on scientific and technical support in the project implementation, the scientific and technical counsel with the West African Regional Coastal Observatory (WARCO), counsel with the regional steering committee and support in the organization of scientific events on coastal hazards management thematics (coastal erosion, pollutions and floods).

The processes related to the updating of the Management Scheme for West Africa Coastal Areas (Coastal areas assessment) and to WARCO include the establishment of a Task Force (TF) and holding of Environment Ministers' meetings.

- **the TF** is an advisory platform where members can supervise processes, coordinate and facilitate reflections and dialogue, share information and align interventions between current or future sub regional initiatives. It is made-up of regional institutions' representatives (WAEMU, IUCN, AbC, CSE) and the World Bank and is open to representatives of any entity wishing to bring a contribution to relevant processes. .
- **the Environment Ministers' meetings** fall within the policy backing of processes related to coastal areas assessment and to WARCO to respond to the needs for

[31] Benin, Togo, Côte d'Ivoire, Senegal and São Tomé & Príncipe.

dialogue and regional integration. Each Ministers' meeting is preceded by a meeting of Experts.

- **At national level,** national steering committees and national project management units (PMU) supported by project national technical committees (TC), are responsible for the coordination and management of national components. Joint committees for the management of cross-border areas have been set up in certain neighboring countries.
    - national Steering Committees are the project guidance bodies;
    - project national technical committees are responsible for a proper technical coordination and commitment of all stakeholders of coastal areas management. They gather representatives of sectors and entities concerned by coastal areas management and involved in the project implementation;
    - national project management units (PMU) manage and coordinate the project with management bodies at regional level;
    - the Benin-Togo joint committee for the management and monitoring of the cross-border coastal segment and its shared ecosystems;
    - the Senegalese-Mauritanian joint committee for ecosystem restoration, coastal erosion monitoring and environmental management of offshore oil and gas activities.

The organs of the joint committees are (i) the ministerial segment which meets once a year in ordinary session, (ii) the technical committee and (iii) the secretariat.

Beside this progress, littoral regional governance has been strengthened thanks to the signature of four additional protocols to the Abidjan Convention, namely:

- the Additional Protocol on environmental norms and standards linked to offshore oil and gas exploration activities;
- the Additional Protocol on sustainable mangrove management;
- the Additional Protocol on Pollution due to sources and activities of telluric origin;
- the Additional Protocol on integrated coastal area management.

The process of internalizing these acts in the WAEMU legal corpus is underway.

The littoral regional governance positions WAEMU as a leader to coordinate collaboration and different partnerships between several regional technical institutions and organizations, countries as well as technical and financial partners.

There is collaboration since the establishment of PRLEC and this is gradually being strengthened under the WACA program in view of:

- adoption of an official agreement establishing collaboration mechanisms and specifying the role of institutions currently involved at regional level (WAEMU, AbC, IUCN, CSE, etc.);
- the adoption of a cooperation framework between regional economic integration institutions (WAEMU, ECOWAS, ECCAS)
- the integration of partner networks in the system, namely:
    - networks of parliamentarians for the environment;
    - the Regional Partnership Coastal and Marine Conservation in West Africa (PRCM);
    - the Network of Marine Protected Areas in West Africa (RAMPAO);
    - initiatives (GEF, etc.)

Role of WACA BAR (regional support office) in the implementation of WACA ResIP

Under the implementation of WACA ResIP, the International Development Association (IDA) signed with WAEMU (West African Economic and Monetary Union) a funding agreement of component 1 of the project, related to regional integration, as well as a project agreement with International Union for Conservation of Nature (IUCN).

WAEMU, which is the contracting party of component 1 on regional integration of the project, signed a subsidiary agreement with IUCN, as contracting party representative, to establish and coordinate the WACA BAR of the project. The Regional Support Office (BAR) of the project is based in the premises of IUCN in Dakar, Senegal.

The WACA BAR is established to ensure the timely execution of activities at regional and national levels. At regional level, it monitors the implementation of activities related to sub-components 1.2 (Regional coastline agreements and protocols), 1.3 (regional coastline observation) and 1.4 (Support to regional implementation) of the project regional component. It provides support in the implementation of national projects, coordinates regional technical activities, facilitates access to high level expertise, fosters know-how exchanges in fiduciary, institutional, environmental and social support to countries and supports the development of a national leadership. WACA BAR acts as technical secretariat of the Regional Steering Committee and produces consolidated progress reports (national + regional) of the project in general and component 1 in particular. Reports are submitted to WAEMU which forwards them to the world Bank.

In its support to countries, WACA collaborates with regional partners namely:

- The Abidjan Convention in charge of assisting six countries in technical issues related to compliance, ratification and implementation of regional as well as international coastal and marine protocols (see chapter 3.1.2 – Regional protocols and agreements in coastal management);
- The Ecological Monitoring Center (CSE) responsible for technical issues in terms of coastal observation and support to countries in the establishment and operationalization of coastal observation systems and early warning systems.
- The Center for Studies and Expertise on Risks, the Environment, Mobility and Urban Planning (Cerema) which provides expertise and technical assistance in coastline engineering and coastal territory planning through technical support to the six (6) WACA ResIP countries.

Role of the PMU in the implementation of WACA ResIP

The WACA ResIP project is implemented in each country by a national PMU integrated to the responsible supervisory ministry or corresponding technical agency. The national PMU of each WACA ResIP country supports the implementation of the project at national scale and coordination with BAR as well as other regional entities, including the possible management of subsidiary agreements with regional beneficiaries. National PMUs prepare annual work and budget plans (AWBP), manage procurement for the national needs of institutions, provide support to counterpart institutions in the implementation of activities at national level. They also make sure the multi-sectoral investment plan remains the mainstay of a coordinated support to allow State and financial partners responding to the most urgent needs in the field of littoral management.

3.2 Regional and technical cooperation framework

3.2.1 Regional Partnership for Coastal and Marine Conservation (PRCM)

The PRCM - Regional Partnership for Coastal and Marine Conservation in West Africa - is a coalition of national and international actors committed to conservation of the West Africa littoral.

The creation of PRCM, in 2003, was motivated by the need to enhance the global consistency of initially scattered and sometimes competing interventions, to promote opportunities for common dialogue and reflections and build the capacity of actors and institutions.

Ten years after its launch, PRCM has moved in 2012 from a program structure towards a partnership platform. Henceforth, it gathers 8 members from different types of actors, operating at different levels, from local to regional level among which the national civil society, central and decentralized governmental institutions, local representations and organizations, organizations operating in research and teaching, networks of regional and sub regional organizations, the private sector, international NGOs and financial partners.

The vision of PRCM is to "promote a healthy coastal and marine environment for the well-being of West African populations". For that purpose, PRCM operates through an extended and perennial platform fulfilling the following functions:

- mobilizing and building the capacities and skills of various littoral stakeholders;
- supporting the alignment and coordination of active interventions at regional, national and local levels;
- conducting an important policy advocacy;
- promoting work in coalition and partnership strengthening between institutions;
- Supporting the alignment and harmonization of policies and agreements;
- mobilizing resources in a sustainable manner;
- acting as mediator and contributing to capacity mobilization and dialogue between various actors;
- leveraging, capitalizing on and sharing findings from research, indigenous knowledge and good practices.

Under its mission of promoting conservation of the marine and coastal area in Africa, PRCM, since its creation, has endeavored to mobilize actors of that area and coordinate their interventions. This dynamics allowed establishing and facilitating several consultation and exchange frameworks between actors. At regional level, we may mention the creation of the Regional Coastal and Marine Forum, of regional thematic networks and several groups of actors around specific thematics. At country level, the PRCM dynamics was focused on the creation of multi-stakeholder national platforms.

The following description gives a picture of the functions of those organs and animation frameworks and a summary assessment of their achievements during the previous phases of PRCM. The Regional Coastal and Marine Forum is described in chapter " 3.5 Support in west Africacoastal areas management ".

Regional thematic networks

Regional thematic networks have an important role in the architecture and effectiveness of PRCM intervention; Their establishment is justified by the need to share information, pool experiences, harmonize procedures and methods, manage together species or shared habitats, design tools or training modules of collective interest, organize common advocacy operations, etc.

PRCM inspired the creation of several formal and informal thematic networks. The most important one is the MPA regional network, RAMPAO (Network of Marine Protected Areas in West Africa) established in 2007. Its success comes mostly from the quality of services it provides to its members. But its success also comes from the support received from political authorities of involved countries which have signed an official support declaration to the network.

Another flagship network gathers parliamentarians and local elected representatives of PRCM countries for the environment within the Alliance of Parliamentarians and Local Elected Representatives for the Protection of the West African littoral named APPEL. In the "Praia Declaration", corresponding to its birth act in 2009, parliamentarians have together made decisions to contribute to the environmental governance of the West African marine and coastal area.

The experience of RAMPAO and APPEL, as well as other networks have been supported by PRCM such as REPAO network on fisheries policies, BIOMAC on biodiversity, PREE for environmental education, GP-Sirène for shared governance or else networks of journalists for environment, allows learning some key lessons. The most effective networks are those providing services and responding to the needs of their members.

Groups of actors

Groups of actors gather different PRCM members according to their category and interest as part of the management of the West African marine and coastal area. While being a framework for the operationalization of PRCM activities, groups are the basis for the participation of different categories of actors in the governance of the Partnership and making of strategic decisions through their representatives in the Board. The following six groups have been created:

- one national civil society group;
- one group for governmental institutions;
- One group for national and local elected representatives;
- one group for fisheries professional organizations;
- one group for research and teaching;
- one group for international NGOs.

National platforms

National platforms are consultation, mobilization and action frameworks on national coastal and marine zone conservation issues (CMZ). They gather several categories of actors operating on the CMZ including state national institutions as well as civil society organizations, broadly speaking. They were established during the PRCM third operational phase 2012-2017, to enshrine at national level the PRCM objectives. They are operational in countries such as Guinea-Bissau, the Gambia, Mauritania, Sierra Leone and Guinea.

3.2.2 GI WACAF – Another look at over 10 years of technical cooperation with the region's stakeholders

GI WACAF (Global Initiative for West, Central and Southern Africa) is a joint initiative between the International Maritime Organization (IMO), a specialized United Nations institution in charge of the safety and security of navigation and marine environment protection, and IPIECA, the global oil and gas industry association for advancing environmental and social performance, created as part of the global initiative program. Launched in 2006, the aim of the project is to build capacities in preparedness and response to oil spills in 22 West, Central and Southern Africa countries, thus contributing to a better protection of the region's marine and coastal environment. The whole countries covered by the 2020 coastal assessments with GI WACAF.

GI WACAF works in close collaboration with the relevant national authorities of 22 African countries, providing its support in building their capacities in preparedness and response to oil spills. In so doing, it contributes to a better protection of the marine environment in the region and encourages the industry and governments to work together, and supports them in this undertaking.

The project activities are supported and facilitated by its dedicated network of industrial and governmental focal points. The GI WACAF regional conference, one of the many activities implemented, is a key element of the biennial project management system. Every other year, it gathers industrial and governmental focal points of the whole region to share their experiences, review the progress made and define priority objectives for the following biennial exercise. GI WACAF collaborates with national authorities to continuously adapt to the various needs of partner countries and integrate them in the work program. The project may organize different activities such as workshops or training sessions, technical consultancy missions or exercises.

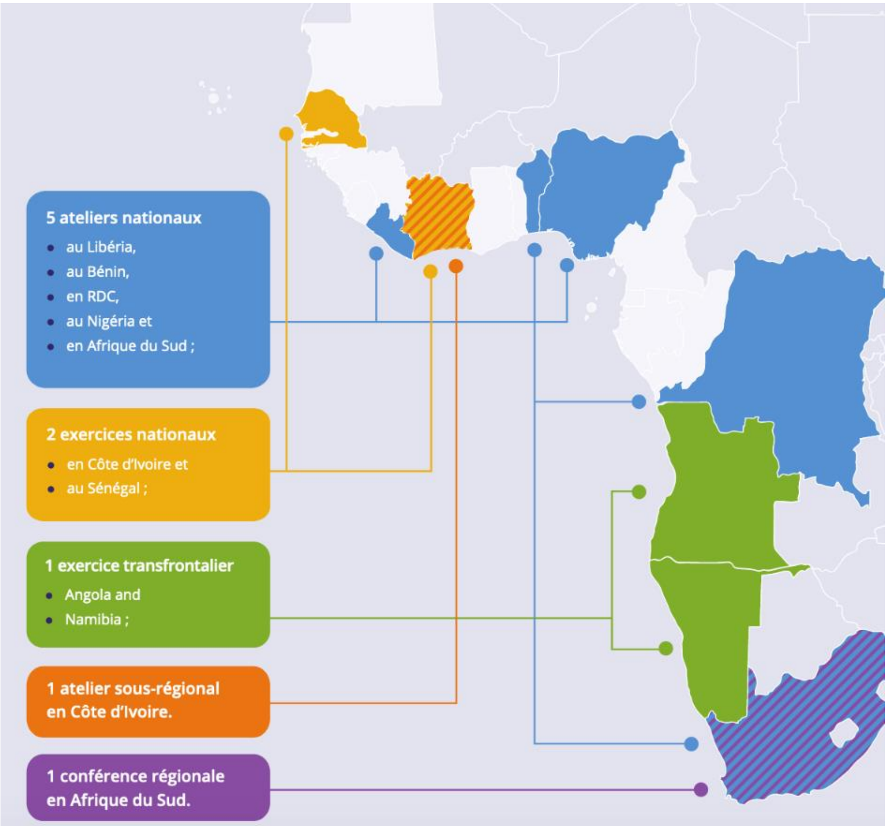


Figure 20: Activities established by the GI WACAF project in 2019

GI WACAF adopts a three-step systemic approach, which allows developing an effective national preparedness and response system against oil spills, still by building on progress achieved and by adapting to the specificities of each country:

- at first, establish a legislative and regulatory framework, basis of an effective national preparedness and response system;
- then, encourage countries to establish policies, procedures and tools to apply a legislative and regulatory framework;
- Finally, recognize the importance of cross-cutting aspects such as transboundary cooperation and the establishment of procedures to facilitate international assistance, as critical elements to a successful approach.

By contributing to the effective implementation of international agreements and relevant conventions, GI WACAF helps governments and operators reach high levels of contingency planning and then mitigate the environmental and social consequences of a large-scale oil spill. Both the industry and States benefit from this approach. On the one hand, countries build their capacities of preparedness and response to oil spills, on the other hand, the industry benefits from an improvement of the legislative and institutional framework which reduces uncertainties in regulations and enhances collaboration with competent authorities.

3.2.3 Spatial and multi-sectoral planning at regional scale

Planning the development of the West Africa's coastline calls for a dual integration challenge: spatial and institutional. Removing the political, environmental, social and economic barriers more or less affecting directly the quality of natural resources and provision of services to populations is as equally important as managing coastal and marine areas.

Some countries of the Abidjan Convention have already developed their spatial plan. Valuing the blue economy has been the entry point for spatial planning in Gabon (Blue Gabon) and South Africa (Pakhissa). Thanks to the support of the Abidjan Convention, Benin, Côte d'Ivoire and Ghana are involved in planning processes. Côte d'Ivoire has taken the option of biodiversity conservation with the creation of marine protected areas. But then, Benin and Ghana have preferred infrastructure development. Other countries which benefited from capacity building shall certainly progressively launch national marine spatial planning processes.

To better reflect protocols into action plans, ten strategic areas have been identified. We may divide them into three categories: the core business of each implementing action plan of the said protocol, investment mobilization and cross-cutting issues. From action plans results a strong and recurrent expression, on the one hand of needs to build the institutional and legal framework to supervise the littoral development and planning actions, and on the other hand needs for important investments in terms of planning and also skills improvement so as to grasp the stakes, control the management and monitoring of phenomena.

Action plans for the integrated management of coastal areas

The integrated management of coastal areas builds on the promotion and valuation of ecosystemic services of a coordinated use of the littoral as well as its resources. The action plan highlights the need to establish governance systems allowing consultation to better address and conciliate the use of resources and spaces. It includes a list of actions for the protection of the littoral as well as its resources, against telluric pollution of oil and gas exploitation, from human settlements, farming activities as well as other forms of pollution. A substantial investment is also planned for the establishment and operation of a warning, forecast as well as natural, ecological and anthropic risks system, the approach centered on watersheds and coastal areas is also promoted.

As for research actions, the lay the emphasis on the strengthening and/or creation of specialized research centers by building the capacity of centers in the different regions of large marine currents, the networking of various initiatives launched by national or regional thematic research groups on ICZM and the development of a knowledge and information management system on the coastal area.

Actions plans for sustainable mangrove management

The legal and institutional framework for mangrove management calls for a debate on the status of mangroves as a specific, fragile ecosystem which legal framework organizing its sustainable use should not be diluted in environmental and forestry instruments (codes). Thus, the action plan proposes as specific actions:

- Identifying gaps in policy documents, regulatory frameworks and national institutions;
- Producing a guidance note for the establishment of political, legal and institutional frameworks;
- Revising policy documents, regulatory and institutional frameworks;
- Identifying and analyzing the modalities of implication of the various stakeholders.
- Establishing consultation frameworks between the various national and local stakeholders;
- Harmonizing the legal and institutional framework.

Action plan for the management of telluric pollution

Four key words form the structure of the action plan on telluric pollution: pollution prevention, reduction, response and control. Actions focus, among others, on the elaboration of a baseline report on the marine and coastal environment for purposes of monitoring the quality of water, identifying pollution sources, developing an action plan to combat pollutions, complying with environmental standards and finally promoting the use of clean technologies. It is also planned to enhance the communication and awareness of actors on the necessity to preserve the environment through clean production actions.

Action plan for the oil and gas business

As regards the chemical products management system, the said protocol namely in its appendices I and II provides for two scenarios: prohibiting discharges in the Convention area and products which discharge is subject to a special authorization. A group of experts at national level will be established to evaluate applications for approval of chemical products; a robust system and process will be established to guarantee the confidentiality of HOCNF[32] and chemical compositions. Actions will also focus on the identification of bio-indicator species of the area for ecotoxicity tests; the required ecotoxicity tests; the development of robust programs of equivalence tests to compare the sensitivities of the main indicator species of West Africa and those used in the North sea (establish inter-comparison tests of toxicity test results between reference laboratories of the area of the Oslo-Paris Commission (OSPAR) and those of the Abidjan Convention area.

The global action plan recognizes the need to establish **regional sea monitoring as well as surveillance procedures and programs**. The purpose is to identify environment quality parameters, develop a program and a monitoring as well as surveillance plan, implement the program as well as

[32] Harmonized Offshore Chemical Notification Format (HOCNF). The OSPAR Commission is established to monitor substances/preparations used and spilled at sea and considered as carrying a little or no risk for the environment.

monitoring and surveillance plan and finally set-up a task force in charge of collecting data and producing reports.

Cross-cutting issues relate to:

- **Research**: Multidisciplinary teams are required to identify mangrove knowledge. Actions focus on the establishment of research requirements of mangrove areas, institutional support to researchers and laboratories to build their technical, operational and financial capacities, the establishment of thematic working groups on mangroves as well as the development of multi-disciplinary research programs. Those actions complete the creation of the mangrove observatory and establishment of a research scholarship program on mangrove-related thematics. It is also planned to train research actors on innovating issues and methodologies related to climate change and mangrove, support the establishment of scientific and technical councils within the existing networks of local elected representatives.
- **Co-management, protection, conservation and restoration:** It is one of the cornerstones of this action plan. It addresses the relationships between stakeholders, incentives, the fair sharing of profits what guarantees the effective participation of actors. Coming back to protection, conservation and restoration action, the action plan lays the emphasis at first on knowledge of what exists, its status and options of projected development. Based on that, consensual access rules will be defined. Management actions will be promoted according to the ecosystem's health and load capacity. The plan includes also the development of guidelines for mangrove reforestation and alternative income generating activities reducing the impact of anthropic activities on mangrove.
- **Mobilization of investments**: it is planned to develop and implement a mobilization strategy of internal and external resources, organize round tables of financial partners.
- **Governance**: Each action plan projects the appointment of a Focal Point of the protocol to liaise with the Secretariat and Country. It is also planned to establish a national protocol implementing committee, the ratification process as well as transposition of the protocol in the national legislation.
- **Capacity building**: parliamentarians and local elected representatives are targets in the management of coastal spaces, state institutions responsible for marine environment management as well as the civil society, research, the media...
- **Education, Information and Communication**: the constitutive elements of this component are: the resource center, communication tools and materials, targeted communication activities, partnerships between institutions, civil society organizations, schools and universities.
- **Monitoring, evaluation and learning** : Protocol implementing action plans include the following elements:
  - ✓ Specific Objective: Objectives based on different action plans developed by consultants and task forces;
  - ✓ Interim result: results in direct relation with the objective;
  - ✓ Indicator: Indicator based on the Convention's Monitoring-Evaluation framework. If no indicator seems satisfactory, a new indicator is proposed:
  - ✓ The Target is structured around the following elements: Quantity, Quality (Purpose, Target, Beneficiary), Period, Geographic Area (country, Marine Current, Zone, …) ;
  - ✓ Means of verification: data source;

- ✓ Assumption: Condition to reach the result and factor which may contribute to the non-attainment of the result.

Regional Strategic Action Plan for Investments

The Regional Strategic Action Plan for Investments (PARSI) fits into the search for a harmonized regional vision of priority investment needs to enhance the resilience of coastal communities and coastal areas, planning for their implementation and a follow-up system of investments made[33] and preparation of future investments to reduce exposure to coastal hazards. This initiative was launched in 2020 by the West African Economic and Monetary Union (WAEMU) and shall be completed by the end of 2021.

3.2.4 Analyses of the legal and institutional framework

Coastline management finds it hard to move away from a logic "of lack of harmonization of legal instruments, institutional segmentation, centralized and top-down governance".

Development strategies have often and for a long time overlooked the value and interest of the littoral perceived as a "separate" space or for the exploitation of only private entrepreneurs.

Because of the diversity of situations and stakes, combined with a certain economic comfort for some territories, the whole political and economic actors of the littoral did not seek so far a common strategy. The runaway population growth, industrial development and more generally the economic impetus of the littoral have not been controlled (ports, power plants, mining and oil permits, integrated resorts... etc.).

This favors the degradation of the littoral, more visible in big cities. Faced with pressures on the littoral, establishing procedures or more or less authoritative regulatory bodies may hide the lack of a global policy.

Yet, such actions though indispensable turn out to be insufficient and many reports highlight the need for a new vision in the development policy of the littoral. Among other considerations, the need for a new governance seems to be critical.

Then, it seems that the only possible effective and modern way is to implement a participatory legal and institutional reform to achieve an Integrated Coastal Zone Management (ICZM).

This integrated management is, in legal and operational terms, the way selected by many countries[34] having vulnerable marine and coastal areas and comprising natural resources (hydrocarbons, mines, fisheries, tourism…etc.), for the sustainable development of this space.

Recent works on the legal and institutional framework of coastal areas management in the Region (Bonnin M. et al., 2013, 2014, 2019; Bonnin M., Le Tixerant M., et al., 2016; Bonnin M., Ly I., et al., 2016; Le Tixerant et al., 2020; Le Brun O. et al., 2020) allowed notably underlining :

[33] Investments: physical (works, urban planning,), social, strengthening activities of institutions and governance systems, preparation of law instruments and coastal policies, spatial planning, coastal observation system.

[34] Côte d'Ivoire (littoral act of July 2017), Benin (littoral act of July 2018), Kingdom of Morocco (littoral act of July 2015).

- **errors, anomalies, inaccuracies or inconsistencies in geographic limits** :
  - ✓ " In Guinea, one of the geographic points allowing to delineate the MPA (Marine Protected Area) of Tristao (Decree n° 2013/037/PRG/SGG, on the creation of Tristao managed natural reserve) is located in the neighboring country, in Guinea-Bissau.
  - ✓ In the case of the Langue de Barbarie National Park of Senegal, the challenge originates from the fact that the environment having strongly evolved with the opening of breaches in the sandy barrier of the littoral (Durand, Anselme, Thomas, 2010), the official park delineation is no longer relevant today. Those anomalies and inaccuracies could lead to legal consequences in case of conflicts on uses of spaces and/or legal actions. A modification of erroneous or obsolete instruments is then to be expected" (Extrait de Le Tixerant et al., 2020).
  - ✓ The existence of a "grey zone" between the maritime borders of Cape Verde, Senegal and the Gambia.
  - ✓ « […] we may also mention the issue of the maritime border between Guinea and Sierra Leone. Set in Guinean law by decree dating from 1980 (parallel 9°03'18''N), this delineation raises a question, because it seems to be far from the virtual equidistance line which could have been considered according to the Montego Bay convention and thus deprives Guinea of nearly half of its potential Exclusive Economic Zone. An agreement between both countries was signed on March 24, 2012 according to the press (agreement not reached under this research), but the fisheries development and management plan of 2013, like the one of 2011, confirms the south border established by the 1980 decree. » (Extract from Le Tixerant et al., 2020).
- **inconsistencies and incompatibilities between legal provisions** :
  - ✓ "For instance, the inconsistencies between the international border law, between Senegal and Guinea-Bissau, and the national Senegalese law on maritime fishing. The agreement of October 14,1993[35] put an end to the dispute between Senegal and Guinea-Bissau concerning the definition of the sea border through the creation of a maritime border for cooperation and exploitation of its resources. A protocol[36] established a Management and Cooperation Agency between Senegal and Guinea-Bissau (AGC) for the management of this common zone of mining and oil resources, on the one hand, (governed by Senegalese legislation) and fishing resources, on the other hand, (governed by Guinea-Bissau legislation). Yet, Decree n° 2016-1804 (introducing enforcement of Law n° 2015-18 on Maritime fishing code) seems to overlook those provisions which shall be addressed by the next update.
  - ✓ Uneasy complementarity of rules from different ministries in a multipurpose context in the Lévrier Bay in Mauritania: economic activities (mineral port, port dedicated to hydrocarbons, fishing port, small-scale fishing and aquaculture activities) get along with sites with high environmental stakes (White Cap reserve, Star bay, Banc d'Arguin National Park). This tangle of sectoral regulations hinders an effective and efficient application of regulatory actions by local actors.

[35] " A management and cooperation agreement between the Government of the Republic of Guinea Bissau and the Government of the Republic of Senegal" signed in Dakar on October 14, 1993 by both Heads of State.

[36] "Memorandum of Understanding on the organization and functioning of the management and cooperation agency between the Republic of Senegal and the Republic of Guinea-Bissau", signed in Bissau on June 12, 1995.

- **Gaps in littoral governance,** as highlighted in Mauritania (Créocéan & CSE, 2021) :
  - ✓ The poor use of strategic and legal tools namely because of the operationalization tools of conceptual instruments. Indeed, the PDALM has segregated the use of the littoral by taking into account principles of land use and function, but to apply those measures, it referred to more practical tools such as the Coastal Development Guidelines (CDG)[37]. CDGs are operational tools allowing a better organization as well as a harmonious and integrated development of socioeconomic activities of each zone of the coast depending on its specificity.
  - ✓ Poor compliance with regulatory standards: standards are often mentioned in scopes of work appended to Temporary Occupation Authorizations (AOT) of the Public Maritime Domain and in the Environmental and Social Management Plan. Requirements in contractual documents are too often disregarded.
  - ✓ Dysfunction of inter-sectoral coordination organs: Total absence of inter-sectoral coordination as provided in legislative instruments, such as the National Environment and Sustainable Development Council (CNED), the Regional Environment Council (CRED), the CNED Technical Committee (CTED), The National Fisheries Advisory Council (CCNADP), the National Coastline Advisory Council (CCNL), the shoreline commission… Additionally, environmental information is not disseminated from one body to another, and as a consequence, departments meet only in case of serious situation.
  - ✓ There are two causes to overlapping of responsibilities, namely: (i) overlapping[38] of instruments like for instance the Public Maritime Domain management (decree DPM n°92/2006 and ordinance n°2007-037 of April 17, 2007) (ii) the Ministry of Environment and Sustainable Development which does not communicate enough on instruments setting its missions and powers[39], what leads often to a duplication of competencies with sectoral departments.

Those anomalies and inaccuracies could bring about legal consequences in case of uses of space and/or legal remedy. A modifications of erroneous or obsolete instruments is then to be expected. Also, considering the interest of the cartographic representation of marine and littoral environment law (see box below) it would seem relevant to extend it to the whole West African countries, what would bring better legibility than the systematic listing of regulatory and legislative instruments.

[37] CDGs are operational and sectoral variants of PDALM.

[38] PDALM 2017 § 9.3.8. Main institutional stakes - Stake 1 - Fragmentation of institutional competencies.

[39] Decree of 057/2014/PM setting the powers of the Minister of Environment and Sustainable Development and organization of the central administration of its department.

CARTOGRAPHIC REPRESENTATION OF MARINE ENVIRONMENT LAW

As part of the "CARTOREG West Africa" project launched in 2012 by the Sub Regional Fisheries Commission (SRFC) in collaboration with the International Union for Conservation of Nature (IUCN) under a larger program concerning Marine Protected Areas, a joint reflection was undertaken on the methods and processes of a "marine spatial planning" in West Africa. Among the tools available to organize optimally sea activities taking into consideration local populations, the cartographic representation of marine environment law in Wes Africa were studied. These first works allowed defining a methodological, generic and replicable approach, for the production, development and sustainability of cartographic atlases of marine and coastal environment law in West Africa. This pertinent approach favors a bottom-up understanding (synthetic vision) and allows highlighting anomalies and legal inconsistencies which, if addressed, could facilitate the implementation of an **informed and optimized planning of the marine space through a cross-cutting approach in a multi-activity, multi-sectoral and multi-scale context**.

One first phase of works allowed producing a cartographic atlas on the marine and coastal environment law in **Mauritania**, in **Senegal** and in **Guinea** (Bonnin M. et al., 2013). In 2016, a second phase targeted **Cape Verde** (Bonnin M., Le Tixerant M., et al., 2016). Under the international research project PADDLE also coordinated by the French Research and Development Institute (IRD), an update on the Senegalese marine and coastal domain (Bonnin M. et al., 2019) was made.

The Atlas reviews most of the environmental issues related to marine and coastal environment protection. As regards the form, methodology or structure, the Atlas is fairly simple and very didactic to facilitate the reading and general understanding of issues to be reviewed. At first, it is the status of international law on marine environment protection which was reviewed, both as regards multilateral, regional or sub regional instruments and relevant national legislations of Senegal.

From this viewpoint, several States have adopted national legislations to address marine and coastal environment protection, including the littoral. Besides, the issues subject to research in the Atlas elaborated for Senegal are almost similar to those found in the whole Guinea Gulf coastal states. Then, it would be interesting to study, under the project of elaboration of an Atlas for the whole countries covered by SDLAO, maritime activities or services, which have direct or indirect impacts on the marine, coastal and littoral environment of concerned States. Indeed, the Atlas to be elaborated could review issues on maritime fisheries, mining exploration and exploitation and sand extraction, offshore oil and gas developments, urban planning and resort tourism, port developments, sea discharges, tellluric marine pollutions, accidental or operational marine pollutions due to vessels, etc. One may add in this Atlas issues on dispute resolution systems, the definition of systems of punishment and indemnification or environmental damage compensations.

One may maintain this Atlas structure, even if as the state of play proceeds in each State concerned by the project, to remove sections or chapters not relevant for the purposes of a review.

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3.3 Investments for coastal hazards protection and reduction

3.3.1 Overview of coastline protection solutions

3.3.1.1 *Solutions for protection and coastal hazards reduction*

The systematic building of coastal protection and development works has been, until recently, a preferred response to coastal erosion and flooding. Then, progressively, soft engineering solutions are frequently mentioned as more environment-friendly solutions, because they work with nature to protect the coastline rather than interfering with natural processes. They have been considered as a paradigm shift in coastal protection and risk reduction compared to traditional hard engineering solutions which involve exclusively structural features such as dikes and breakwaters (Pontee et al., 2016). Soft engineering tries to have a beneficial influence on coastal processes and, as such, improve the service level provided by a maritime defense or coastal protection work. It uses ecological principles and practices, and has a lesser impact on natural environment. Implementing and maintaining soft engineering is cost-effective and creates a longer term sustainable solution than hard engineering projects.

The assessment of coastal hazards through CHW shows that the main identified hazards and related risk level in West Africa are: floods (very high risk), erosion (very high risk), progressive floods (high risk), as well as salt water intrusion (high risk). Regarding ecosystem disturbance, although findings show a medium risk, the extent of other hazards will, in the end, damage the ecosystem integrity where hazards occur, and the current result must not be treated as unimportant. Considering those risks, management options are advocated to preserve the coastal space (Appelquist L. R., 2016). They have been pre-selected thanks to a coastal hazard wheel matrix. The matrix shows how the most commonly used options apply to different coastal environments and what types of risk they mainly manage. These options may focus on one or several hazard types and may be used separately or as combined actions.

The identified management options for 8 countries to which the methodology was applied are all identical: 24 options are identified for the Gambia and Cameroon, while 23 options are identified for Senegal, Guinea, Côte d'Ivoire Ghana, Togo and Benin. This is due to a high level of similarity in geophysical parameters of those countries, what is reflected by similar types of coastal classification, and then by similar potential management options.

In collaboration with national focal points during regional workshops, management options have been selected and classified. The following criteria have been used to set priorities (Global CAD et al., 2019) :

- Capacity to respond to most of the hazard combinations;
- Showcase "no regret" options prioritizing first "soft" before "hard" engineering options;
- Alignment on countries interest to focus on ecosystemic management options.

As a result, 8 highly priority management options (Table XVI) were validated and confirmed during the regional online workshop held on October 9-10, 2019 with WACOM Focal Points, and classified during the regional meeting held in Dakar on November 27-28, 2019.

Table XVI : Coastal hazards management options classified by priority order

PRIORITY N° (SCORE)	MANAGEMENT OPTION	DESCRIPTION[40]
1 (10.00)	Wetlands restoration	Wetlands restoration may cover activities such as the restoration of shallow and intertidal aquatic habitats, the rehabilitation of previously existing functions, as well as maintenance of the current coastline position (different from realignment).
2 (8.67)	Coastal zoning	Division of coastal zones into areas which may be assigned different objectives and use restrictions.
3 (8.60)	Ecosystemic management	An environment management approach which recognizes a whole range of interactions within an ecosystem, including human beings, rather than considering separately issues, species or ecosystemic services.
4 (8.00)	Dune rehabilitation	Natural or artificial dune restoration from a rather degraded functioning state, to a less or non-degraded state, to gain the greatest benefits in terms of coastal protection.
5 (7.25)	River sediment management	Holistic management of water courses sediments supply until the coast, taking into account the whole human activities in the watershed.
6 (6.40)	Dikes	Dikes are used to protect low coastal areas from floods by sea under extreme conditions. But they are not intended to preserve beaches which may be found before the work or any other unprotected adjacent beach.
7 (6.25)	Beach nourishment	Beach nourishment is a soft engineering approach to coastal protection, which implies adding artificially appropriate quality sediments in a beach zone which has a deficit of sediments.
8 (5.20)	Breakwaters	Separate or sea breakwaters are works parallel to the shore located off the surf zone and designed to intercept and reduce the energy of waves surfing on the shore.

For each strategic technological option selected, the following aspects have been developed:

- Technology definition;
- Technology description;
- Advantages;
- Inconveniences;
- Qualitative estimations of costs and financial needs;
- Required institutional and organizational capacities;
- Factors hindering its implementation;
- Factors promoting its implementation;
- A case study.

40 Based on the definition described in the coastal hazard wheel catalogue.

Table XVII and Table XVIII identify the whole hard and soft solutions existing and deployed in West Africa for shoreline management. Further down in the chapter, examples at regional level are given.

Table XVII : Hard engineering solution (Alves Rodrigues B. et al., 2020)

SOLUTION	CHARACTERISTICS	ADVANTAGES	DISADVANTAGES	WHERE APPLIED IN WEST AFRICA
Offshore breakwater *shore-parallel hard engineering protection structures situated just offshore of the surf zone*	Intercept and reduce incoming wave energy at the shoreline	Reduces coastal erosion Requires basic monitoring and maintenance Construction of shorter breakwaters in series allows some wave action at the coast, which can be beneficial for recreation	Expensive Requires high level of technical knowhow Understanding of the area's wave transmission is required	Togo – between Kpeme Gumukope and Aneho Abidjan (Côte d'Ivoire) Benin
Groynes *narrow, shore-perpendicular generally solid and durable hard structures designed to interrupt longshore sediment transport thereby trapping a portion of the sediment which is otherwise transported alongshore.*	Commonly located on drift-aligned coasts where erosion problems are generated by gradients in the longshore transport Dimensions between groynes length and spacing generally varies from 1:4 on sandy beaches to 1:2 on gravel beaches Length should be approximately 40-60% of the average surf zone width	Material selection can be tailored to local availability Ideally designed groyne field allows sediment to accumulate and eventually bypass the buried groyne, without causing significant downdrift erosion Trap sediment which widens beach width for recreation and tourism Reduced erosion and greater wave energy dissipation	The ideal design is rarely achieved, hence having negative impact on downdrift coastlines through sediment starvation and erosion further downstream Relatively expensive, depending on material used for construction.	Keta, Sakomono, Ada, New Takoradi, Elmina –Ghana Cotonou – Benin Senegal (Petite Côte) Nigeria
Jetties *hard structures constructed on the banks of tidal inlets and river mouths designed to trap a portion of the longshore sediment transport, thereby stabilising the inlet and preventing siltation of the channel*	Typically larger and also extend to greater offshore distances than groynes Constructed from a wide variety of materials including rock armour, concrete, dolos, tetrapods and steel piling	Ensure robust and reliable stabilisation of tidal inlets or river mouths Control the development of unwanted features which obstruct open channel to the sea	May not allow beach formation Aesthetically displeasing	Takoradi harbor, Elmina – Ghana Cotonou – Benin Bight of Benin
Revetments *Designed to dissipate and reduce wave action at the boundary between the sea and land*	Generally very solid, durable, shore-parallel, sloping structures, constructed landwards of the beach Typically protect a soft landform (dune area, coastal slope, dike or seawall) Materials used include logs, wood planks, fence rails, fascines, gabions, hurdles, sods, or stones.	Reduces coastal erosion	Aesthetically displeasing Choice of materials affects durability	Jamestown, Labadi – Accra (Ghana) Saint-Louis (Senegal) Grande Corniche, Dakar - en projet (Senegal)

SOLUTION	CHARACTERISTICS	ADVANTAGES	DISADVANTAGES	WHERE APPLIED IN WEST AFRICA
Seawalls *designed to prevent sliding of the soil, while providing protection from wave action*	Built parallel to the shore Usually used in areas where further shoreline erosion will result in extreme damage	Prevent further erosion of the shoreline Act as coastal flood defences Vertical seawalls take less space hence, reduce construction cost	Not permanent solution to coastal erosion General reduction of available sediment in the coastal cell Down-drift erosion Basal scour Beach down-draw Affects accessibility to the sea	Rufisque, Diokoul (Senegal) Keta (Ghana)
Dikes *Designed to have a high volume, which helps to resist water pressure, sloping sides to reduce wave loadings and crest heights sufficient to prevent overtopping by flood waters*	Sloped seaward edge and crest heights Geotechnical stable under normal and extreme conditions	Greater wave energy dissipation and reduced wave loadings on structure Enable economic and socio-economic activities at high water levels	Requires large volumes of building materials – expensive Construction requires significant areas of land	-
Storm surge barrier/closure dam *Capable of protecting tidal inlets, rivers and estuaries from occasional storm surge events*	Can be movable or fixed barriers or gates Surge barriers are movable or fixed barriers or gates which are closed when an extreme water level is forecast Closure dams are fixed and permanently close off a river mouth or estuary	Effectively reduce the height of extreme water levels in the area behind the barrier Reduce both construction and maintenance costs for defences on the landward side of these structures	High capital and maintenance costs Movable barriers also require simultaneous investment in flood warning systems Can cause flooding on the landward side of the barrier when river levels are high or remain closed for extended periods	-
Land claim (or reclamation) *to create new land from areas that were previously below high tide for agricultural or development purposes*	More aggressive form of coastal protection	Gain of additional coastal land for agriculture or development purposes	Causes the direct loss of intertidal habitats such as salt marshes, intertidal flats and sand dunes Increase the tidal range upstream Can introduce contamination to the coastal zone and acidification of coastal waters.	Keta project (Ghana)
Cliff stabilisation *smoothing and regrading of sloping soft rock coasts to stabilise the coastline*	Natural processes to protect the shoreline against flooding and erosion May involve the addition of extra sediment from other sources	More sustainable and sometimes cheaper Improved public safety Maintains the amenity value of these areas	It interferes with the natural coastal dynamics Smoothing and regrading of slopes causes land loss May cause erosion in the long run	-

Table XVIII : Soft engineering solution (Alves Rodrigues B. et al., 2020)

SOLUTION (NAME)	CHARACTERISTICS	ADVANTAGES	DISADVANTAGES	WHERE APPLIED IN WEST AFRICA
Beach nourishment *involves beach recharge, beach fill, replenishment, re-nourishment and beach feeding*	Rebuild and maintain the sandy beach for wave energy dissipation	Accentuates wave energy dissipation Preserves the aesthetic integrity of the beach	Does not provide a long-term solution. Repetitive nature of this method makes it expensive	The bar beach of Victoria Island in Lagos (Nigeria) The beaches of Banjul and Kololi (Gambia)
Dune construction/rehabilitation *creating structures to mimic the functioning of natural dunes*	Restore natural or artificial dunes from a more impaired to a less impaired state of overall function	Reduces both coastal erosion and flooding in adjacent coastal lowlands	Expensive Not appropriate for places with high wave energy	Nouakchott (Mauritania)
Wetland and mangrove restoration *rehabilitation of previously existing wetland functions from a more impaired to a less impaired state of overall function*	Water quality and climate regulation Accumulation sites for sediment carbon and nutrients Provide vital breeding and nursery ground for a variety of birds, fish and mammals	Can be re-established while maintaining the present coastline position through vegetative transplants from healthy marshes Can reduce or even reverse wetland loss as a result of coastal development Relatively cheap	High soil salinity can make the approach disappointing Climate change may affect the approach	Island of Djirnda in Saloum (Senegal) Gagué Sharif in Sine (Senegal)
Fluvial sediment management *Holistic management of sediment supply from rivers to the coast, taking the full range of human activities at river basin level into account*	Encompasses a holistic view of a whole river basin and downstream coastline to find best means to manage fluvial sediment	Minimises coastal erosion and land subsidence Maintaining fertile lands, often in delta areas for agricultural purposes	Requires highly specialised expertise and collaboration between range of different institutions	

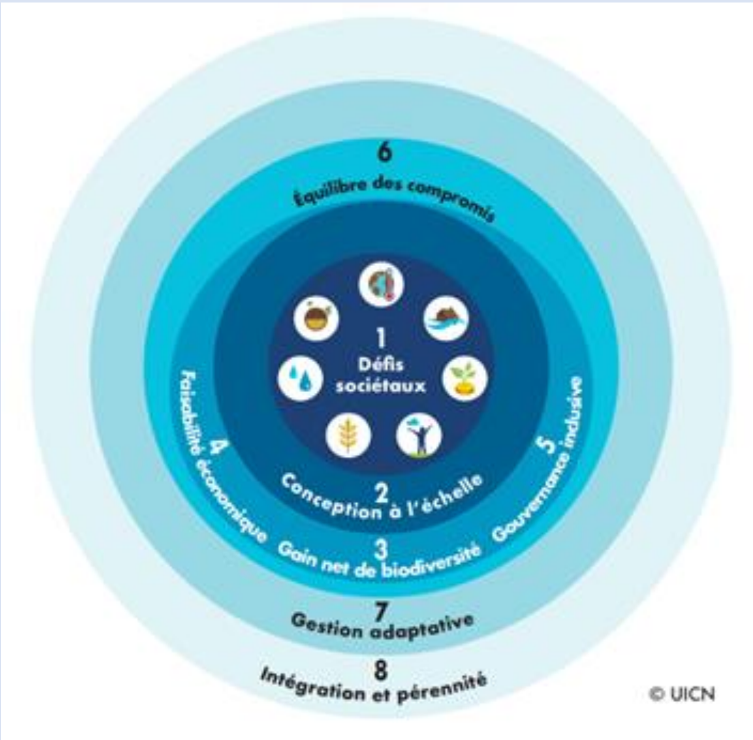
NATURE-BASED SOLUTIONS

The International Union for Conservation of Nature defines Nature-Based Solutions - NbS as actions aiming at protecting, sustainably managing and restoring natural or modified ecosystems, to directly meet in an effective and adaptable way the stakes of society while ensuring human well-being and advantages for biodiversity (UICN, 2020).

Since its emergence, the concept has regularly been associated with various coastal protection interventions such as the dune revegetation or restoration without this always producing benefits to the society as well as nature. To clarify and specify what this concept implies and the required conditions to profit at best from the potential of NbS in response to the various societal challenges and namely the reduction of coastal hazards and climate change, IUCN launched in 2020 a Global Standard for NbS.

The Standard comprises 8 criteria and 28 indicators. A self-assessment tool has been designed so that users of the standard can calculate the adequacy standard of their intervention compared with the 8 criteria and determine if they comply with IUCN global standard for NbS. The main target users of the Standard are: national governments, local governments and cities, developers, enterprise financiers, financial institutions such as development banks and non-governmental organizations.

IUCN's Central and West Africa Program (PACO) coordinates in collaboration withe the Global ecosystems management program (GEMP) a capacity building process for West Africa marine and coastal management actors on the Standard.



The eight criteria of IUCN global standard for NbS (UICN, 2020)

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Institutions : **International Union for Conservation of Nature**

3.3.1.2 *Mapping of West Africa region projects in response to coastal area degradation challenges*

Despite the significance of coastal erosion-related issues, budgets made available by countries still do not seem to meet the needs to combat the phenomenon. Infrastructure building is often the action taken (rocking, dike, tetrapods, etc.), but littoral ecosystems conservation is also required, as well as a planning of coastal area occupancy.

Nevertheless, many coastal hazards protection and reduction projects (grey infrastructure, soft solutions, etc.), under the aegis of various donors, are currently being implemented in West Africa coastal countries. Nonetheless, the analysis of projects submitted here is not comprehensive, based on the major projects reported (in relation with focal points in countries) as part of the update of the detailed management scheme. Under these circumstances, the situation is mainly addressed at regional level. Apart from Senegal, for which information on 11 projects have been collected, the analysis will be made on regional projects and on a comparison of national projects at regional level.

Regional projects almost involve the whole Senegal. But Guinea-Bissau, Guinea, Togo and Benin are also the most frequent beneficiaries. MAVA Foundation is the most active in the traditional 7 operating countries (Mauritania, Senegal, Cape Verde, Guinea-Bissau, Guinea, Gambia and Sierra Leone) with funding comprised between 1 and 5 million euros. The most frequent thematics are: coastal resources management, Marine Protected Areas (MPA) creation of management and climate change adaptation.

Concerning national projects, out of 11 projects counted in Senegal, World Bank, European Union and AFD are the most active with variable financing, mainly on population resilience, the creation of income generating activities and climate change adaptation above all centered on the Saloum Delta and in Saint-Louis.

As regards other countries (from Gambia to Benin, plus Mauritania), the number of projects, varying between 1 and 3 projects per country for a total of 19 projects, is too low to allow making an analysis per country. The following short analysis is then made globally over the whole countries. Between the lowest financing amounts and those of over 50 million, there are not real trends emerging: we have all kinds of financing. For donors, the GEF and MAVA are the most active with respectively 7 and 6 national projects financed. Finally, the most often financed thematics are Marine Protected Areas creation or management, population resilience, mangrove restoration/conservation and infrastructure building to respond to coastal erosion.

Despite the fact that collecting information on projects underway in the coastal area has been challenging and that information provided here are not comprehensive, we may nonetheless notice mobilization from donors to face the challenges of coastal erosion and coastal ecosystems conservation.

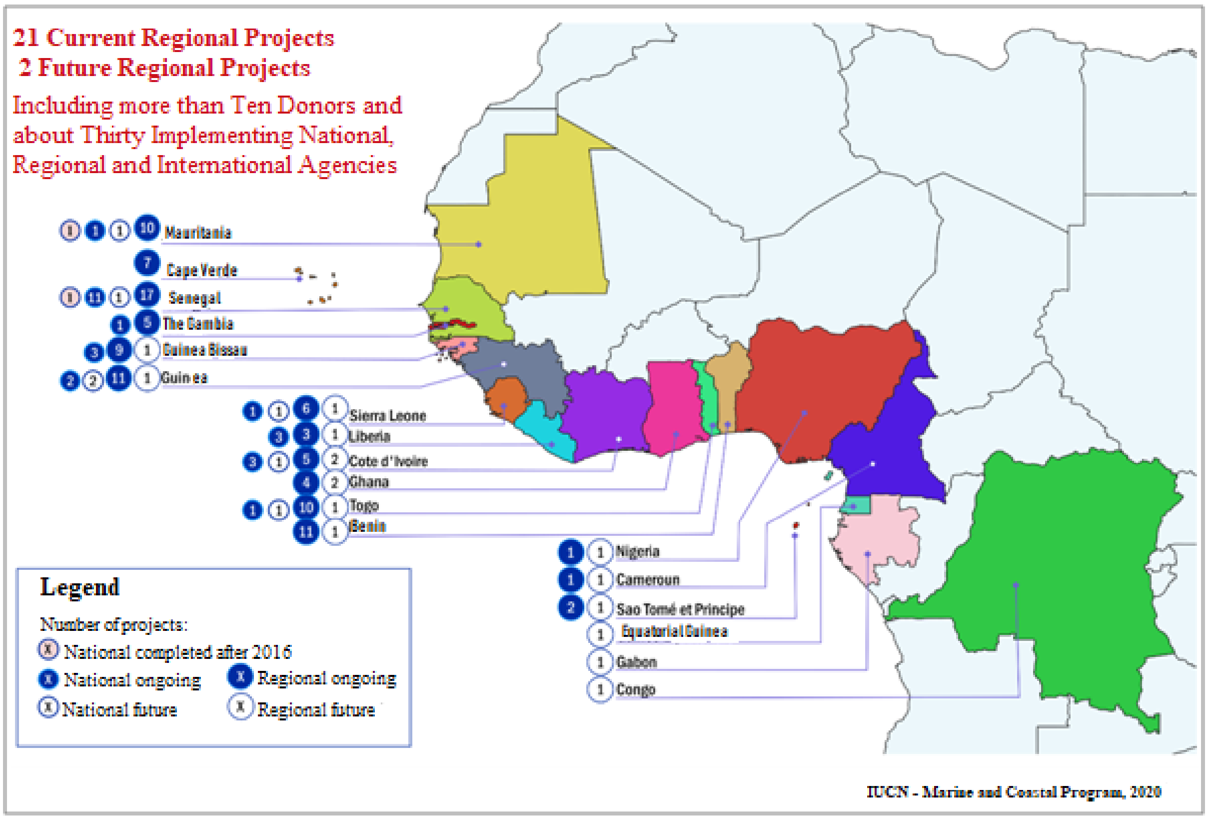

Figure 21 : Map of West Africa coastal projects

Projects with significant amounts financed by the world Bank and GEF are complemented by other financing from MAVA, FFEM of the European Union to the most targeted activities. In priority, financing is directed towards improvement of population resilience, coastal ecosystems conservation (Mangroves and MPAs) and climate change adaptation.

It seems fairly relevant to maintain this data collection and update a database on the sector's projects and the types of responses they provide to better direct investments in favor of communities resilience and ecosystems.

REGIONAL PROJECTS

Several initiatives are underway in West Africa to face risks related to hydrometry and climate change, for all countries, including those with vulnerable coasts. These initiatives will be reinforced by WA-CIFI EWS and include, among others, the following initiatives:

The Natural Disaster Risks Reduction Program

This (ACP-EU NDRR) **program** provides support to the development:

- of an ECOWAS floods management strategy;
- of ECOWAS Hydrometry initiative which is an investment plan capturing the priority needs of weather, hydrological as well as risk reduction and reconstruction services in the West Africa sub region.

The World Bank and ECOWAS implement this program.

The West Africa Coastal Areas Management Program (WACA)

This program which covers six West African countries: Mauritania, Senegal, Côte d'Ivoire, Togo, Benin and São Tomé & Príncipe, aims at enhancing the resilience of communities and targeted coastal areas.

The investment project in resilience is carried out under the West Africa coastal areas management program (WACA) and is steered by beneficiary countries. Studies carried out focused on:

- The cost of coastal degradation (Benin, Côte d'Ivoire, Senegal and Togo) ;
- Sedimentation and coastal erosion (Benin, Senegal and Togo) ;
- the evaluation of human interventions and climate change on West Africa sedimentary stock;
- the evaluation of the degradation cost of coastal environment;
- Investment plans for climate change adaptation (Benin, Togo, Côte d'Ivoire, Mauritania) ;
- the economic analysis of actors and policies (Ghana, Togo, Benin and Côte d'Ivoire).

In line with the Dakar declaration, the project currently studies the bases for the creation of a regional West Africa coast observatory and has started making diagnostics of some national institutions.

The West African Economic and Monetary Union (WAEMU) implements this project by collaboration namely with the following organizations: the Abidjan Convention, the Ecological Monitoring Center (CSE) of Dakar and the International Union for Conservation of Nature (IUCN).

Projects to Reduce the Impacts of Infrastructure on Coastal Ecosystems in West Africa (PRISE 1 and PRISE 2) – period 2019-2021

PRISE 1 and PRISE 2 projects aim at filling the gaps concerning the development of sustainable infrastructure in West Africa coastal areas.

PRISE 1 project managed by Wetlands International Africa is focused on the formulation and update of planning, management and capacity building tools. It is implemented in Mauritania, in Senegal, in Guinea-Bissau, in Guinea and in Cape Verde. The emphasis is laid on:

- The updating and promotion of zoning tools (PDAL, SDAL);
- The implementation of environmental monitoring-evaluation tools (SSEE, EIA);
- The adoption of coastal ecosystems protection measures, and capacity building of technical services in charge of environmental monitoring and control, of executives and civil society.

PRISE 2 project, implemented by PRCM, is centered on the strengthening of legal frameworks and advocacy for the reduction of the impacts of infrastructure in the priority sites of 5 West African countries: Mauritania (PNBA), Senegal (Saloum Delta), Guinea (Kapatchez delta), Guinea-Bissau (Bijagos) and Cape Verde (Boa Vista).

“ Open Cities Africa ”

“Open Cities Africa” is a program of “Open Data for Resilience Initiative” of the Global Facility for Disaster Reduction and Recovery (GFDRR) in collaboration with the World Bank Africa Urban, Resilience and Land Unit, made possible thanks to the European Union Disaster Risk Financing Program in Africa (ADRF). ADRF financed activities carried out between June 2018 and December 2019 in the following West Africa cities: Accra (Ghana) ; Kinshasa (Democratic Republic of Congo) ; Monrovia (Liberia) ; Pointe-Noire (Republic of Congo) ; Saint-Louis (Senegal). Financing from different sources supported the extension of the Open Cities program to Abidjan (Côte d’Ivoire); Bamako (Mali) ; Brazzaville (Congo) ; Niamey (Niger).

Open Cities mapped more than 1 000 000 geographic entities, made accessible high quality updated data, built institutional capacities, improved digital skills, created a practical regional community and influenced a variety of subsequent local investments (infrastructure to prevent erosion [Kinshasa], rehabilitation and drainage activity [Pointe noire], development o a sustainable coastal hazards management solution [Saint-Louis],.).

3.3.1.3 *Management and rehabilitation of coastal ecosystems*

3.3.1.3.1 Management of outstanding coastal natural spaces

Marine and coastal conservation actors have rapidly recognized the need to address the coastal area management and its resources at sub regional level. Indeed, several factors have buttressed this decisions:

- The presence of migratory species;
- Shared resources;
- Transboundary habitats;
- The mobility of users, namely fishermen.

A coordinated approach became necessary to ensure the conservation of the structure and functions of marine and coastal ecosystems at regional level.

Since the 2002 Regional Strategy for MPAs, several steps have been followed leading to the Regional Network of Marine Protection Areas in West Africa (RAMPAO) officially created in 2007 towards an institutional and financial autonomy. In 2015, recognizing the need to work towards institutional, organizational and financial autonomy, several studies were carried out for its sustainability. Following reflections, network members decided to agree on the creation of a foreign association under the laws of Senegal. In 2018, in accordance with the provisions of the civil and commercial obligations code of Senegal, was created the “Regional Network of Marine Protected Areas in West Africa” or “RAMPAO” under decree N°010586 MINT/ DGAT dated May 14, 2018.

This evolution is also combined with a progressive geographic extension of the network. This concerned 4 countries in 2007 (Mauritania, Senegal, Guinea-Bissau, Gambia) and seeks by 2022 to include 13 countries (Mauritania, Senegal, Guinea-Bissau, Gambia, Cape Verde, Guinea, Sierra Leone, Liberia, Côte d’Ivoire, Ghana, Togo, Benin, Nigeria). This geographic extension is also reflected by an increase in the number of Marine Protected Areas included in RAMPAO (15 MPAs in 2007, 25 MPAs in 2013, 38 MPAs in 2018).

For ten years, RAMPAO has considerably contributed in improving the effectiveness of MPA management, namely through the networking of a set of MPA representatives, the rehabilitation and restoration of some critical habitats, the exchange and mutual learning between network members and support for operational MPAs, responding, optimally, to the conservation objectives assigned to them. The current RAMPAO initiatives focus namely on:

- Analysis processes of MPAs ecosystem services;
- MPA databases in West Africa;
- Network extension processes in Liberia, Côte d’Ivoire, Ghana, Togo and Benin under the Biodiversity and Protected Areas Management Program (BIOPAMA).

There has been much progress in the network extension process in Benin, where there is no official MPA. There are regional and international wetlands and biodiversity conservation community areas (BCCA). Located on the South-West part of the Benin littoral, the Biodiversity Conservation Community Area (BCCA) of Bouche du Roy, (Ramsar site 1017), is a strategic mouth area for Benin because of the :

- transit of marine animals towards brackish and fresh waters of the coastal lagoon for their life-cycle;

- critical habitats and endangered flora and fauna species in Benin and Africa (mangroves, egg-laying and breeding sites of fishing resources, marine turtles and hippos, protected species migratory birds, etc.).

The economic, ecological, social and cultural values of this coastal reserve have led to its identification as an ecologically and biologically significant area (EBSA) under the implementation of the Abidjan Convention activities by the Integrated Marine and Coastal Areas Management project (GIZMaC) of Benin (DGEC/MCVDD, 2019). The description and mapping of these critical EBSA for the sound functioning of marine ecosystems are made to support the planning and application of different management tools, namely Marine Protected Areas (MPAs).

Several projects aiming at recognizing some sites as outstanding natural spaces are being reviewed between Togo and Benin:

- Pipeline transboundary marine area

  Management rules of a buffer zone around the pipeline namely as regards navigation and fishing are currently existing in Togo and Benin. This area being already regulated in terms of navigation, people are reflecting on the opportunity of creating an MPA.

- Transoundary Ramsar site of Gbaga channel

  The development and implementation of the management plan in 2018 will allow:

  - ✓ Finalizing the registration of the Gbaga Channel as second transboundary Ramsar site in West Africa after the Niumi-Saloum transboundary Ramsar site between the Gambia and Senegal;
  - ✓ Contributing in developing in this part of Benin and Togo a network of permanent areas favorable to the safeguard of ecosystemic goods and services. Indeed, the Gbaga Channel is a coastal wetland which lies between Ramsar site 1017 in Benin, Ramsar site 1722 in Togo and included in the transboundary biosphere reserve of Low Mono Delta between Togo and Benin;
  - ✓ Creating large permanent wetlands spaces securing the availability of resources required for the breeding of migratory species in general and particularly those migrating between the sea and the continent.

Finally, on September 23, 2020, the Ivorian government announced the creation of 5 marine protected areas responding to IUCN criteria. These are permanently flooded land areas, covering sometimes the coast and sea, and which landscapes have special aesthetic, ecological or cultural qualities, resulting from the former interaction of man and nature. These areas have also a great biological diversity and have been identified depending on criteria defined by IUCN, and are, from the West to the East of the country:

- The transboundary site of the River Cavally mouth ;
- The Grand-Bereby site (in the west) ;
- The classified forest site of Dassioko ;
- The Azagny national park ;
- The transboundary Côte d'Ivoire — Ghana coastal site

Table XVII: Marine Protected Area members of RAMPAO in 2020

Country	Protected Area
Mauritania	Banc d'Arguin National Park
	Cap Blanc Satellite Reserve
	Diawling National Park
Senegal	Langue de Barbarie National Park
	Madeleine islands National Park
	Saloum delta National Park
	Popenguine Natural Reserve
	Bamboung community MPA
	Kayar MPA
	Joal-Fadiouth MPA
	Saint-Louis MPA
	Indigenous Community Heritage Area (Kawawana)
	Palmarin Community natural reserve
	Somone community interest natural reserve
	Gandoul MPA
	Niamone Kalounayes MPA
	Kassa-Balantacounda MPA
	Sangomar MPA
	"Kapac Olal de Mlom" MPA
Gambia	Niumi National Park
	Tanji shores and Bijol island reserve
	Bao Bolong wetland reserve
	Tanbi National Park
	Bolong Fenyo Community Fauna Reserve
Guinea-Bissau	Rio Cacheu river natural mangrove reserve
	Orango National Park
	Joao Vieira-Poilao National Marine Park
	Urok Community Marine Protected Area
	Cantanhez National Park
Guinea	Tristao islands Managed Natural Reserve
	Loos islands fauna sanctuary
	Alcatraz Integral Natural Reserve
	Rio Kapatchez Managed Natural Reserve
Sierra Leone	Yawri Bay
Cape Verde	Costa De Fragata Natural Reserve
	Tartaruga natural reserve
	Baia de Murdeira Natural Reserve
	Santa Luzia Integral Reserve

3.3.1.3.2 Mangrove management and rehabilitation

Coastal vegetation ecosystems, such as mangrove forests, sea grasses and salt marshes, have for a long time provided benefits to human communities and fisheries, and these recent years, they have been recognized for their role in carbon sequestration / storage and contribution in mitigating climate change impacts (Barbier et al., 2011; Nellemann C & Corcoran E., 2009).

Considering the services that mangroves and other vegetated coastal habitats provide to the international community, many governments, communities, enterprises and the civil society around the world support more and more their conservation as a mitigating strategy of climate change impacts (Herr D, 2015).

At regional level, there was a big push to preserve mangrove forests from new destruction. Many national governments have adopted laws and signed international conventions, namely the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity (Rio de Janeiro, 1992), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, 1973), the Vienna Convention for the protection of the ozone layer (Vienna, 1985) and the Ramsar Convention on wetlands (Wetlands International, 2012).

Nevertheless, according to Feka (2015), there are too many institutions, with decentralized roles and responsibilities in charge of managing mangrove forests. The region's countries have ratified several international conventions and use associated national legislations on natural resources to support mangrove management. However, practices and methods of harvesting mangrove wood are almost not regulated in those countries. Mangrove wood harvesting is strongly influenced by the market, rather than existing legislations used to manage mangroves.

International institutions joined national and international NGOs to implement projects contributing in mitigating the anthropic pressures of mangrove forests. This marginal performance is the result of limited logistical capacity, a lack of sustainable financial resources, legislations, irrelevant policies and a lack of political interest, combined with a lack of data on the economic value of mangrove forests in the region's countries. So, mangrove forests deserve regulations and appropriate policies taking into account their socioeconomic and ecological specificities. These legislations should highlight economic incentives promoting the conservation of ecosystems; and management systems with good governance indicators measuring and promoting ecosystems' health and stakeholders' interests. Bryan et al. (2020) Propose that at regional level, to create a support program and an information exchange center namely to help countries in their mangrove conservation approach. This assistance could include socio-economic evaluations and monitoring of mangroves condition, facilitation of enhanced regional cooperation, or development of strategies/solutions to access to international financing sources.

At national level, mangrove conservation efforts are often fragmented. From a legal and administrative perspective, mangrove forests are a composite and unstable zone. Despite those challenges, efforts must be maintain to support national mapping activities to focus on identifying key areas which will be crucial for climate change mitigation and adaptation. Those efforts could lead to the production of maps which could help classify the most important areas for coastal protection, fishery production, climate change mitigation and adaptation. The additional key aspects of mangrove conservation are sustainable management at landscape scale, increased community awareness-raising and benefit sharing.

Due to the increasing quantity of information available on carbon storage capacity, international financing mechanisms are more and more ready to be deployed to pay this service as part of the effort to reduce GHG emissions through market creation (Herr et al.2015). Besides, a better evaluation of other benefits provided by mangrove forests and vegetated coastal ecosystems may lead to additional markets to pay for these ecosystem services (PES) - potentially integrating carbon sequestration and storage.

Besides, thanks to a better knowledge of ecosystem services namely provided by mangrove, conservation and/or restoration efforts of those habitats have increased during the 5 to 6 last years. If those actions help raise the awareness on the status and ecological and economic values of mangroves, the current knowledge do not allow saying if those restoration projects participate in its regeneration because:

- Replanting projects do not fit into medium and long term programs including the monitoring of actions undertaken ;
- Most of the mangrove restoration efforts have stressed on planting as the main management tool of degraded areas, rather than evaluating the causes of degradation, then evaluate opportunities of natural regeneration. Yet, the mangrove ecosystem is dynamic and degraded mangrove areas can naturally regenerate. Natural reclamation must be considered before starting any mangrove planting activity, warned the United Nations document.

Also, it is worth reminding here some golden rules to be considered for mangrove restoration and proposed by Enright & Wodehouse (2019) :

- Limit the restoration action to vegetation areas where the forest is degraded and lost ;
- Consider the rehabilitation of degraded mangroves as a program and not as a short term project;
- Involve local community members as early as the planning stage ;
- Conduct a monitoring of mangrove restoration projects.

Finally, the United Nations Organization recommends the development of alternative income generating activities (IGA) targeting all mangrove users, including mangrove cutters.

FOCUS ON SOME RECENT MANGROVE MANAGEMENT AND REHABILITATION PROJECTS IN WEST AFRICA

West Africa Biodiversity and Climate Change Project – WA BiCC Program – Period 2015 - 2021

The WA BiCC program has been working in the region to improve coastal resilience through integrated policy planning and strengthening the capacity of local, national and regional actors. The Program's activities were informed by comprehensive Climate Change Vulnerability Assessments that were multi-sectoral by design, with teams comprised of climate change experts, national and local governmental and non-governmental organizations and universities. To ensure local ownership the findings and recommendations of the Assessments were presented to communities and government agencies as decision-making inputs to assist them to determine the most locally appropriate priorities and decide on activities that could be implemented immediately through WA BiCC - support pilot landscape programs in Fresco and along the Sierra Leone coastline.

Using this newly generated and synthesized information WA BiCC is working with local partners to develop climate change adaptation plans within the two aforementioned "learning landscapes" in **Sierra Leone** and **Côte d'Ivoire**. The aim is to implement intensive site-based coastal adaptation activities and to document interventions that effectively reduce climate change risk and foster adaptive capacity:

- The Sierra Leone coastal landscape comprises four Marine Protected Areas where local communities have lived for generations, far preceding the more recent formal MPA designation.
- The biologically diverse and fishery-rich coastal landscape of Fresco, Côte d'Ivoire, is suffering from severe erosion over the last decades, leading first to the total reclamation of Fresco town by the sea and its subsequent relocation to higher ground.

Both landscapes require ecosystem-based climate change adaptation and mitigation actions that are designed to conserve biodiversity, enhance livelihoods and protect natural resources - including fisheries, freshwater resources, forests and farmlands. Management and restoration of forests, watersheds, and mangroves across these two landscapes are critical to increase the resilience of coastal communities to climate change and to contribute to the countries' commitments under the United Nations Framework Convention on Climate Change. These activities are complemented by regional policy actions and implemented in close collaboration with ECOWAS, the Mano River Union and the Abidjan Convention.

Support Program for the preservation of biodiversity and fragile ecosystems, environmental governance and climate change in West Africa PAPBIO (IUCN – Wetlands – 5Delta – EU funding) – Period 2019

Component 2 of PAPBio - Mangrove forests management from Senegal to Benin-PAPBio C1 - Mangroves aims at reaching an integrated protection of biodiversity and fragile mangrove ecosystems in West Africa and their enhanced resilience to climate change.

The objective is to strengthen relationships between protected areas management actors and unprotected mangrove sites. The purpose is to link governance and production systems with mangrove conservation bodies in territories. Those links will be created through exchanges between actors in decision-making on the use of spaces and best practices, to establish or strengthen platforms for dialogue within landscapes and provide grants to support management and conservation actions, based on calls for competitive proposals.

Besides, under its execution the PAPBio C1- Mangroves project has established a grant mechanism to support local biodiversity conservation initiatives and sustainable use of natural resources in the landscape.

Three outcomes are expected:

- The socioeconomic and sectoral activities in landscapes are coordinated in an integrated manner.
- Effective protected areas management systems are developed and operational.
- Riparian populations draw a sustainable benefit from Protected Areas and are more resilient to climate change.

3.3.1.3.3 Coastal dune and beach restoration and fixation

Sandy coasts, accounting for 35% of the West African littoral, are particularly dynamic and vulnerable (UICN & WAEMU, 2010) to various disturbances in this area, including due to coastal works. They are made up of sandy dune formations extending from Mauritania to Dakar, Senegal and include also sand spits and sandy terraces. The response against coastal erosion through coastal ecosystems management and rehabilitation is then relevant for this type of coast.

Coastal dunes are natural barriers playing a protective role against coastal hazards, namely shoreline recession and marine submersions. To face the vulnerability of coastal communities to weather-marine hazards, several dune ecosystems restoration solutions are advocated ad some are experimented in West Africa.

Dune restoration

Dunes are formed of sediments mobilized by wind, currents or waves. The dune restoration in littoral area consists of any action aiming at rehabilitating the functional processes and integrity of the ecosystems of degraded, damaged or destroyed coastal dunes so as to be able to better provide ecosystem services.

There are various types of action reported in literature (Martínez et al., 2013 ; NSW Department of Land and Water Conservation, 2001) some of which favor dune fixation in the dune restoration process. We may mention:

- Sediment trapping devices or wind breaks related or not to vegetation;
- Artificial sediment supply for dune reconstruction and reprofiling;
- Vegetation or improvement of biodiversity of the environment, among others, through reintroduction or regeneration of indigenous species;
- Covering existing dunes with straw or geo textile to avoid loss of sediments;
- The establishment of various developments (fence, access roads, etc.) to avoid dune trampling and;
- The withdrawal of human activities and works to allow a resumption of natural processes.

Some dune restoration and fixation actions to be promoted and strengthened

Investments for coastal areas resilience in West Africa have for a long time been focused on civil engineering solutions with major consequences on sedimentary dynamics. These recent years, often raised experiences of solutions based on coastal ecosystem restoration are linked to mangroves on delta coasts (Cf. Input on mangroves). On open sandy coasts, beach and wind break vegetation initiatives are carried out for dune restoration and fixation.

As part of the project for the rehabilitation and extension of Nouakchott green belt which started in 2000 and ended in 2007, 800 ha of continental dunes were stabilized and fixed, as well as 7 ha to favor recharge of the coastal dune cordons in the West of the capital-city (Charles Jacques Berte et al., 2010). The ACCC Project - Adaptation to Climate and Coastal Change in West Africa (2008-2011) (Roncerel, 2011) also contributed to the rehabilitation of the dune cordon in Nouakchott with the establishment of sand trapping devices and reforestation on the city coast, between the Wharf and fish market on a 4 km length and 50 ha surface area. The WACA ResIP project also invests in dune fixation in Nouakchott and Diawling.

Figure 22 : Google Earth aerial view of the dune restoration site-ACCC Project and picture of the same site / © Meimine O. Saleck-2010

On the Langue de Barbarie in Saint-Louis, Senegal, the experimentation of dune restoration started on April 2019 with the commitment of Saint Louis Marine Protected Area (MPA). This, under the “Soft Solutions and Coastal Risk Monitoring in Benin, Senegal and Togo” (WACA FFEM) project for which the Ecological Monitoring Center (CSE) of Dakar is the contracting party and IUCN, the technical assistant to the contracting party. For that purpose, a wind-break device has been designed, installed and monitored by the MPA of Saint-Louis thanks to the advisory support of the French Coastal Protection Agency and the association SAVE. The device named "Typhavelle" is made up of palisades locally made with reed (*Typha australis*) and covers a length of 1.5 kilometer on the coast.

Figure 23 : Dune restoration on the Langue de Barbarie Saint-Louis with Typhavelles (on the left ©CdL, October 2019 and on the right ©MPA Saint-Louis, May 2020)

The regular monitoring of the beach profile evolution conducted by the Saint Louis MPA team to assess the efficiency of this device shows remarkable results already felt by local communities. The latter, which have been practicing market gardening for several years in the area, faced periodically production losses due to marine submersion and soil salinization. Thanks to dune restoration, the agro-ecological conditions of the environment in general and market gardening zone in particular have been significantly improved. Then, this dune restoration is strengthened by reforestation actions with casuarina (*Casuarina* *equisetifolia*). This action of the WACA FFEM project allowed enhancing dialogue between local populations and Saint-Louis MPA managers.

Under this project, more than 15 ha of casuarina have also been reforested on the langue de barbarie and 4 ha of *Chrysobalanus icaco* in Palmarin and Dionewar (region of Fatick) for sediment fixation on the coast. The use of casuarina has been a real success as natural coastal protection solution namely in Senegal where a massive strip of casuarina borders the coast between Dakar and Saint-Louis over more than 200 km, though this reforestation with almost a single species may be a weakness to be underlined. Besides, most of these reforestation actions aimed above all at fighting against farming land silting up and human settlements.

These beach and dune restoration initiatives are rare in the region, but those documented for experience sharing are even rarer. Table XVIII proposes a list, based on literature, of known initiatives of dune and beach restoration implemented in West Africa over the recent years.

Table XVIII : Dune or beach restoration/fixation on open sandy coasts

Location	Dune or beach restoration/fixation on open sandy coasts	Implementing framework/Project	Year	Donors
Dakar to Saint Louis (SN)	12 000 ha of casuarina for dune fixation41	-	1974 - 1990	UNDP-UNSO, CIDA, USAID
Cotonou (BN)	Dike in geo textile	Experimental project	1997	"Espace Pur" Group
Nouakchott (MR)	7 ha of reforestation of *Tamarix aphylla, T. senegalensis*	Green belt rehabilitation and extension project (Charles Jacques Berte et al., 2010)	2000-2007	Wallonnia region
Thiès and Louga (SN)	2 037 ha of casuarina and eucalyptus for dune fixation	PRL[42]	2001-2006	JICA (Japan)
Nouakchott (MR)	50 ha of palisades for dune restoration	ACCC Project	2008-2011	GEF, Government
Region of Fatick (SN)	Planting of 9.2 ha (12 km) of barrier beach with casuarina and other species (*Eucalyptus, Niaouli, Prosopis sp, Tamarix senegalensis*) (Mbengue A., 2014)	ACCC Project	2009-2012	GEF, National budget
Pilote Barre (SN)	Beach recharge over 700 m x 20 m	GIZC Program[43]	2015	European Union (EU)
Cotonou (BN)	Beach recharge	Phase II of East Cotonou coast protection project	2018	National Budget, African Dev. Fund
Avlékété (BN)	Beach recharge	WACA ResIP	In progress (2020)	world Bank, Government
Saint-Louis (SN)	Dune restoration in Saint-Louis MPA on the langue de Barbarie over nearly 1200 of length	WACA-FFEM	2019-2020	FFEM
Nouakchott/Diawling (MR)	Dune fixation over 10 km in Nouakchott and 10 ha in Diawling	WACA ResIP	2019-2020	world Bank, Government
Saint-Louis (SN)	Casuarina reforestation over nearly 15 ha	WACA-FFEM	2019-2020	FFEM

42 http://www.environnement.gouv.sn/programmes-et-projets/prl-projet-de-reboisement-du-littoral

43 http://www.denv.gouv.sn/index.php/81-deec/actualites/245-une-methode-de-protection-douce-dite-ensablement-sauve-le-village-de-pilote-barre-dans-le-gandiolais

Location	Dune or beach restoration/fixation on open sandy coasts	Implementing framework/Project	Year	Donors
Sangomar (SN)	Reforestation of 4 ha of *Chrysobalanus icaco*	WACA-FFEM	2020	FFEM

True it is that dune and beach restoration include several limits namely:

- The uncertainty linked to the necessary deadline to get dune and beach profiles and a substantial vegetation; this is all the more important as populations often expect rapid effects;
- The likelihood of acts of vandalism (NSW Department of Land and Water Conservation, 2001) and ;
- The need for monitoring over a relatively long time to avoid sediments being remobilized and palisades transformed into debris on beaches (for the case of trapping devices).

Nevertheless, it is an interesting solution faced with coastal risks on West Africa sandy coasts especially due to their low negative impact on the environment, their reduced cost and the possibility they provide to involve local communities.

3.3.1.4 Management of telluric pollution

The littoral, interface between land and sea, is a complex, ecologically rich and very coveted environment. Presently, 60% of the global population lives with less than 60 km of coasts and littoral urbanization may be amplified, since we expect 75 of the global population on the coasts by 2025 (Amara, 2011). The goods and services from marine and coastal ecosystems generate more than $20 billion globally, i.e. more than the third of the global gross product (World Bank, 2009). But, these ecosystems are strongly threatened by various pressures, including human pressure through marine pollution. According to the United Nations Environment Program (UNEP), 80% of marine pollutions have a terrestrial and human origin (UNEP, 2010).

Marine pollution is defined as being the introduction by man, directly or indirectly, of substances or energy in coastal and marine environments causing adverse effects such as nuisances towards biological resources, hazards for man's health, challenges against marine activities, and an alteration of sea water quality as regards its use and a degradation of amenities (UN, 2010). A long term pollution may deteriorate coastal and marine ecosystems and damage natural resources and populations' livelihoods.

Like other continents, Africa, namely West Africa is not spared. The first workshop of the Ports Environmental Network-Africa – PENAf) for West and Central Africa, held in Ghana in 2010, allowed identifying the main environmental issues: wastes from maritime transportation, oil spills, bad ballast water management, dredging, discharge of effluents, degradation of water quality, noise, dust, atmospheric pollution and habitat degradation (Echart et al., 2012).

Investments planned in terms of pollution prevention, control and management in WACA ResIP countries[44] focus on coastal pollution control by:

- improvement of sewage and waste water management (installation and maintenance of waste water treatment plants; effluents management);

[44] West Africa Coastal Areas management program (WACA) whose financing was approved by the World Bank on April 09, 2018. It is currently operating in Mauritania, Senegal, Côte d'Ivoire, Togo and Benin. However, 17 West Africa countries will benefit from the WACA program.

- management of solid wastes, leachates and plastic debris (thanks to the improvement of collection, sorting and disposal practices in coastal urban centers);
- reduction of the pollution of chemical substances and heavy metals;
- the management and reduction of marine wastes resulting from insufficient waste management and lack of an adequate solid and industrial waste recycling and collection policy, the double advantage of which is to recycle and avoid blocking drainage channels; and
- the prevention and management of oil spills, decontamination of hydrocarbons and reduction of oil spill risks from oil platforms.

Since its launch in 2018 in Mauritania, Senegal, Côte d'Ivoire, Togo and Benin, different actions are being implemented. The specific cases of Benin and Togo are outlined below.

TELLURIC POLLUTION MANAGEMENT

TOGO : FEASIBILITY STUDY OF PHOSPHATE WASTES

Togo covers a narrow land strip in West Africa, between Ghana and Benin and is open to the Benin Bay in the Guinea Gulf. Endowed with phosphate deposits, the country is facing marine pollution due to discharges of phosphate wastes in Kpémé by the Société Nouvelle des Phosphates du Togo (SNPT) in the area located between the village of Gbodjomé (West) until Aného (East) through Kpémé.

Discharge of phosphate wastes in the sea at Kpémé
(Melila M. et al., 2012)

To face this phenomenon, it is expected to conduct an in-depth feasibility study of the treatment of phosphate waste discharges into the sea by the Mining Development and Governance Project (PDGM) with a pilot project which will be implemented by WACA ResIP Togo. The WACA ResIP Togo pilot project will be combined with an Environmental and Social Impact Assessment (ESIA) of the treatment of phosphate wastes discharged into the sea. The objective is to contribute in reducing pollution due to the discharge of phosphate wastes into the sea which adverse impacts on resources are not only limited to Kpémé, discharge place of wastes, but, are also very intense in Goumoukopé, in Agbodrafo upstream and not negligible until Aného at the border and even in Benin.

TOGO : COMBATING WASTE WATER DISCHARGE INTO LOMÉ BEACH

22 sewers open up into the Lomé beach including 8 which spill the waste waters of the city directly into the beach without any treatment, and fourteen buried by sand. When built, the spill front of those sewers was close to the foreshore. But, since the building of Lomé port jetties, the coastal dynamics has changed, leading to the silting up of outlets. This has blocked any water runoff towards the sea. Waste waters not being discharged in the sea, small water ponds filled with liquid and solid wastes pollute the beach (picture opposite).

Waste water outlet into Lomé beach

Those effluents affect the sea and tourist activities. Yet, those beaches are crowded. To settle the problem of sewers silting-up and beach and sea pollution by waste waters, a feasibility study was carried out in 2016. Under the WACA ResIP project, it is planned to update this study and implement it.

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3.3.1.5 *Management of hydrocarbon pollution*

The risk of marine pollution by hydrocarbons is a reality in countries of the region (cf. 1.2.3 Characterization of « marine oil pollution » hazard. When this risk becomes real, they may bring about major environmental and socioeconomic consequences. Therefore, anticipation is critical, to be able to face this pollution, if it occurs - this is the purpose of preparedness and response to oil spills.

This section focuses on actions taken to mitigate the impacts of this disaster risk, and not on actions taken to limit this risk (prevention). There are two complementary thematics, but they are not systematically governed by the same dynamics, by the same national authorities, or the same international and national instruments.

Main elements of preparedness and response to hydrocarbon pollutions

Mitigation of oil spill impacts is a complex thematic which raises many institutional, technical and socio-economic issues. Indeed, preparedness and response are at the crossroads of disaster risk reduction, marine and coastal environment protection, and the protection of communities depending on it, and contingency planning. In fact, as explained in the 1990 International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC 90)[45] in its article 6, States-Parties have the responsibility to establish a national system to respond rapidly and effectively to pollution events. This national system, which may be complemented by a regional system, is based on two main pillars:

- An institutional pillar : appointment of the national authority or authorities responsible for the preparedness and response to pollution, the receipt and transmission of pollution reports, and the requests for and/or provision of assistance to other States in case of large-scale pollution; and
- A pillar linked to contingency planning: development and update of a national contingency plan for the preparedness and response which comprises the flow chart between various relevant organizations, whether public or private.

These two pillars are the keystones of a national system, once established, to be fully operational, must be complemented and detailed by a set of sectoral policies addressing technical aspects (use of dispersants, response plan in coastal environment, stakeholders training plan response plan to the fauna affected by hydrocarbons, etc.) and by a special attention paid to the transposition and implementation into national law of different international instruments ratified by countries.

Evolution of national preparedness and response systems in the region's countries

The whole studied countries under this research participate in the GI WACAF project, and, as such, have been providing to this project data related to their national preparedness and response systems since 2006. Thanks to this data, we can see the evolution of both above-mentioned pillars: the institutional pillar and the pillar linked to contingency planning.

[45] The OPRC 90 Convention is an International Maritime Organization convention, a specialized United Nations institution in charge of establishing standards for the security, safety and environmental performance of international maritime transportation. The OPRC 90 Convention was developed to provide a framework for international cooperation for the response to pollution events by hydrocarbons. Adopted by 113 States, including 11 out of 12 covered by the 2020 assessment, this Convention is today recognized as a basic instrument in the field of preparedness and response to oil spills.

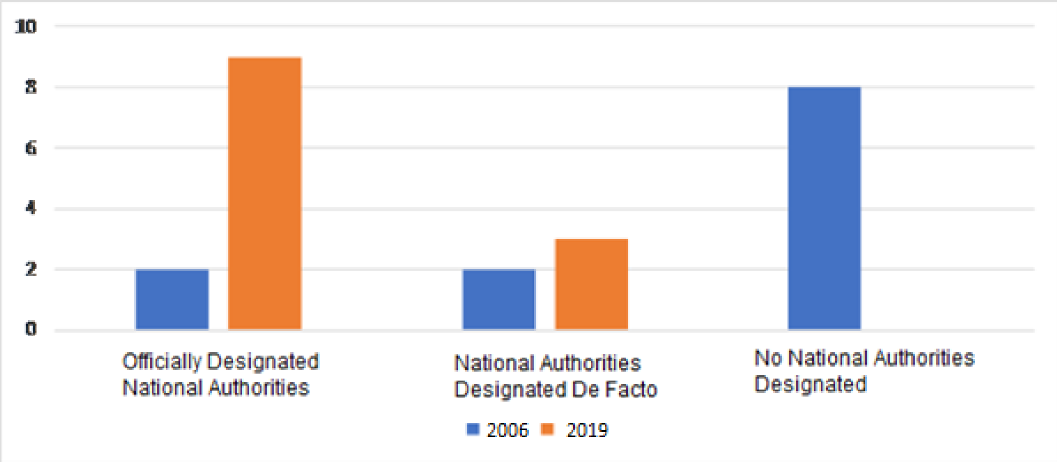

Figure 24 : Evolution of the designation of national authorities in 12 countries of the region (institutional pillar) (GI WACAF, 2019)

The available data show a significant progress between 2006 and 2019. In 2006, most of the countries of the region did not have national designated authorities competent for the preparedness and response to marine pollutions by hydrocarbons (8 out of 12). In 2019, the whole countries had national authorities responsible of these issues, either they are officially designated (9) of de facto responsible (3), without this responsibility being officialized by an instrument.

There is also a remarkable evolution as regards the establishment of a national contingency plan: 8 countries did not have a contingency plan in 2006, against no one in 2019 according to provided data. **In 2019, half of the region's countries had a contingency plan developed, officially validated and regularly updated.** The other half had a contingency plan developed, but not validated, or which has not been updated for more than 10 years. Let us note that in the second case, the effectiveness of this document may be limited, even if it is anyway a framework-document which exists and allows guiding the actions of stakeholders in the field of preparedness and response.

The evolutions of both indicator show a net trend towards improvement in preparedness and response in the region. The relevant countries are aware of the stake and build their skills in this respect, whether on the institutional or planning aspect, which are *in fine* intrinsically related. Nevertheless, this initiative must be lasting, since preparedness and response are thematics requiring continuous efforts in human, material and planning levels. Additionally, some aspects may also be enhanced, as detailed in the concluding paragraph of this contribution.

MANAGEMENT OF POLLUTIONS CAUSED BY ACCIDENTAL OIL SPILLS

BENIN: ABANDONED OFFSHORE OIL PLATFORM OF SEME-PODJI

Located in the Guinea Gulf, Benin is among the most oil rich regions in the world these recent years after the Middle-East. Thus, 13% of the Cotonou Port imports is generated by oil products, and several navigation lines used by oil tankers sail not far from Benin coasts, what is a source of concern in terms marine pollution for the country. The second source of concern for authorities is the former oil field of Sémé-Podji, which ceased its activities in 1998. The facilities have been abandoned for twenty tears and are severely degraded causing oil leaks in the sea (5 platforms out of 6 are defective). To manage this situation, the WACA ResIP project ***Benin as planned two major actions : building the capacity of actors and conducting of*** studies and design of prevention instruments against hydrocarbon pollution.

Overview of the abandoned oil platform in Sèmè-Podji (Koumba et *al*, 2019)

Capacity building

In Benin territorial waters, off the littoral community of Sémé-Podji, a former oil platform is abandoned and poses a real risk of accidental spill.

The project will develop and allow establishing a capacity building program for the whole Beninese actors, state institutions and local administrations on coastal hazards related to accidental oil spills to develop the required competences to prevent and respond to a potential accident and face the ecological threat. The result is to establish a training plan of actors managing the oil field and also the coastal area and preserve the coastal and marine ecosystem from adverse impacts of accidental oil spills in Sèmè-Podji.

Carrying-out studies and developing prevention instruments against oil spills into the sea

The project has also planned to finance: (I) the operational costs linked to the implementation of the surveillance plan of the platform, (ii) the carrying-out of a study to identify the immediate responses to hazards related to the platform, and (iii) the establishment of immediate response means in case of spills (dispersants, floating dams…). For this activity, an evaluation of national expertise concerning the general inspection (depth and surface) of the abandoned facilities in the oil field of Sèmé is planned. For this purpose, international bidding documents have been developed for the conduct of the in-depth submarine and surface inspection, of the abandoned facilities on the oil field for the update of the feasibility study for the decommissioning of facilities. The final objective is to prevent coastal risks due to accidental hydrocarbon pollutions which might come from the offshore platform abandoned off the community of Sèmè-Podji.

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Transboundary and Regional Scale

Marine hydrocarbon pollution knows no borders. As mentioned in article 6, and developed in article 10 of the OPRC 90 Convention, a national preparedness and response system therefore deserves to be complemented by an international dimension. This can appear as an enhanced cooperation with neighboring countries or regional countries, certain harmonized strategies and policies (such as the use of disseminators, for example), or even developed bilateral or multilateral contingency plans.

In the region, all countries are part of the “Convention for Cooperation in the Protection and Development of the Marine Environment and Coastal Areas of the West and Central African Region” (Abidjan Convention) and its “Protocol on Cooperation in Combating Pollution in Cases of Emergency” (the Protocol), which provide a legal and institutional framework for regional cooperative actions to combat accidental marine pollution. These two instruments have been complemented from an operational perspective by a Regional Contingency Plan adopted at COP 9 (2011), which aims at coordinating the efforts of all the States Parties to the Abidjan Convention in this field.

Efforts have also been made by 5 countries in the region (The Gambia, Guinea, Guinea-Bissau, Mauritania and Senegal) under the Canary Current Large Marine Ecosystem (CCLME) project, to develop a sub-regional plan to combat pollution by accidental oil spills in the marine environment.

Moreover, the GI WACAF project (see dedicated box: Example of a national preparedness system: the case of Senegal) has been supporting all the countries in the region since 2006 on the specific capacity building aspect in pollution preparedness and response. A large part of the project's activities are focused on supporting the national level of each of these countries, but the transboundary and regional scales are also subject to significant efforts. Several workshops involving the MOLOA zone countries have been held since the project started, which also regularly hold conferences gathering all the project's focal points from the national authorities in charge of these issues, as well as private sector actors. These actions have thus allowed developing a network of officials, who can easily communicate with each other in case of pollution, especially if the impacts can affect several countries.

Potential Avenues for Improvement

The regional States are aware of the hydrocarbon pollution risk and, in fact, they have considerably strengthened their preparedness and response systems. However, this includes a long-term action and national authorities should ensure making progress in building and maintaining their national and regional systems. Several improvement areas exist. Some of them can be mention here as examples:

- National Contingency Plans should be regularly updated, whether to reflect the considered new risks (related to the expansion of the offshore oil and gas sector in Mauritania and Senegal, for example) or potential ministerial and institutional reorganizations;
- National Contingency Plans must be complemented by sectoral policies to be fully operational. Technical issues such as contaminated waste management, coastal response, vulnerability mapping, the use of dispersants, contaminated fauna response, etc. are all subjects to be addressed;
- In countries where oil exploration and production is significant and/or expanding, national authorities must maintain constant contact with private operators in this sector, in order to specify their roles and responsibilities in the national preparedness and response architecture. National platforms, gathering representatives of all the parties involved (public and private sectors), have thus been created in several historically oil-producing countries, such as ACEPA in Angola or UPEGA in Gabon;

- The bilateral and regional scale of contingency planning should be also strengthened, particularly by operationalizing existing initiatives and initiating new ones. The regional scale is often an excellent first step, but it is particularly complex to obtain an operational solution at this scale. Often, the bilateral or sub-regional scale is more appropriate for developing concrete and operational preparedness and response plans. International experience[46] also shows that hosting these plans by already existing structures is an efficient and cost-effective method;
- Some harmonized bilateral or regional sectoral policies, particularly using disseminator policies, is also an important point to be developed, particularly in order to strengthen operational cooperation between the different countries in the region; and
- At the legal and institutional level, the States in the region have ratified the main international conventions related to preparedness and response (OPRC 90, but also the liability and compensation conventions such as the 1992 Civil Liability Convention (CLC) or the 1992 Fund Convention). It is now essential to transpose the provisions of these conventions into national law, in order to make them effective and to be able to implement them at the national level, and thus benefit fully from them.

46See for example the conclusions of the "*Regional Oil Spill Contingency Planning in the BCLME Region"* report, written by Patrick Morant in 2007 for the Benguela Current Large Marine Ecosystem Program.

POLLUTION MANAGEMENT RELATED TO ACCIDENTAL OIL SPILL

EXAMPLE OF A NATIONAL PREPAREDNESS SYSTEM: THE CASE OF SENEGAL

Senegal has a robust national preparedness and response system, based on both a strong institutional foundation and a strong focus on contingency planning.

This national system is in part related to the country's recent maritime history. In 2002, the sinking of the Senegalese-flagged passenger vessel named “Joola” off The Gambian coast killed more than 1,800 people according to official statistics. This disaster, the deadliest shipwreck of the 21st century, left an everlasting impression. To respond to this crisis, a succession of reforms has modified the administrative and institutional landscape dedicated to maritime safety and security issues in Senegal. This wave of reforms has created new structures with new responsibilities, including the protection of the marine environment and the preparedness and response to oil spills.

This is the case of the **High Authority in charge of the Coordination of Maritime Security, Maritime Safety and Protection of the Marine Environment (HASSMAR)**, created by Decree No. 2006-322 of 7 April 2006. This administration, directly attached to the Presidency, is responsible for coordinating all the actors and actions carried out under the Government Action at Sea. As such, it represents the authority in chargemarine contingency planning, whose main tool is the National Marine Contingency Response Plan (PNIUM) - Decree n°2006-323 of April 7, 2006, which is supplemented by the Organization and Operation of the National Marine Pollution Response Plan (PLAN POLMAR) - Order n°07022 of July 16, 2009.

The effectiveness of the institutional pillar is partly based on the HASSMAR positioning, directly attached to the Presidency, which allows it coordinating the actions of several ministries and agencies, and thus limiting the multiplication of roles and the dilution of responsibilities among multiple stakeholders. This is an important aspect of the marine pollution preparedness and response, which often involves many administrations (typically the Navy, Ministry of Environment, Ministry of Interior, Ministry of Health, etc.) and requires a clear assignment of roles and responsibilities.

The successful development of the “contingency planning” pillar benefits from this strong institutional foundation which makes HASSMAR the authority in charge of the POLMAR Plan. For instance, when a weakness is identified, such as the lack of a clearly defined strategy at the interface between land (covered by the National Disaster Relief Plan - ORSEC) and sea (covered by the POLMAR plan) in the event of a pollution incident, HASSMAR can respond and reinforce this aspect.

Today, new challenges related to oil spill preparedness and responses await Senegal. The same applies to the rapid growth of offshore oil and gas exploration in the Senegalese waters, a pollution risk driver that must be considered. In addition, the existence of shared resources with Mauritania will undoubtedly require a strengthened cooperation between these two countries, and reminds us of the importance of reasoning on a bilateral or even multilateral scale when talking about preparedness and response to marine oil pollution.

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The following text reflects only the ideas and opinions of its authors and not the institutions to which they are attached.

3.3.2 Resettlement Processes and Population Resilience Building

3.3.2.1 *Resettlement Guidelines*

In order to reduce the risks relating to climate change and natural hazards, exposure and vulnerability must be minimized and the communities' resilience capacities strengthened. This is a dynamic process that requires a continuous effort in the economic, social, cultural, environmental, institutional, and political fields to move from vulnerability to resilience.

Unplanned settlement patterns, overexploited coastal resources, and degraded coastal ecosystems and watersheds are among the factors that contribute to the vulnerability of coastal populations. The effects are exacerbated by climate change, sea level rise and damage from storm surges, waves and cyclones. These phenomena make the communities question the viability of existing settlements considering the changing risk profiles and - in many cases - the tragic casualties in natural disasters. When living conditions in a given area are deemed too hazardous to be tolerated, planned relocation of threatened stakes can be an alternative to conventional coastal engineering responses (riprap, dikes, groins, breakwaters offshore...). Relocation is a concept based on the resilience of natural areas: instead of combating sea attacks to maintain the threatened stakes, it is assumed that the preventive deconstruction or relocation of assets and activities enables giving new impetus to coastal ecosystems, and thereby sustainably reduces risk.

Planned relocation is a strategic process, undertaken under national resilience planning that commits communities to voluntarily resettle in safer areas.

However, resettlement can be a terrible experience for those who must leave their homes and move to a new area, even if that area is nearby. It disrupts the normal way of life, can have an impact on the social fabric of a community, and can negatively affect livelihoods. A number of recommendations can be made to contribute to the acceptance and success of the process:

- Engaging Overall Stakeholders from the Design Phase. Planned relocation could work better when people are informed of the risks of not moving and assess themselves the benefits or request this type of response. Committing communities is essential to ensure a mutual understanding of the risks, and to explore relocation options as a way to prevent future damage and loss. In many cases, the safest area targeted for new settlements is already used or occupied. In such situations, adequate compensation should be negotiated with land users before the space can be designated for the new settlement. In cases people are moving into areas already inhabited by others, it is important to ensure that the host population is included in discussions about resettlement plans. The host population should also be able to benefit from the resettlement program advantages, such as improved services. This is essential to defuse any potential conflict between the groups.
- Considering the Livelihoods of People in the New Area. It is important to ensure that resettlement does not put people in a situation worse than that of the original zone. Resettlement would be better when the new areas have equal or improved access to social services (such as electricity, schools, water, roads) and livelihood opportunities. A successful livelihoods planning also prevents people from returning to risky areas by ensuring that they meet their needs in the new areas.
- Planning Measures to Ensure that the Risky Area is not Reoccupied. For example, the area could be converted into communal or leisure areas where the community can still enjoy access to the sea, but without permanent settlement.

- Maintaining Socio-Cultural ties. Ensuring that families stay together is important to the social fabric of a community, especially under stressful conditions such as permanent resettlement far from a familiar area.
- Developing Resettlement Action Plans. When acquiring private or occupied land is needed, it is important to specify the process of acquiring resettlement sites with private owners/land users and to negotiate fair compensation, preferably land-for-land compensation for farmers. A Resettlement Action Plan (RAP) establishes a formal framework for affected people so to obtain fair and timely compensation for losses. The compensation needed must be completed before civil works begin, and it is essential to monitor the timeliness and accuracy of payments to private landowners or users. A resettlement action plan enables identifying the relevant needs and establishing an accountable and efficient mechanism to address them.

Under the WACA, a decision-making framework for voluntary resettlement has been proposed for consultation (Figure 25).

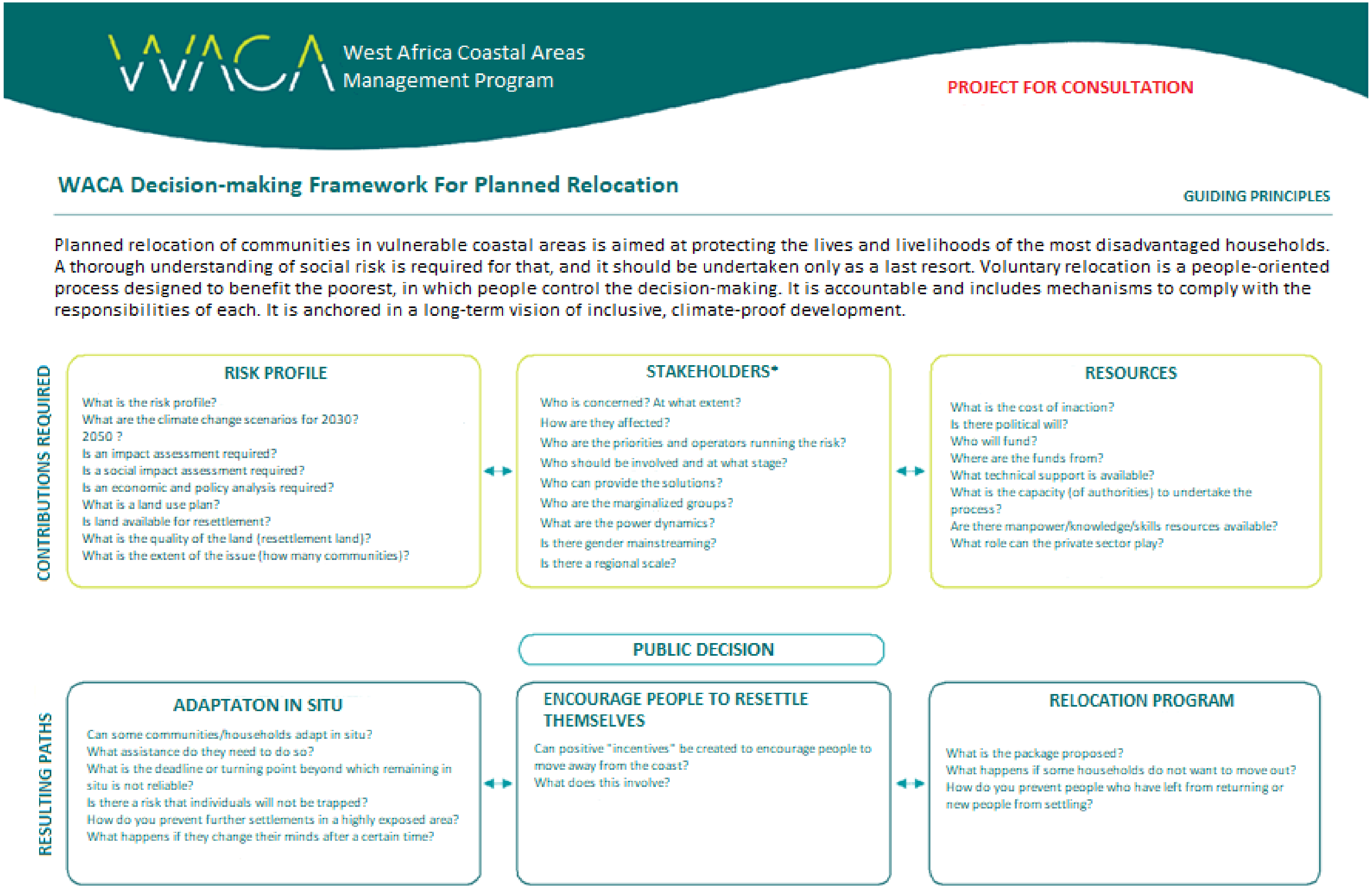

Figure 25 : WACA Decision-Making Project for Planned Resettlement

EXAMPLE OF PLANNED RESETTLEMENT

São Tome & Príncipe

The case of São Tomé and Príncipe illustrates a climate change adaptation strategy based on the planned resettlement process. The São Tomé & Príncipe coastal areas undergo the consequences of climate change and anthropic activities such as sand extraction, with coastal erosion and strong floods caused by the changing storm surges and river floods. To address these natural hazards, São Tomé & Príncipe has recently developed a strategy aimed at helping coastal communities to better cope with climate change and to become more resilient. The essence of this strategy, currently led by the government, is to effectively manage the planned **resettlement of people from risky coastal areas to safer areas on higher ground**. This approach responds to a public demand following the unusually strong and damaging storms of 2014-2015.

One of the steps in the strategy was to **characterize the coastline evolution**. This was done by comparing 1950s topographic maps with current high-resolution satellite images. This work enabled to map the changing settlements, to estimate their risk exposure, and to calculate the real coastline retreat rate. For the Malanza community, for example, it became clear that the coastline retreated more than 100 meters in 60 years. Comparing maps and satellite images enabled to project the future hazard patterns and the most exposed areas were identified. These projections were shared and discussed with communities to ensure a common understanding of the risks, and explore resettlement options as a means of preventing future damage and loss. In parallel with the mapping of vulnerable households, communities participated in the **identification of the poorest households**. The results of these two exercises were **validated jointly with the community** so that there was general agreement on who was vulnerable and should therefore be prioritized regarding resettlement to safer areas.

For São Tomé & Príncipe, an important factor on the community vulnerability and risk exposure is the uncontrolled extension of houses built near or directly on the beach and in flood-prone areas. This is worsened by the fact that even after the settlements are swept away by a hurricane or flood, people return to build new houses in the same area. Therefore, the Government has secured an area, called the **extension zone**, to build new settlements in a safe location so as to house the poor families from vulnerable areas. The proposed extension area was delimited and converted from rural to urbanized land. The area lots were for the most vulnerable households on the beach, who have formal rights to the new lots, which they did not have before. This gives them security of tenure in the new area.

These new extension areas also aim at attracting new people, and becoming development hubs. To ensure long-term growth, the extension areas planning must include providing basic socio-economic services, and ensuring that the houses have sufficient space around them for future extension. Moreover, the extension areas development plans include facilities such as **schools** and **health centers**, area for **small businesses**, **sports fields**, and **green spaces**. In addition, some **social houses for poor or vulnerable citizens** (including the elderly and disabled) could be included in the extension areas. Although this process is still ongoing, important lessons can already be drawn, such as the need to commit the population from the beginning. Community commitment and leadership at every stage of the planned resettlement process emerged as an essential success driver. This enabled anticipating and addressing community concerns, including who would be prioritized when resettling to safer areas. In São Tomé & Príncipe, this issue was addressed through a participatory approach to identify risky areas and vulnerable groups. Validating the results with the affected people proved essential to ensure the population commitment, as well as to ensure accountability and acceptance of the process. A top-down process that involves the community only at the last minute should be avoided. The community would then oppose the plans or speculate on the land value.

Finally, maintaining valuable socio-cultural ties can be difficult and requires effort from planning authorities and communities. In São Tomé and Príncipe, the fact that communities have extended into adjacent areas facilitates maintaining social and economic ties.

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EXAMPLE OF PLANNED RESETTLEMENT

LANGUE DE BARBARIE - SAINT LOUIS, SENEGAL

A relocation scenario is being considered for the densely populated Guet-Ndar fishermen district (Saint Louis, Senegal), which is located very close to the ocean. This sector is undergoing erosion that can reach 1 to 3 m per year according to the sources and the entire sections of the neighborhood have already been eaten away by erosion. In the very short term, a riprap was been built to reduce the neighborhoods exposure to swells. A longer-term scenario considers planned relocation strategies. This illustrates the need for **temporality in the solutions** that must be considered jointly and perhaps in sequence also, each being best at a specific space and time scale.

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Institutions: World Bank

3.3.2.2 *Population Resilience Building: Community-Based Commitment and Local Actions*

Community-Based Activities to Build Resilience, IGAs

In addition to the physical measures for reduced vulnerability (through tools such as flood protection mechanisms, relocation, safe building practices...), protecting people from coastal hazards requires building the capacity of communities to respond, cope, and recover from natural hazards. Community resilience building must be integrated into any risk management strategy or project.

Mobilizing Community Capacities to Protect the Coastline and Build Resilience: Organized communities have great mastery of risk management based on their experience. Therefore, they should be stakeholders in building resilience rather than simple beneficiaries. Research shows that community leaders can set priorities, influence public policy, and design and implement investment programs that meet community needs. Communities can lead the way, but they must be connected to higher-level policy, technical assistance, and information to have a sustainable impact. Promoting citizen commitment in coastal risk management and partnerships between communities and local/national authorities enable to build resilience.

The Response Area to Build Community Resilience is Large: Improved and varied livelihoods, sustained natural resource management, improved health and safety, environment-related education and awareness activities, risk awareness, participating in small-scale works or preparedness activities for reduced climate change and disaster risk, and varied livelihood including income-generating activities.

These activities can be implemented by local authorities, communes, local groups, associations or NGOs, based on a community-driven development approach.

INCOME GENERATING ACTIVITIES (IGAS): CASE OF BENIN

In its social investments for reduced coastal risk, Benin projected Income Generating Activities to preserve the natural resources of its Ramsar site 1017.

The biological diversity of Benin's Ramsar 1017 site, which is a protected area under the Ramsar Convention, is threatened by an increasing anthropogenic pressure.

In order to reduce this pressure, the WACA ResIP Benin project funded the development and implementation of alternative income-generating activities (IGAs) for the riparian populations in the Community Biodiversity Conservation Areas (CBCAs) as the recent experiences in Benin between 2010 and 2017, under other projects funded by the World Bank, including i) the Community Management of Marine and Coastal Biodiversity Project (PGCBMC), ii) the Riparian Forest and Land Management Project (PGFTR), and iii) the Protected Areas Management Support Project (PAGAP) have shown that IGAs are an efficient tool for improved living conditions of the populations and for reduced pressure on the natural resources of protected areas.

Types of IGAs Funded by the WACA ResIP Benin

The main activities funded concern (i) small businesses; (ii) agricultural activities including market gardening, fish farming, rice farming, fisheries and poultry, goat and pig breeding; (iii) processing activities comprising palm and peanut oil production units, fish smoking areas, and gari, starchy cookies, and small-scale soap production units; (iv) salt production; and (v) beekeeping.

IGA Selection Procedure

Ten major steps characterize the selection process. These include: (i) Information / Awareness raising; (ii) promoter registration; (iii) micro-projects pre-selection; (iv) environmental and social screening; (v) micro-project files preparation; (vi) file supporting by promoters; (vii) request for a no-objection opinion from the World Bank; (viii) funding agreement selection and signing; (ix) Setting up financial resources and community procurement; (x) implementation follow-up/control and support/advice.

Some Results

Thus, implementing alternative income-generating activities (IGA) has been effective with the signed thirty-two (32) agreements for four hundred and ninety-five (495) direct beneficiaries (75% of whom are women) for the first generation of IGAs. The amount committed at the end of April 2020 for this first generation is FCFA 268,594,639 i.e. an average of FCFA 8,393,582 per cooperative and the amounts of the project subsidy vary between 1,600,000 FCFA and 25,000,000 FCFA. Furthermore, in order to mitigate the Covid-19 impacts, 595 IGA funding agreements were signed for 846 direct riparian beneficiaries (85% of whom are women) in the Community Biodiversity Conservation Areas (CBCAs) for the second generation. The amount committed at the end of November 2020 for the second generation is estimated at FCFA 69,584,045 or an average of FCFA 117,000.Funding allocations by type of IGA micro project are capped as follows:(i) individual micro project: CFAF 50,000 to 200,000; (ii) micro project for microenterprises:250,000 to 1,000,000 CFCA; (iii) micro project for cooperatives:1,100,000 to 5,000,000 CFCA

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Institutions: WACA ResIP Benin Project PMU

Description of Some IGAs under Implementation

All selected and retained IGAs are subject to the environmental and social management procedure in accordance with the world Bank's Operational Policies (OP) triggered under the WACA and national regulations on environmental and social assessment.

Small Businesses

These include seasonal products sale activities (fish, foodstuffs), cheap erstaurants, handicrafts (hairdressing, beauty care, etc.).They account for about two hundred and are run by associations or individuals. As such, seventy-seven (77) requests for support have already benefited and will benefit nearly a thousand people.

Market Gardening, Fish Farming and Rice Farming

Market gardening includes seventy-one (71) micro projects distributed in seven communes in the response area (Ouidah, Athieme, Lokossa, Houeyogbe, Aplahoue, Come and Grand-Popo). These are mostly market gardening areas ranging from 0.5ha to 9ha wide.

Rice farming micro projects are concentrated in the communes of Dogbo (5) and Athieme (6).The rice fields are 0.5ha to 9ha wide.

Photo 1:Onion Farming in Ouidah (Noudehou D., 2020)

Photo 2 :Tomato Farming in Ouidah (Noudehou D., 2020)

Photo 3 :Rice field Perimeter (Noudehou D., 2020)

Photo 4 :Fish Farming Facility (Kouchade M.., 2020)

There are 8 fish farming micro projects distributed in five communes (Ouidah, Athieme, Lokossa, Come, and Grand-Popo). For most of these micro projects, the requested funding is for building or rehabilitating a maximum of 5 ponds.

Livestock

There are a total of 47 livestock micro projects in almost all the communes except Grand-Popo. They cover poultry, pig, rabbit and goat breeding. Apart from the eight cases of table egg production, all the others are hutches.

Photo 5 :Pig Breeding in Deve (Kouchade M., 2020)

Photo 6 :Poultry Farming in Athieme (Noudehou D., 2020)

Agricultural Product Processing Units

These are micro projects to build and exploit gari (processing cassava into flour), palm and peanut oil, soap and cookies production units. They are found in all the communes of the response area, except Abomey-Calavi and Grand-Popo. 34 out of 52 production units are dedicated to the production of palm oil and by-products.

Photo 7 : Peanut Shelling (Noudehou D., 2020)

Photo 8 :Palm Nut Pulping (Noudehou D., 2020)

Salt Production (salt farming)

These include micro projects for acquiring and sometimes developing small spaces for the heating required for salt production. They are thirteen (13) and they are exclusively found in the Ouidah commune.

Photo 9 : Brine Extraction Devices (Noudehou D., 2020)

Photo 10 :Salt Heating Area (Noudehou D., 2020)

3.4 West African Coastline Observation for Producing Data and Establishing an Early Warning System

While questioning on climate change and global sea level rise, what attitude should be adopted in order to protect the stakes against the combined hazards of marine submersion, coastal erosion, and other concerns such as pollution or early warning actions? The stakes are particularly high in a territory gathering an increasing number of people and activities (real estate, tourism, industry, transport, port activities...). In order to meet this knowledge and sharing requirement, the WACA program supports West African countries in the process of establishing a West African Regional Coast Observatory (WARCO), which will cover twelve (12) countries (Benin, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mauritania, Sao Tome & Principe, Senegal, Sierra Leone and Togo), support them in their will manifested since July 2018 to transform the West African Coastal Observatory Mission (MOLOA) with dedicated funds.

3.4.1 Towards a West African Regional Coastal Observatory (WARCO)

The objectives and organization of the West African Regional Coastal Observatory (WARCO) can be summarized as "**Observe to better understand, better understand to better decide**" and can be translated as follows:

- **Improving and enhancing scientific and technical knowledge** by promoting, producing and sharing reliable and homogeneous data through harmonized acquisition protocols;
- **Providing a tool for the assisted and shared understanding, knowledge and management of coastal phenomena** by pooling skills and resources to facilitate emerging joint actions, promoting and participating in actions aimed at communicating, raising awareness and involving civil society in order to disseminate knowledge and increase acquisition sources;
- **Implementing a sustainable and integrated coastal policy** by supporting the emergence of new local observatories, the consolidation of existing observatories or local initiatives in terms of coastal monitoring;
- **Operational organization of the regional observatory.**

3.4.1.1 *Overview of Existing Observation Devices*

The results of the quiz sent to the various structures within the WARCO countries show a varied profile of the data produced, priority themes, production and storage resources requirements, and the recommended collaboration conditions with the regional level.

The structures operating at the national scale are more numerous (85.40%). These include public structures that are competent in all the relevant territories. They also have decentralized services that respond at the level of communes, departments or even locally.31.30% operate at local level, 20.80% at communal level and 14.60% at administrative subdivision level (department or district). 37.50% of the structures operate at the international level. Finally, very few structures operate at the regional and sub-regional levels (Figure 26).

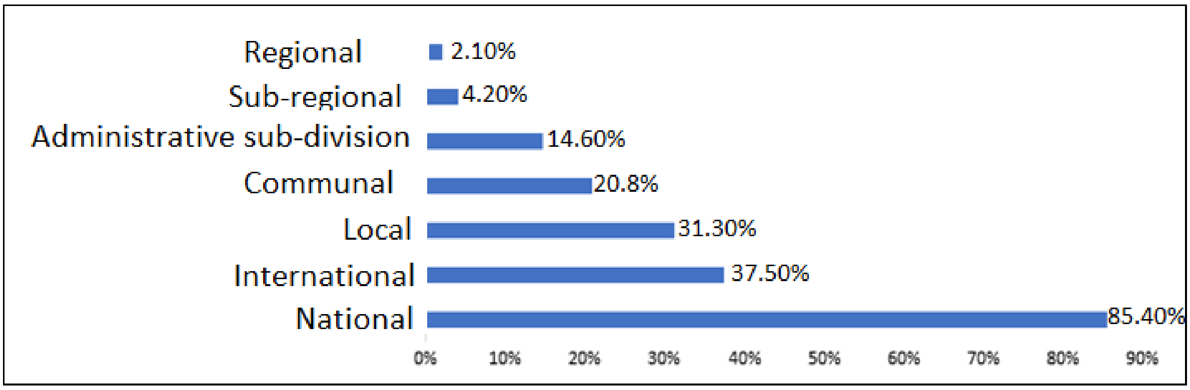

Figure 26 : Response Scale of Existing Observation Devices

Several themes are studied by the structures: the risk components and the coastal risk drivers.

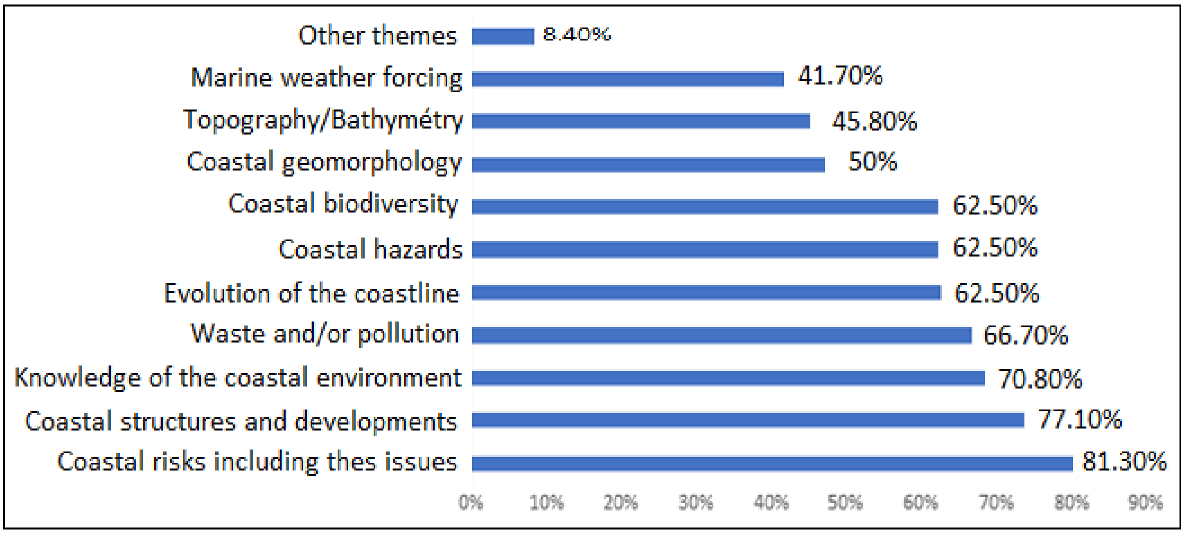

Figure 27 : Themes Studied by the Existing Observation Devices

77.10% of the structures are interested in monitoring the works and the various coastal developments. The structures, which are mostly port, navigation and industrial facilities, are very important for the economy of the countries. They contribute significantly to their GDP. The Kpeme wharf (Togo), which houses the country's phosphate plant, contributed nearly 25% of Togo's GDP in 1988 and the Cotonou port will contribute nearly 60% of Benin's GDP in 2019 (Ministry of the Economy). There are also mineral ports, fishing ports and marinas.

Another category of stakes in which the structures are interested is biodiversity. With degraded and/or eroded coastal areas representing a loss of habitats, several species are threatened and then tend to disappear (e.g. mangrove ecosystems that play very important roles in protecting the coast against several coastal hazards). It is therefore important to follow up these ecosystems in order to preserve and restore them. The "Biodiversity" theme concerns nearly 63% of the organizations.70.80% of the structures are involved in producing and disseminating knowledge on the countries' coastal environment.

As major components of coastal risks, coastal hazards are at the core of the themes followed by 62.50% of the structures. The latter are specifically interested in the dynamics of the coastline, revealing erosion or accretion, marine and river submersion.

The structures have several human resources enabling them to achieve the objectives they set. These objectives are heterogeneous, but are not intended to be homogeneous, only the fact of having a common core of missions counts. The public institutions have teams of state officials who are assigned to the various tasks. As for Universities and research units, they have teaching staff (lecturers, professors, etc.) and trainees (doctoral students, master's students) working on the different themes in the various specialized laboratories. Engineers are also hired on fixed-term contracts for specific projects or missions. The general conclusion is that there is no shortage of human resources. The same does not apply for material and financial resources.

Apart from a few large public structures (less than 10%) that have high-performance equipment, including GPS RTK, rolling stock for traveling within the field, servers, and operating budgets allocated at the beginning of the year, the resources of the other structures are limited to some computers, GIS software and some low-precision GPS. These structures declared having no financial resources enabling them to produce data on the different themes studied. As for the structures serving as focal points for the various regional projects and programs, they have the material resources and subsidies needed to carry out their mission.

Moreover, it is necessary to monitor the sea level using tide gauges, especially in the vicinity of densely populated areas. The Global Sea Level Observing System (GLOSS) of the Intergovernmental Oceanographic Commission (IOC) coordinates the Sea Level Station Monitoring Facility portal. This portal is a global service for monitoring sea level stations in real time. Only two tide gauges broadcasting in real time are operating on the coastline of the observatory (Table XXI).

Table XIXI : Inventory of West African Operating Tide Gauges[47]

City (Country)	Location	Responsible Organization	Other Contact	Commissioning	Source
Dakar (SN)	14.67619100 -17.42035700	National Oceanic and Atmospheric Administration	University of Hawaii Sea Level Center (USA)	1942	http://www.ioc-sealevelmonitoring.org/station.php?code=dakar
Nouakchott (MR)	18,1 / -15,95	Autonomous Port of Nouakchott		2007	http://www.ioc-sealevelmonitoring.org/station.php

The Sea Level Station Monitoring Facility thus disseminates data from these two structures. Only the Dakar tide gauge is disseminated by the UHSLC. Four ports in the observatory area are disseminated by the PSMSL:

- Abidjan (Côte d'Ivoire) from de 1971 to 1976;
- Tema (Ghana) from 1963 to 1982;
- Takoradi (Ghana) from 1929 to 2012;
- Dakar and Dakar 2 (Senegal) respectively from 1942 to 1966 and 1992 to 2018.

[47] http://www.ioc-sealevelmonitoring.org

Some observatories are known, but their measures are not disseminated:

- Autonomous Port of Abidjan (Côte d'Ivoire);
- San Pedro (Côte d'Ivoire) would have a mechanical tide gauge for 10-20 years
- Kpeme (Togo);
- Cotonou (Benin) has a pressure sensor. It appears to be the property of the Fisheries et Oceanographic Research Institute of Benin (IRHOB).

Among the three hundred tidal observatories labeled GLOSS, five are located in the regional observatory perimeter: Dakar (Senegal), Conakry (Guinea), Abidjan (Ivory Coast), Takoradi (Ghana) and São Tomé (São Tomé & Príncipe).

3.4.1.2 *Strengthened Observation Devices for Monitoring Indicators*

The indicators monitoring should be based on the ORLOA, whose feasibility study defined three risk components: stakes, hazards and risk management methods. The "Stakes" component includes both socio-economic and natural stakes. The "Hazards" component includes both natural and anthropogenic drivers. The "Representation and management mode" component concerns the existing management policies and their implementation, but also the collective memory of the risk.

For characterized coastal stakes and hazards, the feasibility study proposed a list of 94 indicators prioritized by the correspondents in the countries (Appendix 3) to better understand the processes and phenomena observed on the coastal strip, by following up the major coastal themes such as:

- coastal dynamics;
- weather and marine forcings
- qualification and quantification of the various stakes (human, economic and environmental);
- natural risks in the coastal environment (erosion and marine submersion);
- pollution and water quality;
- biodiversity as a marker of the coastal environments dynamics (seagrass beds, mangroves, coral reefs, invasive species ...);
- climate change effects.

In the short term, the ORLOA feasibility study validated with the correspondents in the countries, a list of fifteen (15) indicators to be followed up at the regional scale (Table XXII) by satellite imagery and marine meteorological data.

Table XXII : List of Indicators to be Followed up in the Short Term at the Regional Scale

Hazard Component	Theme	Category	Subcategory	Indicator
Stakes	Human	Population	Residing	Number of inhabitants/Density
	Housing	Residential	Houses	Number of residential houses
	Economic	Industries	Potentially polluting	Existence and number of industries
	Heritage	Environmental	Habitats: mangroves, wetlands	Surface evolution
	Equipment and management works	Prevention	Developments and protection	Number of works

Hazard Component	Theme	Category	Subcategory	Indicator
Hazards	Erosion	Coastline location		Coastline progress (erosion, stability, progradation)
		Beach progress		Topographic profiles
	Submersion	Submersion types		By overflows, by crossing of sea packs, by protection failure
		Flood-prone and submersible areas		Surface area (ha)
	Natural predisposing factors	Exposure to the generating factors		Coast orientation relative to swells/currents/winds
	Weather and sea forcing	Sea state	Swell	Significant height/period
	Anthropogenic erosive forcing	Sediment extraction	Onshore	Location and annual quantities
	Pollution	Physical, chemical, biological		Mining
	Flooding of estuarine and lagoon areas	Water height		Records of humidity traces
	Climate change	Sea level rise		Rise in cm/ decade/century projections

Gradually, the strengthened ORLOA observation device, through a network of nineteen (19) wave measurement stations located between 3 and 45 km from the coast, by depths less than 100 meters (Figure 28) proposed by the feasibility study will enable extending the monitoring to sea state indicators.

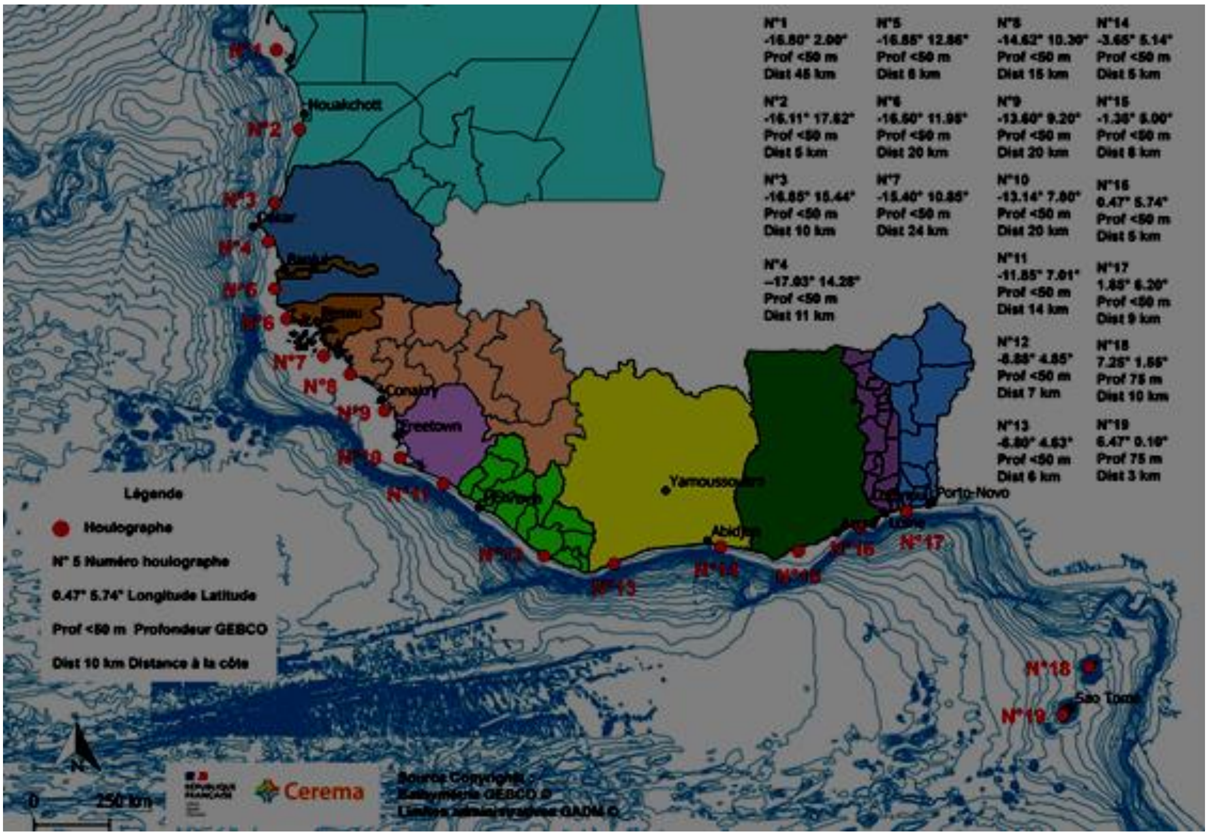

Figure 28 : Swell Measuring Network Project - Overview

The structures presented in the table below are likely to carry the maintenance of swell gauges at national level.

Table XXIII : Targeted Structures for the Swell Gauge Network Management

Regions/Country	Structures	Contact
Benin, Ghana, Liberia, Nigeria, Togo	Central West Gulf of Guinea Fisheries Committee (CPCO)	Website: https://fcwc-fish.org/?lang=fr
Mauritania, Senegal, the Gambia, Guinea, Guinea-Bissau, Sierra Leone	Sub-regional Fishery Committee	Website : http://spcsrp.org/fr Phone :+221 33,864 04 75
Mauritania	Mauritanian Institute of Oceanographic and fisheries Research (IMROP)	Adress: Ministry of Maritime Fisheries and Economy Office: Phone: +222 45 25 46 07 Fax : +222 45 25 31 46 Email : mpem@peches.gov.mr
Senegal	**High Authority in charge of the Coordination of Maritime Security, Maritime Safety and Protection of the Marine Environment (HASSMAR)**	Dakar contact@hassmar.gouv.sn
The Gambia	Sub-regional Fishery Committee	Website : http://spcsrp.org/fr/gambie
Guinea-Bissau	Ministry of Fisheries	Phone : + 245 20 11 57
Guinea	Ministry of Maritime Fisheries, Aquaculture, and Economy	Website: www.peches.gov.gn/index.php/contacts
Sierra Leone	Sub-regional Fishery Committee	Website : http://spcsrp.org/fr/sierra-leone
Côte d'Ivoire	Ministry of Animal and Fisheries Resources	Website: www.ressourcesanimales.gouv.ci/actualite.php?rd=12
Togo	Ministry of Agriculture, Livestock and Rural Development	Website: https://agriculture.gouv.tg/pasa-aux-cotes-des-pecheurs/ presse@agriculture.gouv.tg
Benin	Ministry of Agriculture, Livestock and Fisheries	Website: www.gouv.bj/actualite/477/ministere-de-lagriculture-de-lelevage-et-de-la-peche-lexecution-du-budget-gestion-2020-lancee/
São Tome & Príncipe	Ministry of Public Works, Infrastructure, Natural Resources and Environment	Adress : Po Box 130 - Avinda Marginal 12 de Julho - Sao Tome

A tide gauges network with various conditions depending on the country already exists on the West African coast; it seems important, firstly, to modernize the tide gauge observatories that are still operating today, and to refit the observatories that no longer exist. Priority will be given to the commercial ports of the different countries, due to the geographical and physical locations protected from marine hazards (storms, large swells…), and for easy access and maintenance.

Each tide gauge site will be deployed, controlled and maintained in operational condition thanks to one or more local partners, generally responsible for the port or the installation site (large seaports, local authorities, chamber of commerce and industry, departmental directorate of territories and the sea...). Local university partners should be associated with these structures to source the research and optimize the analyses and uses of the data collected. The operators of the tide gauge installation sites will have to approach the competent and interested local universities in order to carry out this partnership.

The tide gauges network of the West African Coastal Observatory should, for readability and accountability, meet the applicable international measures, the GLOSS network: Global Sea Level Observing System. The study and monitoring of recent and current climate variations in the sea level are organized at the global level under the GLOSS program of the UNESCO's Intergovernmental

Oceanographic Commission. This program is mainly based on a global network of some 300 tide gauge stations around which are built denser regional networks.

The GLOSS stations are typically grouped according to three scientific interest poles (source: http://refmar.SHOM.fr/fr/applications_maregraphiques/programmes-projets/programmes-internationaux/gloss):

- GLOSS-LTT, for studying long-term sea level trends;
- GLOSS-ALT, for "calibrating" satellite-borne radar altimeters;
- GLOSS-OC, for monitoring the general circulation of the oceans.

GLOSS provides supervised and coordinated global and regional sea level networks, and relies on the feedback and guidelines from the local tide gauge operators to maintain the creation of high quality sea level observations. The climate, coastal, and operational service modules of GLOSS contribute to the Global Ocean Observation System (GOOS) by developing progressively the sea level network, data collection and exchange systems, and preparing sea level products for various user groups.

The following structures are targeted for porting locally the proposed tide gauge network.

Table XXIIV : Targeted Structures for the Tide Gauge Network Porting

Country	Port	Bearing Structure	Contact
Mauritania	Nouakchott	Autonomous Port of Nouakchott	Address: Po Box. 5103 Autonomous Port of Nouakchott, Nouakchott Mauritania Phone: +222 45 25 38 59 Email : contact@port-nouakchott.com
Senegal	Dakar	Subdivision of Lighthouses and Beacons (Autonomous Port of Dakar)	Address: Bd de la Libération Phone : +221 33,849 45 45 website : https://www.portdakar.sn/fr/nous-decouvrir/presentation/organigramme/subdivision-des-phares-balises
Gambia	Banjul	Banjul Port	Gambian Port Authority Phone: +220 4228 690 Email: info@gamports.com Website : http://www.gamports.com/
Guinea-Bissau	Bissau	Bissau Port	
Guinea	Conakry	Autonomous Port of Conakry	Email: info@portconakry.com Phone: +224 655 80 00 80 Adress: Northern Coast Road, Almamya, Kaloum Commune Po Box:805, Conakry
Sierra Leone	Freetown	Freetown Port	Email : ftl.com@bollore.com
Liberia	Monrovia	Freeport of Monrovia	Phone : +231 (0)777 756 999 Email : George.g.adjei@apmterminals.com
Côte d'Ivoire	Abidjan	Autonomous Port of Abidjan	Directorate General: Phone: +225 21 23 80 00 Web site: http://www.portabidjan.ci/fr/port-authority/contacts
Ghana	Takoradi	Takoradi Port	Adress: Po Box 708.Takoradi. Ghana Phone :+233 (0) 3120 24073, 2021436, 2024208 Fax +233 (0) 3120 22814 Email :takoradi@ghanaports.gov.gh
Togo	Lomé	Autonomous Port of Lomé	Adress : Po Box 1225 Lomé TOGO Email : togoport@togoport.tg
Benin	Cotonou	Autonomous Port of Cotonou	Phone : contacts@pac.bj Phone :+229 21 31 26 37 Phone : +229 21 31 28 91 Phone : +229 69 85 85 85 Website : http://www.pac.bj

Country	Port	Bearing Structure	Contact
			Website : http://www.portcotonou.com/
São Tome & Príncipe	São Tomé	Empressa National d'Administration des Ports (ENAPORT)	Website : www.enaport.st Phone : +239 12 21,841 Phone : enaport@cstome.net

3.4.2 Satellite observation to support the management of costal areas and marine activities

Disaster Risk Reduction (DRR) is the concept and practice of reducing disaster risks by diminishing exposure to hazards, lessening vulnerability of people and property, managing wisely, and improving preparedness for adverse events. Understanding disaster risk in all its dimensions (hazard characteristics, exposure of people and assets and vulnerability) is the first priority action of the Sendai Framework for Disaster Risk Reduction (2015-2030) (UNISDR U., 2015).

In this framework, satellite Earth Observation (EO) represents a powerful tool to generate uniform information on global scales and covering wide span of risk scenarios. It constitutes a unique source of information that can help monitoring and link hazards, exposure, vulnerability modifiers and risk. Moreover, there had recently been important investments on satellites providing free of cost data, with substantial potential to contribute to DRM and DRR. Most of the biggest EO programmes are moving to free and open source policies so that the data produced can be used without restriction.

Satellite Earth Observation provides valuable information for many applications in support of disasters, especially contributes primarily to the hazard and exposure components of the Disaster Risk management cycle: Exposure mapping to support preparedness/mitigation, early warning & response; Monitoring of up to date, synoptic, and objective infrastructure information concerning assets at risk; Early warning/alert and tracking of a range of natural hazards, including tropical cyclones, landslides, and volcanoes; Hazard mapping and risk assessment; Disaster response following natural and man-made hazards and support for Crisis Mapping/Damage Assessment; and Support to recovery/reconstruction/ rehabilitation.

Satellite Earth Observation data can enable an unprecedented understanding of the global environment. Maritime regions, and in particular coastal zones are notoriously expensive and challenging to measure and monitor using in-situ techniques. Hence, it is in these regions where EO data has a particularly vital role to play; in many cases there are no viable alternatives to accessing information essential to decision-making and management of these zones which are facing increasing anthropogenic pressures. However, the data have be delivered effectively, i.e. as useable, validated and credible information, in the formats and *via* the channels that users require.

Since 2008, the European Space Agency has worked closely with the International Financing Institutions (IFIs) and their client countries to harness the benefits of EO in their operations and resource management. The ESA funded EO4SD Marine and Coastal project[48] is working with WACA to provide access to EO services and training and address barriers to ongoing utilisation of EO as a core element of the coastal and marine zone management 'toolkit'. All data processed for EO4SD are open access, available *via* a data portal that can be accessed *via* the data portal tab at http://eo4sd-marine.eu/ or directly at http://eo4sd.brockmann-consult.de/. This chapter provides a summary of some of the services

[48] http://eo4sd-marine.eu/

being provided. In all cases these are most effectively used in combination with other sources of information, including, most importantly, local knowledge and expertise.

The partnership delivering this contribution includes some of the leading institutes, companies and individuals working in the sphere of satellite oceanography; representing organisations that are at the forefront of applying scientific knowledge to address global marine issues, as well as possessing extensive experience working with and within developing countries.

3.4.2.1 *National and Regional scale Land Cover Mapping to monitor changes of an area*

Coastal land cover types are generated by combining optical (Sentinel-2, Landsat-8) and SAR (Sentinel-1) data. A supervised classification method has been applied to a number of spectral band indices derived from the optical data and statistics from backscatter information from several SAR acquisitions. Training areas are defined by best knowledge from the image and Google Earth images in very high resolution quality. The focus was put on the differentiation of mangroves, forests and agriculture for vegetated areas. Urban and settlements are distinguished as well as water areas. The areas above 40m elevation are masked out as our focus is on the coastal zone. The map in Figure 29 shows the land cover map for Benin based on data from 2019 and 2020. In order to monitor changes of an area, former years need to be classified as well. This would show the change of the most important surface types, e.g. growing urban areas and settlements or changing mangrove habitats. This information can be linked to water quality information such as turbidity or algal bloom occurrence to investigate the influence of the coastal environment.

It is crucial to have a good verification of land cover classification, especially when used for change detection. Therefore, local knowledge is very valuable and not yet integrated in the above shown map.

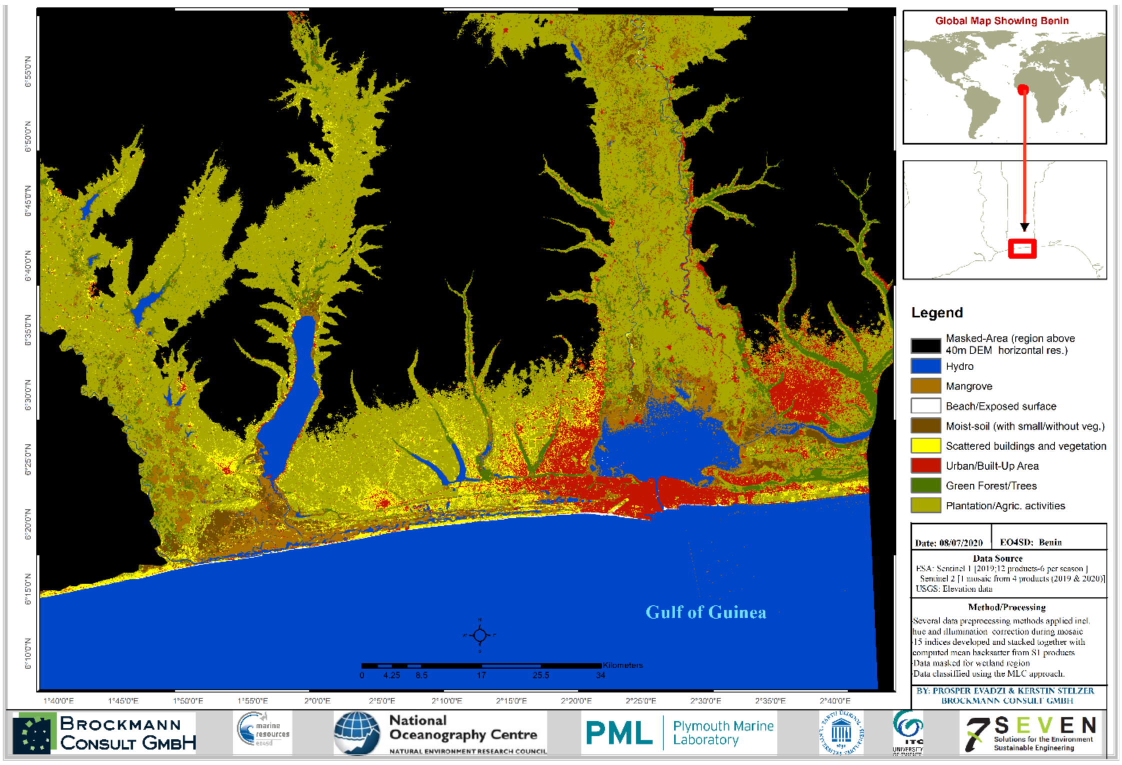

Figure 29 : Coastal Land Cover Map of Benin showing urban, vegetated and water surfaces

The specific case of urban areas

Validation is performed by comparing the classification result with very detailed satellite images provided by Google Earth Pro. Here, historic and recent data can be visualized and overlayed with the classification results. If ground based measurements would become available, a validation can be performed based on those valuable data.

Figure 30: Overlay of urban areas derived from classification method (white line) on high resolution google Earth layer. The map shows good agreement of the urban delineation with the underlaying map (yellow arrows) but also wrongly classified urban areas (orange arrow)

During the processing of several areas and periods, some issues occurred and hindered to produce multi-year time series for showing the development of urban area at this stage. One problem is the availability of cloud free images for suitable seasonal information. Further, the high resolution data of Sentinel-2 and Sentinel-1 is only available since 2015. For former years, Landsat-8 is a good alternative, but has different spatial resolution and therefore, results are slightly different. For some areas (e.g. Senegal, Dakar region), the differentiation between bare soil and build-up areas could not be produced in needed accuracy to perform a trend analysis over several years. More time and effort would be needed to correct for some wrongly classified surfaces in respect to urban areas. Nevertheless, Erreur ! Source du renvoi introuvable. shows an example of urban development from 2011 to 2019 observed with google earth very high resolution layers and which are overlayed with the outline of urban classes from the above described classification from 2019/2020.

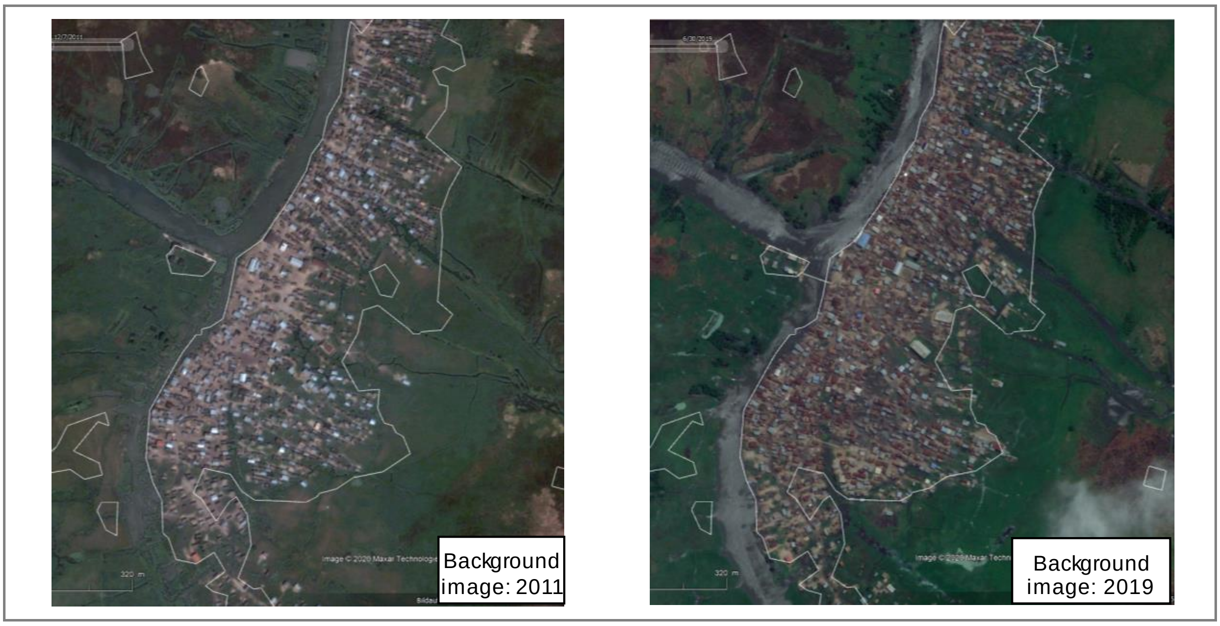

Figure 31: Overlay of 2019/2020 classification in Google Earth Pro on a high resolution image from 2011 (left) and from 2019 (right)

The large-scale analysis of urban development is performed based on existing, publicly available global data sets. More and more data sets, also with higher resolution are available and could be investigated against its quality and applicability for the urban development assessment. A study on comparing those data sets would help to assess the accuracy and reliability. Especially for change detection the accuracy of each single year classification needs to be very high, else real changes in the land use cannot be separated from changes caused by misclassification.

The high resolution classification that is focusing on a certain region is in general more accurate than global products because they contain much more detailed information, and they can be tuned individually. The accuracy increases the more knowledge is available for the respective region in terms of land cover. Here, ground-based information is a great value – on the one hand, for the training of the certain classification method, on the other hand, for the validation of the results.

A combination with third party information such as the urban footprint (https://urbanfootprint.com/) or data about population should be taken into account in order to improve the classification results.

The detection of urban areas profits from using optical and radar data in a common classification system. Especially in areas, where cloud coverage is limiting the acquisition of suitable optical data, radar data have great advantage because they are independent of the cloud conditions. More investigations and experience in combination with ground truth data would lead to better results and consequently a better basis for change detection analyses. Other activities and research groups are also developing and applying urban classification and should be consulted.

Contacting and including experts from remote sensing and from ground i.e engagement with ORLOA Regional Coastal Observatory (regional/national) focal points to scale up this work on subsequent phases or contacting EO4SD urban cluster would be very valuable next steps.

The specific case of mangrove ecosystem monitoring

One of the main goal of the classification was to identify the mangrove areas, but their differentiation from forests is still challenging for very dense vegetation (as the water below cannot be seen).

Advances in Satellite technology, as well as the availability of freely available datasets and open source software, have led to the production of increasingly accurate and comprehensive datasets on mangrove extent, structure, and condition, which can support the evaluation of ecosystem services and stimulate greater conservation and rehabilitation efforts (Worthington et al., 2020). Most commonly, multispectral optical data from the Landsat Earth Observation Archive, the Sentinel-2 archive and Synthetic Aperture Radar satellite data (ALOS PALSAR and Sentinel-1) are used in mapping and monitoring coastal mangrove forests globally and in West Africa (Bunting et al., 2018; Giri et al., 2011; Goldberg et al., 2020; Nwobi et al., 2020; Thomas et al., 2018). However, significant inconsistencies remain among mangrove extent data products, due to the methods used in data collection and analysis, the timing of the study, type of earth observation data, resolution and spatial extent (regional or global) of the data products. These inconsistencies result in uncertainties and sometimes contradictory results.

The advantages of global scale products are vast- they are based on consistent mapping methodology that is repeatable on regular timeframes and therefore allow for multi-year change analysis. Their primary disadvantages are that:

- the 25m - 30m pixel resolution of most products (based on the USGS Landsat dataset archive) does not show small patches and stands,
- there is persistent cloudiness and less historical data available in West Africa, and
- these maps may have difficulty distinguishing mangrove and adjoining wetland and forest types. Regional (West Africa wide), country specific or smaller scale maps usually have higher accuracy and resolution, furthermore, they are important inputs to training and verification of larger extent and repeat measurements.

However, the methodology used is often more labor intensive and hard to repeat.

A detailed description and analysis of global datasets can be found in Worthington et al. (2020). Additional representative maps of mangrove condition, structure and ecosystem services are presented in Table XXV. These represent evaluations of Canopy Height, Biomass, Soil Carbon, Drivers of Change, Tourism, Coastal protection, Fishery enhancement, Conservation Hotspots amongst others. Note that many of these global maps will be less accurate to the West African region because of a lack of *in situ* datasets. Nevertheless, they provide an important overview of the status of mangrove ecosystem services in West Africa.

Table XXIIIV : Global datasets (Worthington et al., 2020) relevant to West African State of the coast; only datasets that are freely available and geospatial are shared

Dataset	Description	Year	Resolution	Link to download or view
Global Mangrove Atlas (Spalding et al., 1997)	Composite extent map based on compiled country-wide remotely sensed approaches	1999-2003	-	https://data.unep-wcmc.org/datasets/5
Global Distribution of Mangroves in 2000 USGS (Giri et al., 2011)	First globally consistent remote-sensing-based map of mangrove extent	2000	30 m	https://data.unep-wcmc.org/datasets/4
Continuous Global Mangrove Forest Cover for the 21st Century (Hamilton & Casey, 2016)	Global analyses of mangrove deforestation based on the GFC dataset	Annual 2000-2012	30m	http://faculty.salisbury.edu/~sehamilton/mangroves/
Global Mangrove Watch (Bunting et al., 2018)	Most current global analysis of extent captures both losses and gains over a 20-year period	1996, 2007-2010, 2015, 2016	25m	https://www.globalmangrovewatch.org/
Global Mangrove Loss Drivers (Goldberg et al., 2020)	Most current global analysis of mangrove loss by main driver of loss	2000-2005 2005-2010 2010-2016	30m	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1768
Global Mangrove height and biomass (Simard et al., 2019)	Canopy height maps based on a digital elevation model and lidar altimetry; Biomass maps based on a network of field measurements and height to biomass model	2000	30m	https://doi.org/10.3334/ORNLDAAC/1665
Global Soil Carbon (Sanderman et al., 2018)	Stock and Variation in soil-carbon density as assessed by machine learning approaches	2000	30m	https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/OCYUIT

While global datasets address many data needs related to mangroves in West Africa, a large gap in available geospatial datasets still exists. Here, developing regionally focused datasets can address not only the inconsistencies between existing mangrove extent datasets but also help fill the data needs for effective coastal management in West Africa. Examples of geospatial data needs for better mangrove management in West Africa are listed in the Table XXVI.

Table XXIVI : Dataset need

Dataset Need	Description
Mangrove species distribution	Maps of Individual species or species zonation
Restoration potential	Maps of areas suited for restoration given current and projected trends of stressors
Fine-grained Socio-Economic Spatial Data	Datasets on local, regional, and national laws and policies that are relevant to mangrove management are needed. This includes maps of for example Land tenure, laws, socio-economic status and other drivers of mangrove degradation
Existing rehabilitation and restoration efforts	Datasets on the location, design, costs, monitoring, and outcomes of rehabilitation and restoration attempts
Protocols for Monitoring and Data collection	Standardised protocols adapted to the West African context for restoration and rehabilitation, Carbon and other ecosystem service measurements
Field and Citizen Science Data	Ground Truthing observations from scientists, monitoring stations and citizen scientists
Real-Time or near real time mangrove monitoring	Maps of mangrove health and extent at frequent time intervals needed to monitor their health

Dataset Need	Description
Invasive species assessment and mapping	Maps of Imported and invasive
Regional Gains and Loss drivers mapping	Maps of country or regionally specific drivers of mangrove changes
Carbon stocks estimation	Locally derived estimates of soil Carbon and Biomass stocks
Ecosystem services	Assessment of local ecosystem services provided by mangroves
Condition and function	Maps of mangrove condition (for example healthy, degraded, impacted)
Vulnerability to climate change and direct anthropogenic effects	Assessment of mangrove vulnerability to current and projected climate change effects and human pressure
Data sharing Platforms	Regionally focused platform for data sharing and integration, Global Mangrove Watch https://www.Globalmangrovewatch.org

3.4.2.2 *Ground motion monitoring using satellite technology, a cost-efficient approach*

In a context of increasing intensity and frequency of disasters related to land instability, it is important to evaluate properly the possible impact of phenomena like landslides and subsidence. To accomplish this aim, cost-efficient techniques can be useful to monitor the ground and infrastructure stability over a wide area (regional global) avoiding large initial investment, increasing the risk management capacities of the developing countries to reduce losses.

The Geohazards Exploitation Platform – Online services for delivery of geohazards-related products. Use case in Senegal

The Geohazards Exploitation Platform (GEP - https://geohazards-tep.eu) is a cloud-based environment providing a set of EO processing services that allow mapping hazard prone land surfaces and monitoring terrain deformation. The platform is continuously expanding including a broad range of on-demand and systematic products and services, to support EO practitioners and end users to better understand geohazards and their impact (Foumelis et al., 2019). The GEP aims to improve acceptance of online-based EO services and products for geohazards assessment and their adoption in decision-making. Being a collaborative platform, it allows users to control their way to engage and interact with other users, for sharing and promoting their assets and/or results. To demonstrate the capabilities of GEP for timely delivery of accurate terrain deformation products, a total number of 352 Copernicus Sentinel-1 acquisitions covering the broader area of Dakar (Senegal) were processed using the Parallel Small BAseline Subset (P-SBAS) on-demand processing service provided by CNR-IREA. P-SBAS algorithm is a technique that permits to retrieve the Earth's surface displacement time series and

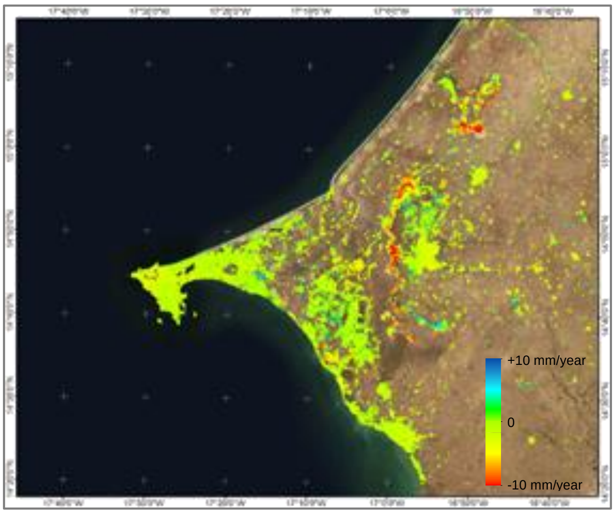

Figure 32: Terrain deformation of Dakar (Senegal) *via* GEP online services. Ground displacements for the period April 2015 – August 2020 based on InSAR processing of Copernicus Sentinel-1 mission data using the P-SBAS on-demand service implemented on GEP

mean velocity maps from a set of Synthetic Aperture Radar (SAR) images (Casu et al., 2014; Manunta et al., 2019). Details for the Copernicus Sentinel-1 SAR mission can be found on Sentinel Online - ESA.

More than ninety thousand (specifically 90.976) measurement points were obtained showing average terrain deformation for the period April 2015 - August 2020. The results highlight the status of the coastal zone of broader Dakar concerning ongoing subsidence or uplift phenomena. The inspection of the displacement time series offers additional information on the temporal behaviour (displacement history) of each measurement point.

Details:

- *Data source: 352 Copernicus Sentinel-1 data, from approx. 09/2015 to 08/2020, accessed online via GEP.*
- *Precision of the measurements: 1-2 mm/year.*
- *Product format: standard CSV file (TAB delimited including processing metadata).*

Interferometric Synthetic-Aperture Radar (InSAR) ground displacements are measured along the Line-of-Sight (LoS) of the satellite, expressing a combination of vertical and horizontal motion. Each measurement corresponds to the average motion within an area of 90x90 m on the surface. The geospatial accuracy of the results is approx. 15 m, while the expected measurement accuracy is 1-2 mm/year (Manunta and *al*. 2019).

Online-based services offer access to mature EO techniques and state-of-the-art technologies for the quick and low-cost investigation of terrain deformation (often at medium spatial resolution), allowing the identification of related hazardous phenomena. The benefit of such solutions is two-fold as it paves the ground for their utilisation directly by EO practitioners for their monitoring purposes; even end users after proper capacity building activities, while supporting the decision on whether or not to proceed with more tailored consultation (e.g. results at higher spatial resolution). The ever-increasing capabilities of EO exploitation platforms and the shallow learning curve requirements increase the prospect of adoption of EO solutions by decision makers, as well as the operational integration of platform-based services in disaster risk reduction schemes.

Use case of satellite technology for measuring subsidence in The Gambia

The EO4SD DRR consortium produced two different outputs measuring terrain deformation based on two different sources of information and using different algorithms. This coupled delivery demonstrates the utility of a multi-scale approach. In this approach, first there are output products produced at lower spatial resolution to obtain a general idea of the ground motion at stake. Then more detailed data can be provided for allowing better and more detailed understanding of the phenomena.

The displacement maps over Greater Banjul area is generated by the Rheticus® platform and delivered under the name of Rheticus® Displacement service. The processing is based on the implementation of the SPINUA algorithm, which uses Persistent Scatterer Interferometry (PSI) to perform InSAR time-series analysis and produce a dense map of measurement points (persistent scatterers and distributed scatterers, PS/DS) representing terrain motion, and providing a quantitative assessment of ground motion through the time series of displacement (mm) and the average velocity (mm/year) for each measured point.

Such detailed mapping of the spatial pattern of the displacement phenomena may contribute to the identification of underlying processes of the ground motion. The thematic interpretation of these results in relation to available local information such as surface morphology, geology, land use or population distribution can be provided as an advanced service (falls out of the present portfolio) by a DRR-expert team. Field campaigns or detailed analysis of in-situ data for a comprehensive end-to-end service are out of the scope of the project but may be provided by an external procurement.

Ground deformation is measured with precision up to 1 mm/year along the satellite's line of sight for coherent targets. The accuracy of the measures is guaranteed by a high level of error compensation of the PSI technique that allows the generation of time series analysis highlighting displacement trends over time.

Details:

- *Data source: 65 COSMO-SkyMed images, from 2011/05/31 to 2018/09/07, provided by the World Bank Group.*
- *Precision of the measurements: 1 mm/year.*
- *Delivery format: shapefile, Rheticus® platform (which including analytics tools to exploit the whole time series).*

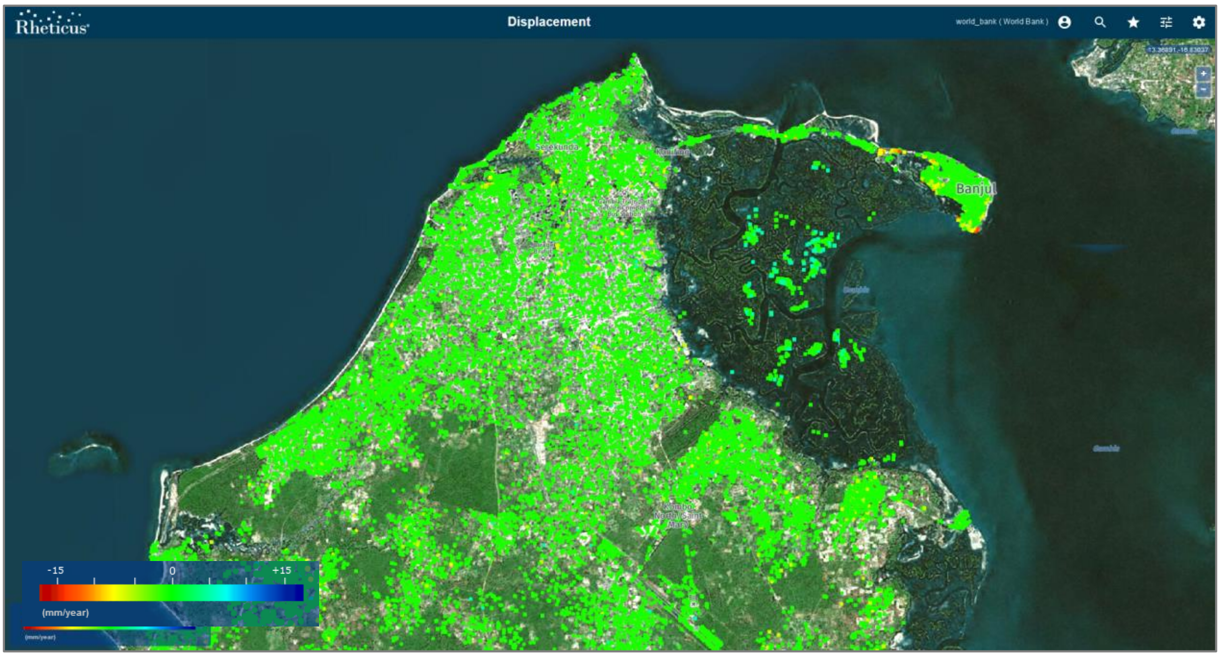

Figure 33: Result of the terrain Deformation processing with Planetek Rheticus performed under EO4SD DRR project. Overview of ground motion over Greater Banjul showing that most of the area does not present differential motion

Such detailed mapping of the spatial pattern of the displacement phenomena may contribute to the identification of underlying processes of the ground motion. The thematic interpretation of these results in relation to available local information such as surface morphology, geology, land use or population distribution can be provided as an advanced service (falls out of the present portfolio) by a DRR-expert team. Field campaigns or detailed analysis of in-situ data for a comprehensive end-to-end service are out of the scope of the project but may be provided by an external procurement.

Ground deformation is measured with precision up to 1 mm/year along the satellite's line of sight for coherent targets. The accuracy of the measures is guaranteed by a high level of error compensation of the PSI technique that allows the generation of time series analysis highlighting displacement trends over time.

Recently, EO-based service providers have focused on creating vertical services based on PSI techniques for the continuous monitoring of land and infrastructure stability to support the public authorities in charge or risks management both to protect citizens from danger and to prevent increased costs and delays to new developments[49].

[49] See as an example of the PSI derived service the Rheticus® Safeland use case to monitor land and infrastructures stability in Friuli Venezia Giulia region.

The availability of ground motion maps in fact enhances the capabilities to monitor and manage subsidence caused by the compaction of susceptible aquifer systems, and reveal new insights to mitigate the impact of physical processes, particularly important for the sustainable urban planning and design of new infrastructure like roads, bridges, electric towers, utilities, etc.

The conclusion of this exercise is that PSI technique facilitates cost-efficient land and infrastructure monitoring. Furthermore, freely availability of Copernicus data like Sentinel-1, and cloud platforms allowing processing and exploitation of such data, help to reduce the need of large initial investments, making the PSI technique extremely useful in developing and emerging countries.

Figure 34: Example of localised ground motion phenomena close to Banjul Harbor, with detailed time series graph of the displacement that shows a total movement of about 14 cm from May '11 to September '18 in the point highlighted in blue. Red and orange circles show clusters with differential terrain movement of more than 10 mm a year

3.4.2.2.1 Storm Surge Analysis

EO4SD Disaster Risk Reduction produced Bathymetry mapping and Storm Surge Analysis in The Gambia.

Satellite Derived Bathymetry. Sentinel-2 data has been processed according to ocean colour methodologies to retrieve simultaneously or independently of the depth and characteristics of the seafloor and the turbidity, i.e. the soil particles not yet deposited on the seafloor. The bathymetry thus calculated is not the depth of the consolidated sediment basement, but the depth of mud suspended sediment layers of various concentrations. The final product provides information of constant suspended sediment and layers of fluid sediment. Satellite imagery confirms the presence of permanent sediment layers fed almost entirely by coastal currents and marginally by Gambia outflows.

Coastal Flooding Analysis. The final product provides water levels (m) to evaluate the impact of floods nowadays and in 2100 in the context of climate change, assuming the three IPCC scenarios (RCP2.6, RCP4.5 and RCP8.5), for effective risk communication (Figure 35). Based on the World Bank DTM information, floods can reach 1.6 m today and between 1.9 and 2.7 m in the next 100 years, depending on the three IPCC scenario that have been considered. The provisional result is valid for the current storm climate, taking into account only a mild evolution of the weather due to climate change, i.e. excluding unprecedented extremes; for a stable shoreline, with no erosion, i.e. retreat of the coast that could reduce significantly the surface of the city; and for a 2100 pessimistic prediction of 2.7 meters rises above the land vertical datum, combining the Intergovernmental Panel on Climate Change (IPCC) worst scenario, spring tides and maximum known meteorological effects.

Our preliminary conclusion is that the main hot spots are (a) the junction between the city of Banjul and the greater Banjul in the West, and (b) the marshes south of Banjul. These assumptions do not take into account the existing civil works that protect the Banjul littoral and the marches vegetation cover which could trap enough sediments to remain emerged. What could be done, finally, to protect the northern side of Banjul and Greater Banjul, would be to polderise the shoreline with material dredged from the St. Mary and Horseshoe banks, which are natural reservoirs regularly replenished with sediments ripped from the West African shoreline.

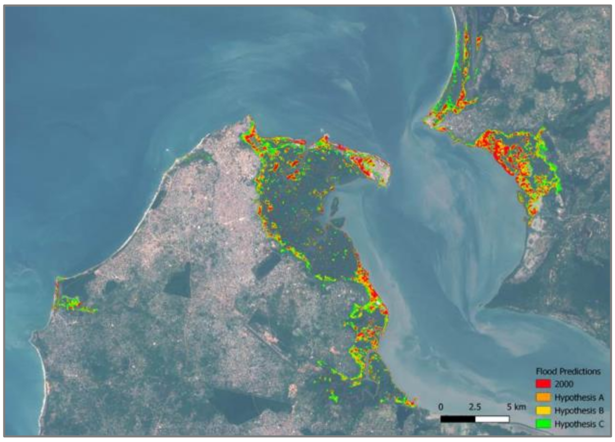

Figure 35: Flood chart of Greater Banjul with different flood predictions performed under the EO4SD DRR project by ARGANS

Additional hydraulics studies and wave modelling, based on an improved, if limited, bathymetry, knowledge of the nearshore seafloor sediments and backshore materials, would be needed to confirm this conclusion. Further speculations obtained by extrapolating nearby Senegal observations seem to indicate that an aggravation of the order of half a meter could be expected from swell and storm wave effect, but these are more guesses than rigorous scientific conjectures.

The quality of flood predictions can be refined by: i) improving the quality of tide predictions essentially by retrieving or programming extended tide observations (tide gauge whose vertical movements are monitored by GPS); ii) checking compatibility between DTM precision and water-level observations; iii) a better knowledge of extreme Sea level statistics; and iv) a better knowledge of wave set-up and runoff, which are unknown.

There are two issues in Africa: coastal protection (erosion) and port protection and access channels (silting up). ARGANS is also experienced for observations on land and at sea with oceanographers and hydrographers with expertise in the field and in collaboration with national and international organizations which have exploitable data (recent and historical). ARGANS is able to associate stakeholders of African countries to carry out regular on-site expertise.

3.4.2.2.2 Exposure mapping of built-up areas

Built-up area is the spatial delineation of human settlements, understood as a city, town, village or any agglomeration of buildings where people live and work. Built-up area evolution identifies spatially where the areas that are becoming part of the cities.

The EO4SD DRR product Built-up area status and evolution mapping for Greater Banjul provides discrete information on where such human settlements are located, their spatial distribution and shape. The evolution of built-up area provides an idea of the urban growth, identifying and quantifying zones of urban expansion. These new settlements can be located in areas prone to hazards and sometimes are occupied by dwellings with construction typologies especially vulnerable to hazards. Both products provide information on the elements at risk, which can be used for calculating the exposure once the hazard component is defined.

The settlements identified in the product encompass different types of elements such as for instance urban fabric from continuous to discontinuous of different densities, transport, industrial, commercial and military units, construction sites and leisure facilities. The product identifies the whole area occupied by the previously mentioned elements as long as they are adjacent.

The methodology to extract built-up area from Copernicus Sentinel-2 imagery is a fully automated processing chain using a Deep Learning model designed and developed by Indra. It uses a Semantic Segmentation Algorithm based on Convolutional Neural Networks, as the core decision-maker piece over annual time series of Copernicus Sentinel-2 images with 10-m resolution (channels: R, G, B, NIR). The model was trained in around 100 different cities of Europe and Latin America. The European training dataset was generated synthetically, using Urban Atlas High Resolution Layer from Copernicus Land Monitoring Service without the intervention of a photo-interpreter whereas non-European training datasets were generated using the alpha version of the model and corrected manually.

Details:

- *Data source: Sentinel-2 time series. 12 images for the year 2016 and 2019.*
- *Overall thematic accuracy: 90,5%.*
- *Delivery format: Delivery format: Geotiff, 8bits, EPGS 32628.*

Validation against visual interpretation of the ground truth represented by Very High-Resolution Imagery (VHR) by an experienced interpreter show an overall accuracy of more than 90%.

It is of particular interest, how the model is able to detect built-up area out of 10-meter resolution images in zones that are virtually impossible to comprehend for an interpreter: the AI model sees beyond what is observable in the imagery for the naked eye (Figure 36).

The model adapts to the calculation of entire regions due to its processing efficiency can be customised for certain geographical context and is able to learn and improve accuracy with each new area analysed and extracted.

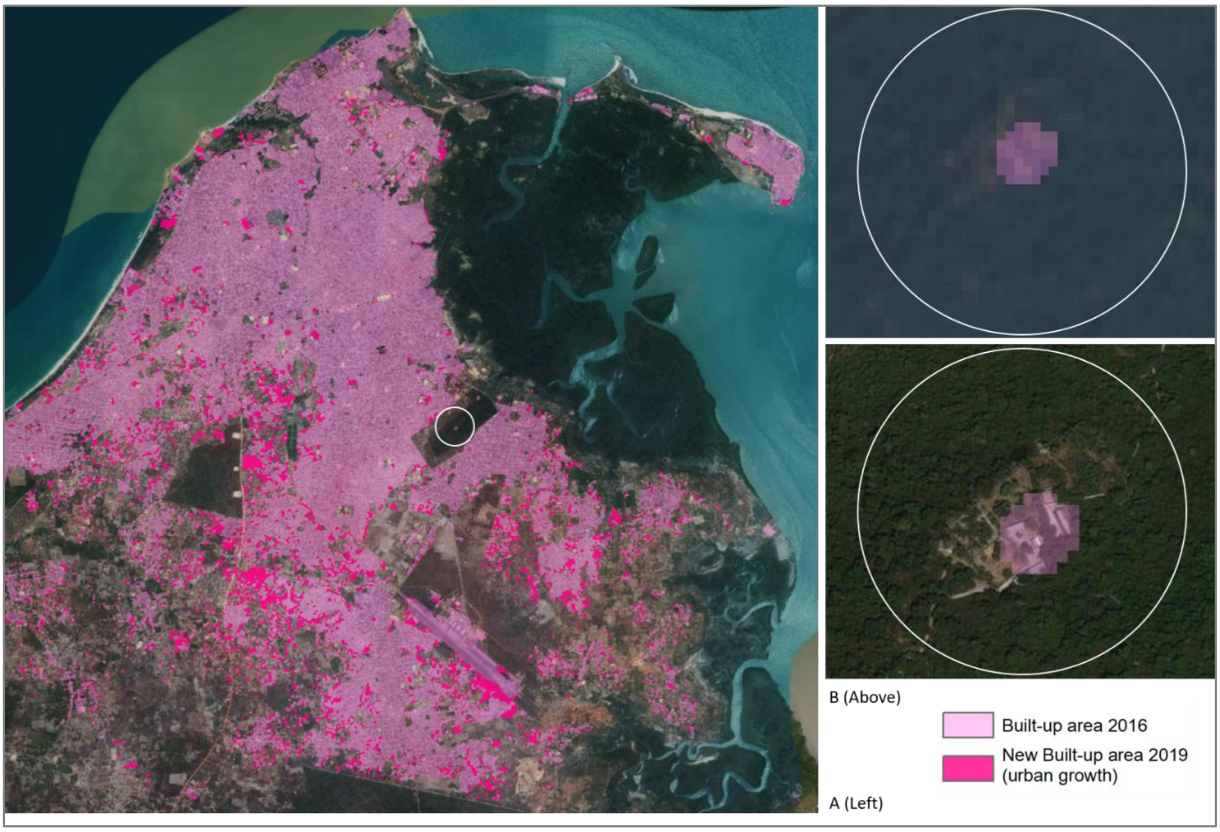

Figure 36: A: Built up-area in 2016 and Built-up area evolution between 2016 and 2019 generated with Copernicus Sentinel-2 imagery by Indra under the EO4SD DRR project. B: Example of the product accuracy with Built-up area superimposed over Copernicus Sentinel-2 imagery (upper image B) and over VHR imagery (lower image B)

3.4.2.3 *National and Regional scale Coastline Change Mapping to visualise the impact of changes*

There are a number of methods that can be used to monitor the location of shorelines from space using optical or radar-based data processing techniques.

For countries scale mapping requested by WACA the adopted approach exploits the processing power of Google Earth Engine to download cloud minimal annual median optical data composites to map shoreline change by using open-sourced tools such as Coastsat (Vos et al., 2019a) and the Digital Shoreline Analysis System (DSAS) (Himmelstoss et al., 2018). Shorelines are synthesised through a process of classification and thresholding using pansharpened Landsat 7,8 and Sentinel-2 images between 2000-2020. A baseline is extracted by using the earliest shorelines to cast transects at 50m intervals along the coast. The process is repeated across numerous regions of interest along the coast to enable a fast analysis at a large (i.e. whole country/region) scale over multi-decade time period. Shoreline change statistics are calculated using automatically generated transects that intersect the satellite-derived shorelines (Figure 37) and a linear forecast using historical erosion or accretion rates are used to predict future shorelines, which makes it possible to visualise the impact of changes at 10- and 20-year intervals. An example from Benin is provided below.

Figure 37 : Shoreline Change Rates at Port de Cotonou, Benin

3.4.2.4 *The Large Scale Water Quality Monitoring is in progress*

EO4SD – Earth Observation for Sustainable Development – is an ESA initiative which aims to achieve a step increase in the uptake of satellite-based environmental information. The EO4SD Portal (https://eo4sd.eofrom.space) contains Sentinel-3 OLCI water-quality data at 300m resolution for the entire coast of Africa from both Sentinel-3A and B satellites. The data are processed at PML and use the Polymer atmospheric correction.

Phytoplankton are the microscopic photosynthetic organisms at the base of the marine food web. Chlorophyll-a is a photosynthetic pigment within the cells of phytoplankton, and its concentration in surface waters can be used as an indicator of phytoplankton biomass. Changes in phytoplankton populations may impact marine life and have implications for food availability and economic productivity. Satellite-derived chlorophyll concentration can be used to study seasonal and interannual phytoplankton dynamics, as well as monitoring coastal water quality, eutrophication and harmful algal blooms. High Chlorophyll-a concentrations can indicate high nutrient concentrations in the surface waters and can possibly be due to eutrophication of coastal waters.

For example, in the Gulf of Guinea, off the coast of Côte d'Ivoire, research by Kassi et al. (2018) "combined remote-sensing ocean-colour observations with *in situ* observations of Sardinella aurita catch, temperature, and nutrient profiles, and re-analyses of wind and sea surface temperature, to investigate relationships between catch and oceanic primary producers (including biomass and phenology of phytoplankton), and between catch and environmental conditions (including upwelling index, and turbulent mixing). They showed that variations in S. aurita catch in the following year may be predicted, with a confidence of 78%, based on a bilinear model using only physical variables, and with a confidence of 40% when using only biological variables. However, the physics-based model alone was found not to be sufficient to explain the mechanism driving the year-to-year variations in S. aurita catch. Based on the analysis of the relationships between biological variables, they demonstrated that on the Ivorian continental shelf, during the study period 1998–2014, population dynamics of S. aurita, and oceanic primary producers, may be controlled, mainly by top-down trophic interactions. Finally, Kassi et al (2018) discussed how predictive models can provide powerful tools to support evaluation and monitoring of fishing activity, which may help towards the development of Fisheries Information and Management System." (Kassi et al., 2018).

The chlorophyll-a concentration provided in the EO4SD portal is derived from the Sentinel-3A and the Sentinel-3B satellite OLCI instruments and processed using the POLYMER algorithm ((Steinmetz et al., 2011).The data are provided daily at 300 m resolution with the units mg Chl-a m^{-3}. The data may be considered as a prototype since no *in situ* validation has been possible, but in the Red Sea the chl-a has been shown to be overestimated. This is due to a number of factors: first, for the earlier satellite (Sentinel-3A) it is possible to apply so-called gain corrections but for the more recent satellite these are not yet available. Second, due to the lack of *in situ* data a generic chl-a algorithm is used as opposed to a regional algorithm or a water-type classification. The latter is under development. Hence, the chl-a estimates should be used as approximate indicators.

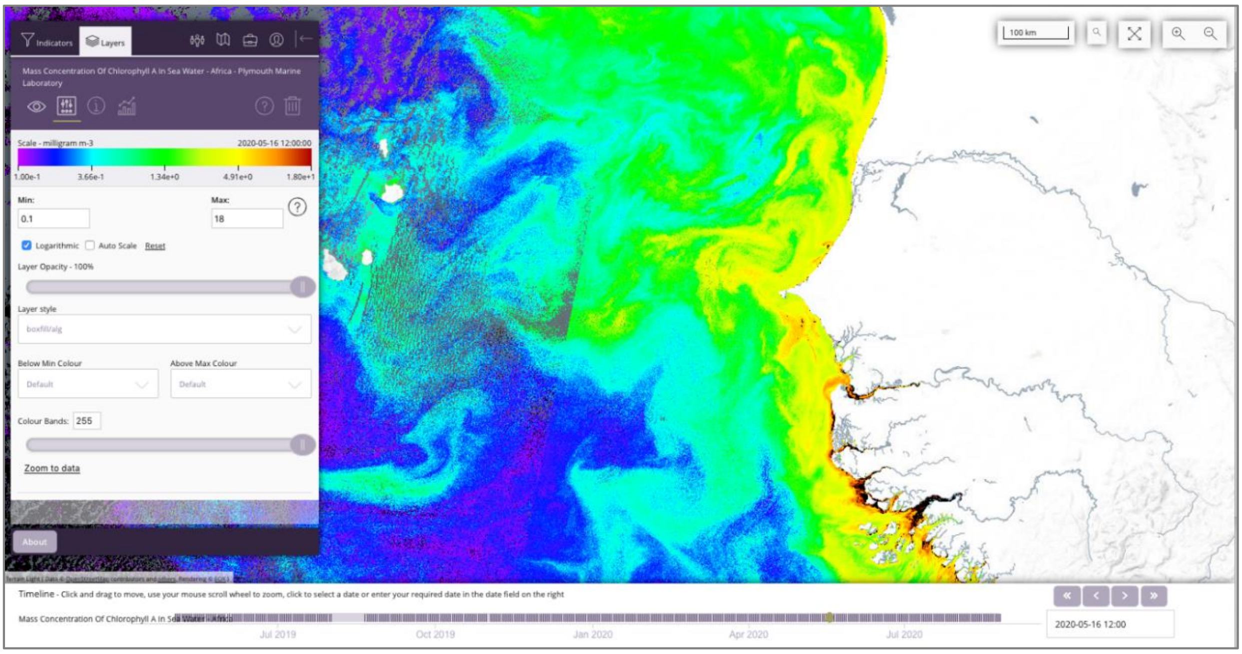

Figure 38 : View of the EO4SD Marine Portal satellite-derived chlorophyll concentration off the west coast of Africa on 16 May 2020. In this area upwelling of nutrient rich deep water occurs and leads to high productivity

3.4.2.5 *The detection of Land-Based Pollution is possible*

EO can be used to identify different types of land-based pollution (LBP) such as :

- untreated sludge or sewage nearshore dredging,
- near-shore oil spill (this is discussed in the next section),
- tourism activities and illegal rubbish dumping (to be detected before being washed out).

In this short note, we provide an example of the detection of land-based effluents of untreated wastewater.

There are two types of land-based effluents influencing coastal waters: indirect and direct. The indirect runoff of wastewater is combined with river runoff and due to the high rates of advection and diffusion, the effluents are well-mixed in the water and their direct detection is challenging. The direct runoff of untreated wastewater is detectable by satellite images as it has three distinctive imprint features on the surface of coastal waters: colour, temperature, and surface roughness. Only the first feature, colour, is detectable at a fine spatial resolution of ~10 m. Satellite products of sea surface temperature are merely available at coarse resolution >500m that is unfit for the fine-scale of land-based pollution. The effect of roughness is most of the time faint and confused with the roughness of the coastal surf zone. The LBP service uses this colour feature to detect and quantify the discharge of untreated sludge in coastal waters.

The colour of untreated sludge is commonly dark and can be detected using sensors observing the reflected light in the visible part of the solar spectrum. Figure 39 shows the apparent discharge of sewage pipelines into coastal waters of the Senegalese coastline to the south of Dakar. This image was acquired by the Sentinel-2 Multispectral Instrument (S23-MSI). This sensor observes the reflected sunlight in the visible part at 10-meter spatial resolution and revisit time of about 5 days. This type of “visible" sensors are affected by the cloud cover, in other words, no detection is possible if the area is cloudy.

Figure 39 : Colour composite from Sentinel-2 MSI image acquired on the 24ed of April 2020. Blue: band 2, Green: band 3 and Red: band 4

The LBP service uses S2-MSI to quantify the discharge of untreated sludge along the coastline and up to 500 m offshore. The service provides probability maps [from 0 to 1] of solid waste, and dissolved waste for cloud-free observations. Figure 40 and figure 41 show the probability of dissolved and solid waste. The probability values were estimated from water quality indicators and light penetration depth. For this purpose, the 2SeaColor model (Salama & Verhoef, 2015)[50] was employed. Validation of the results is still required. Figure 40 and figure 41 show the LBP products on 20m spatial resolution. A superimposed 10m resolution is shown in figure 42 for the dissolved waste to highlight the effect of finer spatial resolution. Although a strip of about 10 m next to the shoreline is now filled with data, the noise is larger in the 10m product (Figure 42).

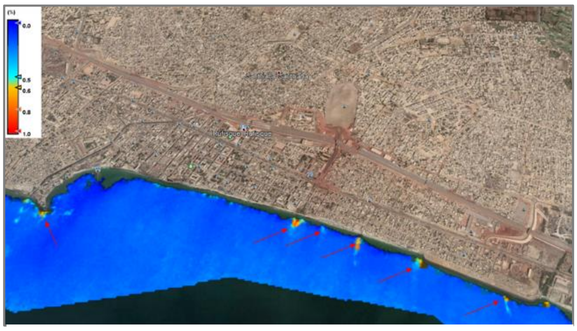

Figure 40: The probability of dissolved waste (due to the discharge of untreated sludge)

This product is derived from S2-MSI images at 20m resolution acquired on the 24th of April 2020.

50 https://github.com/suhybsalama/2SeaColor

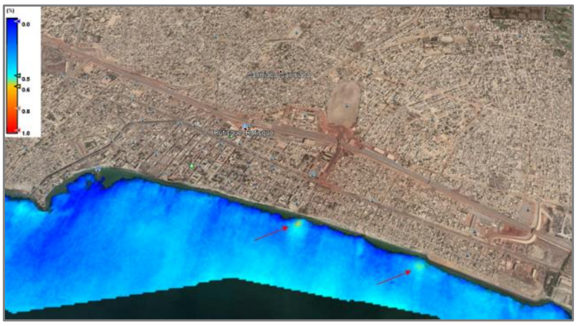

Figure 41: The probability of solid waste (due to the discharge of untreated sludge)

This product is derived from S2-MSI image at 20m resolution acquired on the 24th of April 2020.

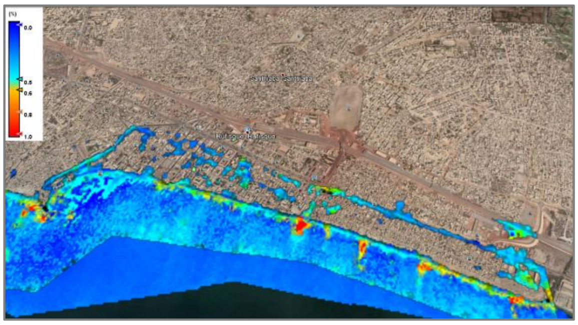

Figure 42: The same as Erreur ! Source du renvoi introuvable. **but at 10m superimposed**

This product is derived from S2-MSI image at 10m resolution acquired on the 24th of April 2020.

3.4.2.6 *The oil spill monitoring, sensors very sensitive*

The service uses Sentinel-1A and Sentinel-1B SAR satellite images provided by the European Space Agency. SAR sensors are very sensitive to variations of sea surface roughness and can successfully detect oil slicks that effectively dampen sea waves. The slicks are visible as dark spots in the SAR images. The system uses a machine-learning approach to delineate potential oil slicks from "lookalikes" associated with variations of wind field, currents or algal blooms.

Details:

- *Data sources: Sentinel-1A and Sentinel-1B synthetic aperture radar (SAR) sensor data.*
- *Revisit time 3 to 12 days*
- *Latency of oil spill detection: about 12 hours for Sentinel-1 SAR sensor.*
- *Data delivery format: Google Earth kml file format.*

The oil spill detection service can be ideally used in partnership with e.g. coastguard and Port authorities to collect the evidence base that can be used to bring forward prosecutions. By combining the evidence from a series of processed images with vessel tracking data (i.e. AIS) authorities can be alerted to request Port State Inspections at the subsequent arrival Port of the vessel, during which records can be checked and evidence gathered for possible breaches of international law. Such a service extension would require a regional / international collaborative approach.

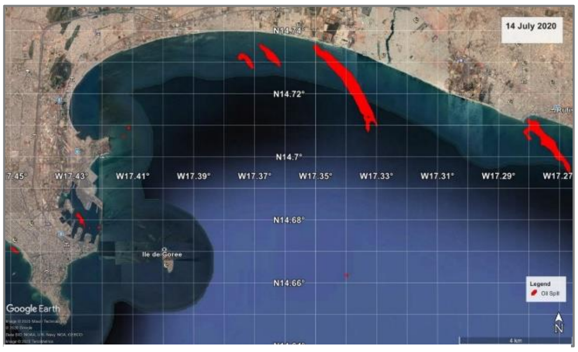

Figure 43 : Oil spill accident, Mbao Senegal, July 2020

The service has been successfully applied for monitoring an oil leak at Mbao in Dakar, Senegal. Marine pollution was originally reported in this area by local fishermen, who observed thick oil slicks scattered in the area from Large Mbao to Small Mbao on 16 July 2020. These oil slicks were automatically detected in satellite images two days earlier, on 14 July 2020. Figure 43 shows in red the location and extent of the detected pollution areas. The largest oil slick in the middle of the image originated at the coast just opposite the African Refining Company. Later on, an inspection was carried out by the company and confirmed an oil leak about 600 meters from the beach.

3.4.3 International Coastal Inundation Forecasting Intiative

The design for a Coastal Inundation Forecasting Initiative (CIFI) Early Warning System (EWS) is being proposed for West Africa (WA-CIFI) as part of the CREWS (Climate Risks & Early Warning Systems) international initiative, in collaboration with the WACA Program. It is expected to be implemented both at country and regional-level through a partnership between the World Meteorological Organization (WMO) and the World Bank Group.

However, recognising the importance of early warning systems for West African coastal communities in particular, especially as they relate to the coastal inundation, WMO through CREWS have initiated plans to implement the WA-CIFI Early Warning System. The WA-CIFI EWS will provide critical forecasts and warnings of coastal hazards, such as storm surge and coastal swell, in combination with natural tidal influences and riverine and flash flooding.

3.4.3.1 *Coastal Inundation Forecasting Systems by WMO*

Coastal inundation occurs throughout the world's vulnerable coastlines. This can regularly lead to major loss of life, through the combination of swell, waves and storm surge (from tropical cyclones, or extra-tropical storms), along with riverine flooding in various tidal states, exacerbated by rising sea level. WMO has been addressing these threats for over a decade and this experience can be applied in West Africa for its vulnerable coastal communities.

Globally, coastal inundations are an increasing threat to the lives and livelihoods of people living in low-lying, highly populated coastal areas. Development in coastal areas is increasing, placing more pressure on the people, resources and infrastructure and thereby, the sustainability of their populations. At the same time, changes are occurring in catchment areas through encroachment on floodplains, land use and resulting modifications to runoff that can be exacerbated by ocean-related storm surge, extreme waves, etc. In many cases, heavy rainfall accompanies the storm surge resulting in rivers overtopping their banks, further worsening the local flooding especially near river mouths. Rising global sea levels also contribute to increased vulnerability. These severe hazards highlight the increasing threat to populations, especially those in coastal areas, pointing to the need for coastal inundation warning systems that adequately reflect the various hazards and their interaction at play.

The range of natural hazards that can cause coastal inundation is shown in figure 44 due to the weather patterns and ocean hazards along the entire West African coast, these hazards can all have an impact either individually or at the same time.

Which hazards impact coastal inundation ?

Storm surge due to weather systems, including cyclones.

Riverine floods and flash floods near the coast.

Sea level, including from climate change.

Tsunami from geophysical and other events.

Inundation due to distant swell.

Local wave impacts.

Tidal influences.

Inundation due to land subsidence.

Figure 44 : Natural Hazards impacting coasts

The WMO Coastal Inundation Forecasting Demonstration Project (CIFDP) (2009 to 2019) has been successful in establishing operational early warning systems in four countries with diverse coastal threats (Swail et al., 2019 and Barret and Canterford, Part A-WMO, 2018): Bangladesh, the Caribbean (Hispaniola), Fiji and Indonesia. The CIFDP was unique in facilitating for the first time, the design and development of a comprehensive alert and warning system for coastal flooding caused by multiple sources. The focus of early warning for these countries was in coastal zones and basins subject to tropical cyclones and storm surges, strong wave action from distant sources, tidal effects; and jointly with riverine flood events.

This CIFDP initiative and its demonstration sub-projects were designed with a view to improving safety-related services for the communities at risk. The demonstration process was facilitated by WMO, in cooperation with the countries, local and international institutions, as well as numerous experts in the field of storm surge, wave and hydrological modelling. The goal was to accurately forecast coastal inundation from the viewpoint of the Total Water Level Envelope (TWLE) and its interactions with riverine environments and vulnerable communities. Figure 45 shows the modelling framework and is illustrative of the complexities that are needed to properly reflect local hazards and their interactions.

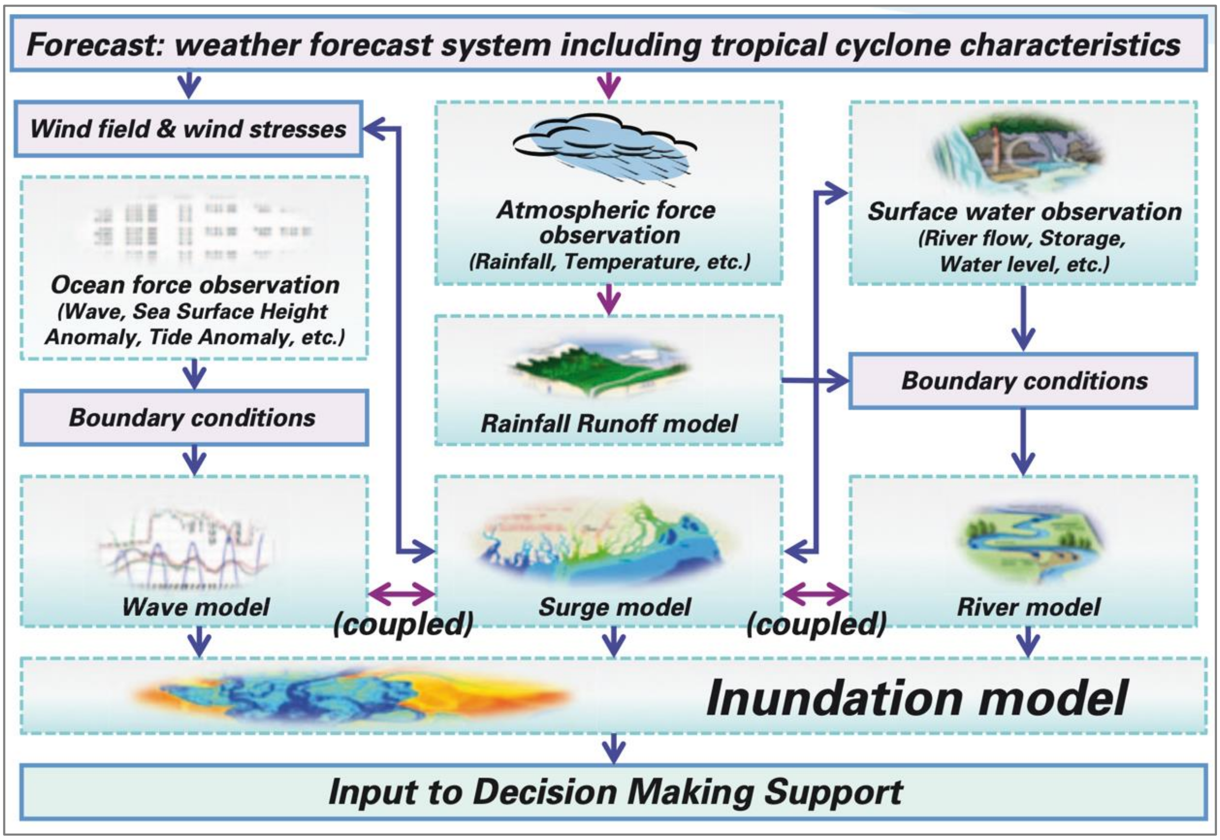

Figure 45 : The WMO CIFI modelling required for coastal inundation that can be adapted to West Africa

3.4.3.2 *The West Africa Coastal Inundation Forecasting Initiatives enhanced by the Early Warning System project (WA-CIFI EWS)*

As a concrete basis for establishing a WA-CIFI EWS, all of the natural hazards listed in Figure 44 are critical to the West African coast. The world Bank Group and WACA (West Africa Coastal Areas Management Program) published in 2019 "The Cost of Coastal Zone Degradation in West Africa: Benin, Côte d'Ivoire, Senegal and Togo (world Bank, 2019) which highlighted the major cost of environmental degradation as coming from flooding, erosion and water pollution. All coastal West Africa countries have already suffered major flooding and erosion and projects addressing this are already underway.

The inclusion of WA-CIFI EWS for coastal inundations, outlined in this sub-chapter, addresses and integrates the other hazards such as storm surge, tidal impacts and climate change Sea level rise (SLR) which are critical in closing the disaster risk gap for coastal communities. In particular.

West Africa is a "hotspot" of climate change according to the "Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment Report" (Niang et al., 2014). Until recently there had been limited detailed work undertaken to assess the physical and economic impacts of climate change. To address this gap the world Bank undertook such a study: "Effects of Climate Change on Coastal Erosion and Flooding, March 2020", focusing on five countries in the region: Mauritania, Senegal, Côte d'Ivoire, Togo and Benin. The study presents coastal conditions and climate change at a regional scale, followed by an overview of each country's coastline - the geomorphological structure of the area and climate characteristics. This study also presents an evaluation of how coastal erosion and coastal flooding are affected by climate change.

There are several initiatives underway in West Africa to address the hydromet and climate change risks. The initiatives will be enhanced by the proposed WA-CIFI EWS outlined in this Sub Chapter. These include, but are not limited to:

- world Bank and ECOWAS are implementing the ACP-EU NDRR program, and through this are supporting the development of (i) an ECOWAS Flood Management Strategy and (ii) an ECOWAS Hydromet Initiative which is an investment plan to capture the priority needs of national meteorological, hydrological and DRR services in the West Africa sub-region ;
- WAEMU (West African Economic and Monetary Union), including Benin, Côte d'Ivoire, Mauritania, São Tomé & Príncipe, Senegal and Togo are implementing the West Africa Coastal Areas Management Program (WACA) to strengthen the resilience of targeted communities and areas in coastal West Africa ; and
- As part of the WACA Resilience Investment Project (WACA ResIP), studies included (i) cost of coastal degradation (Benin, Côte d'Ivoire, Senegal and Togo) (ii) coastal sedimentation and erosion (Benin, Senegal and Togo) (iii) assessment of human interventions and climate change on West African sediment budget (iv) evaluation of the cost of coastal environmental degradation (v) investment plans for adaptation to climate change (Benin, Togo, Côte d'Ivoire, Mauritania) (vi) stakeholder and political economy analysis (Ghana, Togo, Benin and Côte d'Ivoire). In line with the Dakar Declaration, the project is currently considering the basis for establishing a Regional Coastal Observatory for Western Africa.

As highlighted in the introduction, WMO under the CREWS West Africa project supports the 19 ECOWAS and PRESASS countries of West Africa through the implementation of:

- Severe Weather Forecasting Program (SWFP) to enhance the use of global and regional numerical weather prediction outputs at country level, relying upon ANACIM Severe Weather Regional Specialized Meteorological Center (RSMC);
- Flood forecasting support systems based upon Flash Flood Guidance System (FFGS) and other pre-existing systems, such as FANFAR, Niger-HYPE, SLAPIS, FEWS, etc. with support from both ANACIM and AGRHYMET ; and
- the development of a harmonized methodology for urban flood forecasting, which would be tested in Freetown and other coastal cities (Abidjan, Accra).

The CREWS West Africa Project recognised that, as well as the ongoing implementation of SWFP and FFGS in West Africa, it is necessary to also consider the implementation of the Coastal Inundation Forecasting Initiative (CIFI) to complement these key early warning systems: WA-CIFI EWS. There is also an opportunity for the further integration of these projects into national Multi Hazard Early Warning Systems.

Coastal inundation from ocean hazards in WA-CIFI EWS should be coordinated with tsunami warning procedures. For West Africa, these tsunami warnings are undertaken under the auspices of the **IOC-UNESCO's Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic,** the Mediterranean and connected seas (ICG/NEAMTWS). Several West African coastal countries are Members or Observers of this system and will therefore have access to tsunami advisories from other "service provider" countries for use in their own warning systems. Recent advances in tsunami warnings have been promulgated in a recent IOC-UNESCO Symposium Report (February 2018).

3.4.3.3 *The pilot project WA-CIFI EWS underway*

Planning is underway for a demonstration region for testing the WA-CIFI EWS. This will take into consideration coastal inundations, riverine flooding, urban flooding and coastal erosion together in any coastal management plan. Currently WMO and World Bank are engaged together with at least the following, which are possible candidates for a WA-CIFI EWS pilot project:

- Togo (Lake Togo coastal watershed): the CREWS project is expected to propose a methodology for flood forecasting in this coastal watershed;
- Côte d'Ivoire (Abidjan): WMO would propose a methodology for flood forecasting in Abidjan, affected by a combination of coastal inundation, riverine flooding and urban flooding; and
- Sierra Leone: under the CREWS West Africa project, WMO and the World Bank are expected to propose together a methodology for flood forecasting in Freetown.

Initial consideration is being given to Sierra Leone and Togo as there are a range of other projects that would contribute with the implementation and operation of have synergies with WA-CIFI EWS. However, this pilot would require collaboration with other West Africa countries and institutions, including the Regional Coastal Observatory (WARCO). Included in such a pilot would be wider networks of instruments for measuring rainfall, river heights and flows, Sea level gauges, ocean buoys and WMO input from weather and ocean models. The latter model input would come from WMO Global Centers and RSMCs. The effect of climate change on the large-scale sediment transport capacity is also a critical aspect of coastal inundation.

Products for input into the pilot WA-CIFI EWS will include broad scale forecasts of atmosphere and ocean modelling information utilized in coastal inundation forecasts and warnings:

- WMO Global Centers (including Météo-France, ECMWF, US National Weather Service (NWS), UK, Canada and Australia);
- WMO RSMCs (Dakar and Toulouse) for possible modifications and tailoring;
- AGRHYMET Research Centre (Niger);
- Regional Telecommunications Hubs (RTH), Senegal and Niger;
- Regional Climate Centers (RCC);
- WMO Regional Instrument Centre (RIC), Morocco; and
- WMO Regional Training Center (RTC)(Niger).

This information for the pilot would be integrated within the National Meteorological and Hydrological Service (NMHS), or NMS and NHS such as Sierra Leone.

Overall, the WA-CIFI EWS should be designed to be operated jointly by meteorologists with marine forecasting experience and flood hydrologists. It is preferable for this to occur in one organisation or forecasting office, but it not essential as long as high-quality communication links are established and clear processes in place to avoid overlap or confusion. The system operators should have expertise (or be trained) in:

- marine meteorology, with a knowledge of tsunami warnings;
- river hydrology with specific understanding of riverine and flash floods;
- operational hydrometeorological forecasting in the country and region;
- weather-related hazards emergency management;
- capability to analyze marine meteorological, and NWP products; and

- IT for the system/s server administration.

IMPORTANCE OF HISTORICAL DATA FOR COASTAL MONITORING AND THE ESTABLISHMENT OF EARLY WARNING SYSTEMS

There are many advantages to having historical data, particularly if it is digital. This facilitates analysis, forecasts and response in the event of disaster. That enables to highlight the triggering factors of coastal changes.

Within the framework of the WACA-F project, which aims at improving the understanding of coastal flooding, coastal erosion and coastline retreat, orthophotographs and old bathymetric surveys are made available to Senegal, Benin and Togo. The data produced are derived from the analysis of topographic and maritime archives (aerial photos, plans, nautical charts, bathymetric minutes) held by France's Naval Hydrographic and Oceanographic Service (SHOM) and National Geographic Institute (IGN). These archival resources were later digitised and georeferenced. They include image acquisition missions performed in 1954-55 in Senegal and Benin as well as missions in 1969 and 1976 in Togo and historical bathymetric surveys in 1969 - 2012 for the three countries.

In Benin, for example, aerial photographies of 1955 allows to observe that the coastline was regular before the construction of the port of Cotonou and to quantify, using the Digital Shoreline Analysis System (DSAS) method (Himmelstoss et al., 2018), the speed of coastline retreat on critical sectors.

Sectoral evolution of the coastline in Cotonou from 1955 to 2018 (Assogba L.P., 2018)

The same aerial photographies allow observing the rhythm of expansion of the urban fabric (figure below).

Illustration of the evolution of the urban area in the east of Cotonou (in red, the urban area in 1955);

Sources: Aerial photographies 1955 and Google Earth, 2018

Auteurs : Liliane ***Assogba Sessou***[1]

Institutions : ***Union Internationale pour la Conservation de la Nature***

3.5 Support for West Africa Coast Areas Management

3.5.1 Strengthening financing mechanisms

Financing coastal resilience is one of the greatest challenges facing West African coastal states. This challenge is receiving sustained attention from the West African Economic and Monetary Union (WAEMU) Commission. Thus, through regulation n°002/2007/CM/WAEMU, WAEMU instituted the Regional Program for the Control of Coastal Erosion (PRLEC), with a view to supporting its Member States and other West African coastal countries in a common planning and investment approach based on a better understanding of natural and anthropic phenomena related to coastal risks.

In order to meet the financing needs for dealing with coastal risks in West Africa, the WAEMU Commission has initiated, in collaboration with its current partners, the generalization of the investment planning and facilitation process.

The generalization of the investment planning process is based on four pillars:

- technical assistance to States in the formulation and preparation of identified investments**,** to facilitate the meeting of project promoters with potential investors through the organization of events for the promotion of coastal resilience projects in West Africa ("Marketplaces", round tables, various consultations). This technical assistance is currently provided by the WACA platform, which is managed by the world Bank. This platform, which will be transferred to a regional institution, will provide technical and advisory support for the development of multi-sector investment plans (MSIPs) at the country level, as a prelude to the development of new national investment projects;
- coordinating investments between countries and encouraging new countries to join the initiative;
- the Regional Strategic Investment Action Plan (RSIAP). This plan reflects a harmonized regional vision of priority investment needs, the planning of these investments and the monitoring of their implementation;
- the West African Coastal Assessment (periodical update of the master plan). It provides an overview of coastal risks and guides responses through investment planning with a particular focus on priority areas.
- The completion of this strategy is the collective responsibility of all parties concerned, namely regional institutions (WAEMU, ECOWAS, ECCAS, etc.) and/or international (IUCN, ABC, etc.), the countries of the region, financial institutions (World Bank, West African Development Bank (WADB), EBID, AfDB, GEF, etc.), as well as the private sector and civil society.
- Financing the implementation of the strategy requires its mainstreaming into investment facilitation mechanisms that will mobilize additional investment. To this end, the WAEMU Commission, in collaboration with partners, is making efforts to put in place a strategy to raise funding for all the projects identified in the PIMS and/or the countries' strategic development papers on the issue of erosion, pollution and flooding.

3.5.2 Promoting data production and information dissemination

3.5.2.1 *The Marine and Coastal Ecosystems Resource Center*

Following the twelfth Conference of the Parties to the Abidjan Convention, experts and Parties recommended that the Convention coordinate data collection efforts through the creation of a Marine and Coastal Ecosystem Resource Center. This approach is in line with the Multilateral Environmental Agreements ratified by the Parties to the Convention, which emphasize the principle of participation supported by the dissemination of environmental information.

Thus, the Abidjan Convention Secretariat has initiated the establishment of a Resource Centre with the objective of becoming a regional reference platform for Member States, decision makers, researchers, students and all experts in the field wishing to share or access data and information on the coastal and marine environment.

The main objective of the Resource Centre will be to enable the Secretariat of the Convention to work closely with its Parties to facilitate the collection, management and sharing of information and data related to the marine and coastal environment in West, Central and Southern Africa. It is a regional reference platform for Member States, decision makers, researchers, students and all experts in the field wishing to share or access data and information on the coastal and marine environment.

Thus, the establishment of this regional platform will enable to:

- build the capacities of national and regional actors in the management and sharing of environmental data
- support informed decision-making by providing recent, reliable, standardized and endogenous data
- disseminate available information and data at the level of the Convention Secretariat;
- provide Member States and partners with an information-sharing service;
- enable the Convention's focal points to share their monitoring and evaluation data and facilitate communication with the Convention Secretariat;
- host all databases produced by the Convention and its partners - including geo-referenced databases.

Following the establishment of the first prototype of the Resource Center, the Secretariat will engage member countries in a series of workshops to establish a governance system and a data sharing charter, as well as to train Convention focal points and contributors to use the system. This will be followed by a process of data collection at national level to enrich the Resource Center. This data could also be integrated into the geo-referenced information system that the Convention wishes to establish.

Ultimately, such a platform will provide Member States and the region with a tool to facilitate access to endogenous information and data to support informed decision-making and to strengthen the capacity of Member States to share their data.

3.5.2.2 *The Regional Coastal and Marine Forum*

The Regional Coastal and Marine Forum brings together every other year in a different capital city of the PRCM area, the different categories of actors of the coastal and marine area, such as national and intergovernmental institutions, scientific institutions, national and international NGOs, socio-professional organizations, the private sector (fisheries, tourism, oil, infrastructure) and financial partners. Now in its 10th year, it has brought together between 200 and 300 participants from more than a hundred institutions and from a multitude of countries. It is a unique opportunity for dialogue both between the countries of the region and between the sectors involved, with a view to building a shared vision on the evolution of the coastal and marine zone. Moreover, it is within the Regional Coastal and Marine Forum that the strategic orientations of the PRCM, its governance system and the recommendations addressed to the actors are discussed...

Figure 46 : Picture of participants at the Regional Coastal and Marine Forum held in Praia in 2015

By building the capacities of actors and institutions and setting up frameworks for consultation and coordination, the PRCM has created a regional dynamic in favor of the conservation of the West African coastline. It has helped to bring about significant changes in environmental governance and to build a stronger civil society that is better recognized by government bodies. It has also contributed to a better visibility of the countries of the region at the international level, particularly with regard to the issue of marine protected areas, sustainable fisheries and integrated coastal zone management.

The PRCM now represents a model coalition for addressing coastal and marine environmental issues at the scale of an ecoregion, despite some inherent flaws in any human system.

Communication has been based on multiple media and at different paces. The partnership's website www.prcmarine.org and the newsletter produced by the PRCM's communication department provided regularly updated information on the activities of all participants. The social networks 'Facebook, Twitter, etc.' are used to ensure the dissemination of information and the mobilization of actors around emerging issues.

Another function of communication has been to produce tools that have helped train actors while disseminating the lessons and knowledge accumulated in the field. A number of guides have been produced on a wide range of topics and disseminated.

Communication has also been directed outwards, towards those not directly involved in the Partnership. For example, it tried to convince some categories of civil society, politicians and potential donors. Films were made on specific issues.

Efforts to convince have sometimes taken the form of advocacy, where the coalition of partners has proved effective in influencing policies or behaviors that are contrary to the health of the environment.

Figure 47: Examples of PRCM capitalisation and communication tools

These efforts have led to the completion of strategic environmental assessments, the mainstreaming of impact assessments into the legal frameworks of extractive industries, the banning of oil exploitation in some protected areas (in the Gulf of Arguin in particular), the denunciation of illegal fishing or unfair fishing agreements, the installation of infrastructure on a sensitive site, the capture of marine mammals for commercial purposes, etc. Advocacy to combat the use of plastic bags has resulted in instruments regulating the use of plastic bags in most PRCM countries.

The PRCM was able to provide a framework for dialogue and work that has strengthened the overall coherence of initiatives through better articulation and coordination of interventions. One of the results obtained was the integration of the regional dimension, which is now well present in the vision of most actors. The superimposition of this new regional scale on the local and national scales has raised several difficulties. The costs associated with the need for consultation, collaboration and consolidation of individual initiatives have proved to be heavy to bear, *especially* for institutions or organizations with a small staff, which have had to cope with additional demands.

Despite these difficulties, the benefits of taking the regional level into consideration are nevertheless indisputable. Many issues can now be addressed at the relevant scale. The pooling of efforts offers the possibility of tackling common problems such as migratory fishing, of jointly managing shared species or habitats such as marine turtles and mangroves, or of adapting to the connectivity of phenomena in the marine environment such as pollution or coastal erosion that go beyond national borders.

3.5.3 Promoting dialogue and raising awareness

3.5.3.1 *WACA LACE Initiative: Local Action and Citizen Engagement*

WACA is working with civil society partners to develop a Local Action and Citizen Engagement (LACE) initiative. LACE aims to (i) build on the capacity of civil society and local communities, (ii) develop scalable approaches to building community resilience, (iii) promote community-government partnerships for resilience, (iv) foster knowledge sharing, and (v) ensure that all, especially the most vulnerable, benefit from WACA's investments. The LACE initiative focuses on three areas of activity:

1. **Facilitating community-led partnerships for coastal resilience:** This involves identifying and supporting local innovations and good practices for building coastal resilience and promoting collaborative relationships between communities and local authorities to address coastal risk management through direct funding and partnerships with local groups, civil society and/or other local entities. Good practices will be documented and shared between countries via the WACA platform.

2. **Promoting public participation and citizen engagement in the WACA program**: Activities will support public awareness and engagement in WACA communities on coastal protection and climate change issues. This can be done through activities such as social media campaigns on coastal protection; training and engagement of local media in responsible reporting on coastal erosion, disaster risk management and climate change; raising awareness on regional/cross-border issues and a culture of coastal protection; Training and support of community leaders (women, youth, elderly) to guide local efforts related to WACA objectives; Crowdsourcing data collection to inform WACA activities; Participatory socio-environmental monitoring, among others.

3. **Promoting social inclusion**: This involves supporting knowledge sharing and capacity building around the social dimensions of risk as well as activities to promote social inclusion and empowerment of women, people with disabilities, traditional communities, etc. Understanding the social dimensions of risk and vulnerability factors allows for better targeting and improvement of investment projects. Women, the elderly, people with disabilities, migrants, indigenous peoples, the poor and other groups with unequal access to services, decision-making and justice are more affected by extreme events. There is therefore a need to protect and empower those who are socially excluded and therefore more exposed to natural hazards, climate change, environmental degradation and other shocks and stressors.

3.5.3.2 *Strengthening partnership with the private sector*

Regional dialogue on West African coastal resilience

In order to meet the major challenges linked to the combined impacts of coastal erosion, flooding, pollution and climate change, and to ensure the sustainable development of the coastal countries of the region, it is necessary to implement actions involving all the actors of the sectors concerned.

Everyone at his or her level must fully shoulder his or her responsibilities for better planning of the coastal environment, increased protection of coastal infrastructure, promotion of ecotourism, and sustainable management of ecosystems. The sum of these efforts is aimed at the well-being of a large section of the population whose income depends largely on economic activities along the coast.

Recognizing that all public and private sector actors as well as technical and financial partners must be mobilized to provide effective solutions, a regional dialogue on West African coastal resilience was initiated in Abidjan, Côte d'Ivoire from 27-28 February 2019. The event, organized by the World Bank's WACA Platform, was co-sponsored by the Global Facility for Disaster Reduction and Recovery (GFDRR), the Nordic Development Fund (NDF), the NDC Partnership Fund and the Ministry of Environment of Côte d'Ivoire.

The first meeting of this Regional Private Sector Dialogue brought together 180 participants: national, regional and international experts, technical and financial partners, CEOs and company managers operating in the coastal zone, West African port management authorities and port operators. The following sectors were represented: oil and gas, tourism, ports, mining, fishing and agriculture. During the event, a WACA Private Sector Advisory Group and a Port Sector Working Group were established.

The dialogue identified the main obstacles to private sector engagement in sustainable coastal zone management:

- private sector actors do not have access to data and knowledge on the physical and financial impact of coastal erosion on business. This prevents private operators from including coastal resilience in their investment strategies;
- the regulatory environment that could enable private investment in coastal zone management is insufficient, particularly in the areas of spatial zoning, compliance monitoring and enforcement. This creates a fragile and unpredictable investment climate; and
- coastal zone management is seen by the private sector as the exclusive responsibility of the public sector. This is because investments in the coastal zone require specific expertise that private operators do not have or are not equipped to mobilize.

Solutions have been formulated to address these obstacles:

- Public-Private Partnerships (PPP): develop public-private partnerships on the basis of studies describing the opportunities per country and per sector (ports, mines, agriculture, fisheries, urban);
- Funds: explore the establishment of a "Coastal Zone Management Fund": The port private sector has proposed to establish a public/private fund dedicated to the provision of technical assistance for urgent studies, and possibly investments, aimed at identifying solutions for the management of coastal erosion hot spots in West Africa;
- Tools: provide financing mechanisms such as tax exemptions or other fiscal incentives to encourage the private sector to invest in detailed technical studies, coastal protection infrastructure and/or climate change protection of existing or planned infrastructure;
- Knowledge: Establish a knowledge dissemination mechanism/platform where private operators can access existing technical studies and identify priority areas of business opportunity;

- Raising awareness: implement an awareness-raising campaign targeting private operators focusing on the blue economy, sustainable coastal zone management, and the financial and business implications and opportunities of coastal erosion management;
- Consultations: establish advisory groups for each sector to address key issues per sector;
- Ports: develop a sustainable port charter based on inputs from port regulators, port operators and commission holders; and
- Environmental impact management: implement clarify the role of the general public and private actors in environmental management around ports, including erosion.

Dialogue with the port sector

West African ports - 24 in number, from Mauritania to Angola - are state-owned and organized under different national public service arrangements. Their method of operation is generally inspired either by the British model for English-speaking countries, or by the French model for the others; a direct consequence of their colonial past. Until the beginning of the 21st century, their management models were mainly Service Port model for the ports originating from the British colonies and Tool Port model for the others.

Since then, the process of globalization of trade, combined with the increasing liberalization of the economies of the sub-region, has led most states to undertake profound institutional restructuring of their respective port sectors. Today, almost all West African ports have opted for the Landlord Port model, with increased participation of the private sector, particularly in the area of stevedoring and management of specialized terminals.

These reforms have mobilized significant private investment in new port infrastructure, modern handling equipment and targeted expansions that have helped ports overcome their operational inefficiencies of the past. Today, West African ports are also beginning to embrace the contemporary concept of sustainable development and increasingly mainstream it into their planning processes, operations and management. The approaches to achieve this have yet to be institutionalized.

The proposal is to have a participatory and integrated sustainability governance mechanism based on the concept of a Gender and Social Integration Plan (GSIP) that brings together multiple stakeholders - public, private and civil society - related to the port sector - at international, national and regional levels - to work together to develop common rules. Standardized procedures and practices, and sharing resources, ideas and concepts, responsibilities, risks and benefits to achieve the common goal of sustainable port development.

This new governance arrangement will not necessarily be driven by public sector representatives, who will be only one of the actors and not necessarily the main one with regard to the current institutional arrangements for new policy development. The various actors involved, namely : port authorities, maritime administrations and authorities, ship-owners and their agents, stevedores and terminal operators, freight forwarders and logistics operators, local/municipal authorities, line ministries and environmental agencies, customs, maritime police, port industries and companies, civil society organizations, community-based organizations, researchers and scientists, regional economic bodies such as the West and Central African Maritime Organization (WAMO), the Abidjan Convention and others to be identified will be linked together in an inclusive, integrated and iterative coordinated dialogue.

The proposed governance arrangement is motivated by three key factors. First, traditional state-led environmental and sustainability management has generally been ineffective in providing the expected protection and benefits. Second, public funds are limited to provide the necessary investment in environmental risk management and control. Thirdly, private actors and civil society are partly directly linked to the causation and/or protection of the port environment and its sustainability. They therefore have a shared responsibility in the management actions of the sector. Moreover, they might be better placed and willing to commit more ambitious resources and innovations.

Once institutionalized, the governance arrangement could in due course devise its own market and non-market mechanisms that will enable private financial flows to support their actions and implement their decisions.

There is a potential for private actors to increase the level of fees, but this needs to be discussed and mutually agreed upon as part of the governance arrangement. Firstly, different actors have different resources such as knowledge, technology, human capital, financial means, etc. that they can mobilize for the common good. Secondly, companies in the sector already have corporate social responsibilities (CSR) that they assume towards the community and society in general. Part of the CSR budget could be used for actions within the governance framework which will also be part of CSR. There are therefore options that can be taken to avoid that private actors necessarily increase port charges.

At its May 2019 plenary meeting held in Accra, Ghana, the Ports Management Association of West and Central Africa (PMAWCA) approved its partnership with the West African Coastal Action Program (WACA) led by the world Bank and various other donors.

The result of this effort - embodied in a charter approved in 2020 - is a new partnership between West African ports to actively cooperate on the environmental sustainability of their operations and infrastructure - a non-competitive area that affects all equally without threatening the level playing field. The intention is to encourage a kind of virtuous cycle in which ports challenge each other to achieve continuous improvement in sustainability and collaborate on shared mechanisms that make greater sustainability more affordable.

West African ports would be rated against a set of coastal sustainability parameters. Performance would be made public and could involve 'certification' of port performance against certain standards in a manner similar to many existing corporate social responsibility initiatives. Ports and countries in the sub-region have pledged to support this initiative so that it does not distort competition, but rather encourages ports to innovate and become profitable and sustainable.

In addition, it is envisaged to set up a specific financial fund - made up of public and private funding - to enable the development of targeted actions that fall within the framework of this new partnership.

4. What approach for the next coastal areas assessment?

The configuration of the West African Coast Observation Mission (MOLOA) network favours a strong interaction between the regional coordination unit and the national offices (correspondents in the countries) which are strongly associated to the governance bodies that are the Regional Scientific Committee and the Regional Steering Committee. This organization is beneficial to the processes of updating the Master Plan for Coastal West Africa (SDLAO); most of the data and information needed to update the detailed master plan is provided by national offices. With the technical support of IUCN, international expertise is also mobilized on some of the more cross-cutting issues such as climate change, concepts related to coastal management, coastal protection techniques, etc. On this basis, the first version of the SDLAO mobilized more than 130 specialists from state institutions in the region, West African universities, but also from international scientific networks (coastal experts group, ANCORIM: Atlantic Network for COastal RIsks Management, etc.). The 2016 assessment is a clear reflection of the excellent involvement of regional expertise in the updating of the SDLAO. In 2020, the innovation concerning the general report of the assessment focused mainly on the mobilisation of several contributors at both regional and international levels.

A comeback to these different experiences in developing the SDLAO allows us revisiting the main prescriptions made previously for coastal risk management, to note the progress made in the 2020 assessment in this area and to propose methodological guidelines for the next assessment.

FEEDBACK ON THE SDLAO AND THE 2016 ASSESSMENT

The SDLAO, a founding study carried out between 2009 and 2011, established various findings, listed below, regarding coastal risk management in West Africa:

1. The acknowledgement of the importance of the risks that weigh on the coastal urban concentrations and the related challenges (human, but also economic and industrial) in the evolving context of climate change. The trends identified for the 2020 and 2050 horizons highlight the rapid increase in these coastal challenges (population growth, coastalisation of societies, economic development and associated infrastructure). In this situation, the capacity to anticipate and strategically consider the development and planning of coastal territories become vital;
2. The skills and know-how capital within the sub region is significant but not well valorised because it is compartmentalized between states, but also between institutions within states. The opportunities for partnership and rapprochement with institutions in the North facing similar situations are real, but must be approached in a coordinated and consistent manner by the states of the sub region. A sustainable coastline management requires today the networking of competences for decision making and the development of inter-State and inter-institutional cooperation within the regional space and beyond;
3. The development of integrated approaches for the reduction of coastal risks, mobilizing all sectors and actors involved in the coastline, goes through the provision of reliable and up-to-date information, shared and made available at various decision-making levels in order to improve the strategic quality of decisions concerning the development, occupation and conservation of coastal areas.

Under these conditions, the SDLAO has advocated a regional response for coastal risk reduction articulated on three operational pillars or areas/programs (presented below) that complement and reinforce each other. The coherence between these three pillars must be ensured by the establishment of regional mechanisms of coastal risk governance that articulate the different levels of intervention.

N°	Program areas	Objectives
1	Protection and mitigation of impacts	Increase the resistance and resilience of coastal areas occupied by people and human settlements in order to reduce the vulnerability and exposure of the populations and human settlements established on the coastline
2	Watch and vigilance	Identify and detect in advance the situations that generate risks
3	Information and capacity building	Increase the capacity for coordinated individual, collective and institutional responses against coastal risks
Cross-cutting theme: regional governance of coastal risk		

The SDLAO sets out prescriptions for each program area:

Program Area 1- Protection and Mitigation of Impacts:

1. Define a spatial planning policy for the coastline essentially based on a zoning of the coastal space according to risk-friendly arbitrations, with indication of the functional or multifunctional vocation (habitat, industry, port areas, preserved natural space, etc.) and constructability of the different zones;
2. Conduct multi-criteria studies including a benefit/risk analysis of the various shoreline protection solutions prior to any works and set up a monitoring of the impact of the implemented solutions.
3. Develop an inventory of strategic sedimentary reserves that can be used as an alternative to coastal material extraction for the possible restoration of coastal systems (beach recharging);
4. Update the standards for urban planning, hydraulics, civil engineering and coastal engineering in order to take into account the effects of climate change, particularly in terms of flooding risks related to marine submersion, river but also rainfall floodings;
5. Systematically resort to impact studies and strategic environmental assessments for any substantial development in the coastal zone.

Program Area 2- Watch and Vigilance:

1. To carry out the monitoring of coastal systems through the establishment of the West African Regional Coastal Observatory;
2. Set up a network of the actors of the coastline's watch and monitoring program around the West African Regional Coastal Observatory;
3. Involve states and regional organisations (WAEMU, ECOWAS) in the strategic monitoring of the growth and settlement of West Africa's coastal zones.
4. Update the climate projections in coastal areas, create an early warning service, in conjunction with the national meteorological services, on the risks of marine and river flooding.

Program Area 3- Information and Capacity Building:

1. Produce a biannual "communicating" synthesis on the situation and evolution of West African coasts, which will integrate all the information from the observatory, the network of observers, the MPA network and the climatic and meteorological monitoring;
2. Implement an online regional portal on the coastal zone;
3. Produce communication tools and materials including a periodic electronic newsletter dealing with news on the West African coast;
4. Produce didactic information tools intended for the actors of the local coastline management.

The report of the SDLAO has favoured the establishment of the WACOM in order to continue the regional coastal risk management dynamic and to proceed with the first update of the SDLAO (2016 Assessment).

The 2016 Assessment, with the establishment of the WACOM regional coordination unit within CSE, following the signing of the CSE/WAEMU convention, and the technical support of IUCN, has further involved regional expertise in the updating of the SDLAO sectors and fostered a better ownership of the SDLAO methodological approaches. Two regional technical workshops, gathering all the 11 countries, were organized for (i) the preparation of the indicators guide and (ii) the update of the sectors regarding the hazards, challenges, ongoing projects, legal and institutional aspects. The Regional Steering Committee also met to assess the progress of the activities, approve the initial results and provide guidance on the responsibilities and procedures for reporting data from the countries to the regional coordination unit.

In terms of risk reduction and adaptation strategies in the coastal zone, the 2016 assessment confirms the recommendations of the SDLAO in 2011, which have remained relevant, and whose consideration at all scales allows making progress in terms of resilience of West African coastal zones. Nevertheless, the construction of climate change adaptation strategies in the coastal zone is also faced with many difficulties:

1. **the uncertainty** that characterizes the knowledge of the future effects of climate change, and thus the nature of the threats that will affect coastal systems. The management of this uncertainty implies (i) the establishment of monitoring and evaluation systems for the implemented strategies; (ii) the diversification of strategy elements; (iii) the establishment of governance and decision-making mechanisms that are sufficiently effective to limit inertia in the adoption of corrective measures;
2. **the diversity of the uses of coastal areas and resources**, which determines frequent conflicts of use and makes it more difficult to control the effects of adaptation, since actions generating positive effects for some interest groups may become counterproductive for others. Adaptation options mobilise various and often contradictory interests. In a way, we are confronted here with complex problems that are reminiscent of those addressed in the integrated coastal zone management (ICZM);
3. **the differential between, on the one hand, changes that are taking place more and more rapidly and, on the other hand, the time it takes to make decisions and implement them:** the setting up of programs and their implementation in national contexts are carried out over timeframes that are rarely less than 5 years or even 10 years. Given the rapidity of changes affecting coastal zones, it is more than likely that the initial conditions will no longer be the same at the end of these timeframes, and that the responses provided will not always be as justified as they were at the time the program or strategy was designed. This implies that decisions should not only be based on present and known situations, but most of all should anticipate the evolution of these situations and apprehend the coastal issues in all their dynamics.

Furthermore, the 2016 assessment stated that any adaptation strategy in the coastal zone may combine different attitudes in response to potential losses related to coastal risks:

1. **prevention of losses**, by implementing actions aimed at reducing the exposure of the stakes.
2. **acceptance of losses**, where negative impacts are considered acceptable in the short term because they can be borne by the stakes presented without significant damage in the long term;
3. **distribution of losses**, when negative impacts can be distributed over a wider zone. The insurance mechanisms of risk transfer also fall into this category;
4. **changes of activities procedures or activities changes**, allowing to better manage the negative consequences of the climate change or to enhance the positive effects of it;
5. **relocation,** when the continuation of an activity does not depend directly on its location. Here it is simply a matter of reducing exposure;
6. **restoration,** when it comes to restoring systems affected by the effects of climate change or restoring the functioning of natural systems that contribute to the resilience of coastal systems.

Finally, according to the 2016 assessment, adaptation strategies must also combine differentiated approaches between which synergies can be achieved:

1. <u>territorial approach to adaptation</u> : it aims at intervening on the development and organization of coastal territories with a view to promote their resilience and reduce the exposure of the most sensitive vital issues
2. <u>sectoral approaches to adaptation</u>: They aim to develop adapted standards and practices in the sectors directly confronted with coastal risks: port infrastructures, roads, urban planning, tourist settlements, fishing, agriculture, mining activities, etc.
3. <u>Governance to serve adaptation</u>: In the same vein that the effects of climate change are not compartmentalized, and that coastal areas are generally multifunctional, governance must aim to give priority to dialogue and empowerment of the various categories of stakeholders. The need to regularly adjust adaptation approaches in accordance with evolving knowledge requires rapid and transparent decision-making mechanisms. It is also a matter of legislative governance, as demonstrated by the various projects developed by the states of the region, particularly with regard to Coastal Law, but also at the executive level through regulatory measures, such as the prohibition of dune sand removal for example;
4. <u>knowledge enhancement for a better management of uncertainty</u> : the evaluation of climate change effects remains widely marked by uncertainty when in its expressions, but also in the relevance of the responses provided, as long as we do not have sufficient hindsight time and experience to assess the effectiveness and viability of these responses. The mobilization of technical and scientific knowledge and its translation/dissemination into concrete and operational terms underpin the entire adaptation process. The establishment of the MOLOA is part of this mechanism. During its implementation, various constraints were noted, of which the main one is of a structural and institutional nature.

   A second challenge is didactic, namely to produce information and messages that are accessible and usable by decision-makers. The scarce resources dedicated by the states to the establishment and updating of a prospective vision of the rapid evolution of the occupation of coastal areas do not contribute to the management of an increasingly obvious multifunctionality of the coasts.

   A third point, common to all regional initiatives, deals with the spatial and temporal integration of the different scales of coastline monitoring, from localised observation to the monitoring of regional policies for the integration and development of structuring networks of large infrastructures (transport, electricity, etc.), which are precursors of coastal occupation.

THE 2020 ASSESSMENT (PROGRESS AND GAPS)

The 2020 Coastal Areas Assessment was made under specific conditions related to:

- the COVID 19 pandemic, which did not allow the technical meetings to be held in person with the correspondents in the countries;
- a new methodology choosing to mobilise many contributors on the themes addressed, requiring a significant need for coordination and ensuring consistency;
- with much tighter deadlines than for the previous versions: a duration of about one year in 2020, compared to two to three years for the SDLAO and its update in 2016.

However, a few elements listed below have contributed to a conducive environment for the development of the 2020 Assessment:

- The 2020 Assessment occurs in a context where the main features of the strategies to fight against coastal risks are outlined in the SDLAO and the 2016 Assessment (see above); similarly, some basic concepts such as the notion of shoreline, coastline, hazards, issues, maritime public domain, sedimentary cell, etc. have been widely discussed and stabilised in the previous versions ;
- The 2020 assessment is developed in the context of the implementation of the WACA program (already announced in the 2016 Assessment) and particularly in the framework of the WACA ResIP project, which stimulates the mobilisation of teams in the countries involved and gives the possibility of integrating all the countries of the MOLOA network;
- Finally, the simultaneous development of the feasibility study of the WARCO provides a better visibility of the modalities for strengthening coastline observation, which is one of the pillars of the response to coastal risks.

The progress of the 2020 assessment lies mainly in the presentation of the recent work proposed by contributors.

Concerning the state of play, this can be observed, among others, in:

- The characterisation of coastal dynamics (Abessolo O.G., 2020; Almar R. et al., 2019; Anthony et al., 2019; Giardino et al., 2018) that identifies or confirms the key meteoro-oceanographic factors governing sedimentary transit in the West African coastline: oblique waves, west wind. From the WFLOW hydrological model, the effects of anthropogenic interventions (ports, river dams) on sedimentary transit are assessed, especially in the far field at the port of Lomé (Togo) whose effects can be seen up to 50km away. These studies are in line with the recommendations of Program Area 1 - "Protection and Mitigation of impacts" of the SDLAO - concerning the inventory of sedimentary reserves.
- The database on coastal protection infrastructure and coastal management, implemented by CSE in 2020, in conjunction with the correspondents of some countries (based on the methodology developed by Cerema), is also part of this approach and is in line with the Program Area 2 - "Watch and vigilance" of the SDLAO on the monitoring of coastal systems.

Concerning the pressure on the littoral, these elements can be found, among others, through:

- - the data on urban littoral dynamics (Africapolis Club du Sahel, Brockmann Consult), which indicate an urban area that will grow from about 1,000 km² to 2,500 km² in Ghana and from about 800 km² to 1,800 km² in Côte d'Ivoire, between 1992 and 2019. These elements are related to the SDLAO's Program-Area 2 "Watch and Vigilance" relating to the strategic monitoring of growth and settlement in coastal zones in West Africa.

- The updated data of the economic activities. These concern small-scale and industrial fishing in West Africa (CNSHB, 2019; FAO-FIGIS, 2018; FAO, 2018) but also mining and offshore oil and gas activities (OXFAM, 2017; GIZ, 2019). These elements can be linked to the Program Area 1 - "Protection and Mitigation" of the SDLAO, in particular with the systematic use of environmental assessment.

In terms of responses given, the 2020 Assessment built on the processes underway carried out by partners within the framework of the WACA ResIP project, such as the development and adoption of the additional protocols to the Abidjan Convention, the ongoing revitalization of PRLEC governance bodies, and the ongoing design of the ORLOA. These elements also concern the soft solutions carried out within the framework of WACA FFEM project, the cooperation frameworks such as WACAF GI, PRCM, RAMPAO, etc. They can be connected with the program area 1- "Protection and mitigation of impacts" of the SDLAO advocating ***spatial planning and development*** of the littoral and with SDLAO's program area 2- "Watch and vigilance".

On a legal and institutional level, the 2020 Assessment occurs in a context of approval of the WAEMU Regional Space Development Plan (SDER) and the operationalisation of the Regional Observatory for Spatial Analysis of the Community Territory (ORASTEC). These instruments are in line with the adaptation strategies advocated in the 2016 Assessment on governance.

In addition to this, we can associate to the environment of the 2020 Assessment the capacity building dynamics of the stakeholders launched in the framework of the WACA ResIP project on environmental safeguards, coastal risk monitoring indicators, the use of satellite images for coastal risk monitoring, marine spatial planning, etc.

In addition, there are the new tools such as the Coastal Hazard Wheel (CHW) used for coastal risk assessment or the Coupled Model Intercomparison Project 5 for the study of climate change impacts on the coastline of 5 West African countries (Benin, Côte d'Ivoire, Mauritania, Senegal and Togo) with the identification of the most exposed and vulnerable zones.

However, some studies initially planned for being capitalized in the 2020 Assessment could not be taken into account here because they were not finalised. These are the Regional Strategic Action Plan for Investments (PARSI, WAEMU action) and the economic evaluations of ecosystemic services produced by mangroves in Guinea (World Bank and Deltares studies) and in Ghana (Deltares study).

Concerning the detailed report, despite the mass of information provided by country correspondents in difficult circumstances, it was not possible to provide more details on certain sectors concerning the evolution of hazards, issues and the implementation of new projects.

GUIDANCE FOR THE NEXT COASTAL AREAS ASSESSMENT

Basically, it can be expected in the updates of the SDLAO, a highlighting of the progress compared to the previous versions. This is not automatically easy to implement in the general report, given the format and various constraints regarding access to recent data and information. In addition, there is the complexity of assessing whether the various policy and institutional requirements of the SDLAO have been taken into account at the level of each country, especially without a mastery of internal monitoring mechanisms. This is emphasized by the structural and institutional constraints faced by the MOLOA network (national offices). Thus, regarding the assessments, one can get the overall impression of periodic reformulation of coastal risk management strategies in West Africa. However, without being able to formally relate it to a taking into account of the SDLAO guidelines and its updates, some actions taken by the states in the management of coastal risks help to make them a reality. This situation is facilitated by the synergy and the effort of bringing consistency within the framework of regional initiatives taking into account the specificities at the cross-border level. The PRLEC is a precursor in this field and the dynamics is maintained within the framework of the WACA program (in particular the WACA ResIP project), with the involvement of regional partners such as the Abidjan Convention, IUCN, CSE, already in charge of the implementation of unifying initiatives such as the additional protocols, the protection and restoration of mangrove ecosystems, and the coastal observation. Thus, it seems wise to build on the achievements to consolidate the response to coastal risks through the strengthening of coastal observation.

"*The production of a biannual "communicating" synthesis of the situation and the evolution of West African coasts, which will integrate all the information generated by the observatory, the network of observers, the MPA network and the climate and meteorological monitoring component*", recommended by SDLAO's Program Area 3 "Information and capacity building", can now be oriented to the strengthening of the detailed master plan for the next version. Detailed, precise and regular information on the 47 zones and 186 sectors of the SDLAO (now with the joining of São Tomé & Príncipe), can be used in the national and regional systems of coastal risk monitoring and helpful in the development of coastal management plans. Already in practice, it is a data that is well considered by the countries and the regional bodies in the studies and planning perspectives; it is being considered in:

- the framework studies undertaken through the WACA program: (i) Preliminary quantitative assessment of sedimentary stocks and movements (ii) costs of coastal environmental degradation, risk assessment and cost-benefit analysis (iii) stakeholders engagement, knowledge & communication on coastal zone management in West Africa and economic policy analysis;
- the Integrated Coastal Planning and Management Plan (PAGIL) of Côte d'Ivoire, which is currently being prepared;
- the ongoing updating of the national ICZM strategy in Senegal;
- the establishment of a marine meteorological early warning system/monitoring program for the coastal and marine environment in Togo (underway).

Hence, the option can be decisively taken to strengthen the detailed master plan by acquiring complete data, which requires the strengthening of the observation and data collection system at the regional level but also at the national level. The WARCO should be the backbone of the observation and data collection system for the monitoring of hazards and challenges in the SDLAO sectors. The feasibility study of the WARCO in progress, is already laying the foundations of this mechanism with the sizing of measurement instruments (tide gauges, wave gauges) along the coastline and for each country. It has also identified, with the countries, a list of priority indicators (Appendix 3) to be monitored out of a total of 94, based on the responses to the questionnaire concerning the themes deemed to be priorities and which are as follows:

- the study of coastal risks (hazards, stakes, vulnerability): 57% of responses;
- marine pollution: 19 % of responses;
- biodiversity: 9 % of responses;

The follow-up of these indicators offers the possibility to reinforce the information concerning the hazards and stakes on the SDLAO sectors. However, the structural and institutional constraints of the national offices do not, for the time being, allow them to be effective in collecting indicators at the local level. Thus, the follow-up at the regional level is privileged, in the short term, for about fifteen indicators (Appendix 2) based on satellite imagery and meteorological data. The system of marine meteorological data measurement being, for the moment, heterogeneous from one country to another, the emphasis will be put on the use of satellite images to have homogeneous information between the countries. As a result, 6 indicators have been selected below to document, by the time of the next Assessment, the evolution of risks in the SDLAO sectors, 4 of which deal with marine pollution, coastal erosion and flooding, and 2 of which deal with biodiversity (surface area of habitats) and management challenges (number of protective and development works).

Tableau XXVII: List of indicators for coastal risks monitoring in the short term at the regional level by satellite imagery

Component of the risk	Theme	Category	Sub-category	Indicator	Periodicity
Stakes	Economic	Industries	Potentially polluting	Presence and number of industries	2 years
	Patrimonial	Environmental	Habitats, mangroves, wetlands	surface area (ha) evolution	2 years
	Equipment and management infrastructure.	Prevention	Protection facilities	Number of infrastructures	2 years
Hazards	Erosion	Position of the coastline		Coastline evolution (erosion, stability, progradation)	Annual
	Submersion	Linear of concerned coastline	Characterization of the concerned linear	Linear (km)	Annual (seasonal)
		Flood-prone and submersible zones.		Surface area (ha)	Annual (seasonal)

The periodicity of the measurement is annual (seasonal) for hazards and feasible every two years for the stakes. The scientific committee at the level of each country can be mobilized for necessary validations at the local level and for further information on national policies and strategies in terms of spatial planning and land management in relation to the risks of submersion and erosion as well as on the prioritization of actions defined by the states.

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6. Abbreviations

AbC	Abidjan Convention
ACCC	Adaptation to Climate Change in Coastal Areas Program (Senegal)
ACCVC	Adaptation to Climate Change in Coastal Cities project (GIZ / MEDD - Mauritania)
ACEPA	Association of Oil Exploration and Production Companies
AFD	French Development Agency
AGRHYMET	AGRHYMET Regional Center is a specialized institution of the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS)
ALEC	Citizen Commitment and Local Action
ANACIM	National Agency for Civil Aviation and Meteorology
CCLME	“Canary Current Large Marine Ecosystem Protection” Project
CHW	Coastal Hazard Wheel
CIDA	Canadian International Development Agency
CIFDP	Coastal Inundation Forecasting Demonstration Project
CIFI	Coastal Inundation Forecasting Initiative
CLC	Civil Liability Convention of 1992
CMD	Coastline Management Department
COED	Cost of Environmental Degradation
COP	Conference of the Parties
CREWS	Climate Risks & Early Warning Systems
CSE	Ecological Monitoring Center
CSO	Civil Society Organization
CSR	Corporate Social Responsibility
DB	Databases
DEEC	Department of the Environment and Classified Establishments
DEM	Digital Elevation Model
DRR	Disaster Risk Reduction
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
EEZ	Exclusive Economic Zone
ESIA	Environmental and Social Impact Assessment

EWS	Early Warning System
FANFAR	Operational Flood Forecasting and Alerts in West Africa
FAO	United Nations Organiation for Food and Agriculture
FEWS	Famine Early Warning Systems Network
FFGS	Flash Flood Guidance System
FGEF	French Global Environment Facility
FTC	Fixed Term Contract
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEP	Geohazards Exploitation Platform
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gas
GI WACAF	Global Initiative for West, Central and Southern Africa
GILA	Greater Ibadan - Lagos - Accra urban corridor
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (agence de coopération internationale allemande)
GLOSS	Global Sea Level Observing System
GPS	Global Positioning System
HASSMAR	High Authority in charge of the Coordination of Maritime Security, Maritime Safety and Protection of the Marine Environment (Senegal)
IBD	International Bidding Documents
IGA	Income Generating Activities
IGO	Intergovernmental Organization
IMO	International Maritime Organization
InSAR	Interferometric Synthetic-Aperture Radar
IOC	Intergovernmental Oceanographic Commission
IOGP	International Association of Oil and Gas Producers
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
IRD	Research Institute for Development

IRHOB	Fisheries and Oceanographic Research Institute of Benin
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported and Unregulated Fishing
JICA	Japan International Cooperation Agency
LoS	Line-of-Sight
LPSD/PA	Fisheries and Aquaculture Sector Development Policy Letter
MARPOL	Marine Pollution
MCA	Management and Cooperation Agency
MESD	Ministry of the Environment and Sustainable Development
MOLOA	West African Coastal Observation Mission
MOWCA	Maritime Organization of West and Central Africa
MPA	Marine Protected Area
NASA	National Aeronautics and Space Administration
NDC	Nationally Determined Contribution
NDF	Nordic Development Fund
NGO	Non-Governmental Organization
NPAA/CTF	National Protected Areas Authority/Conservation Trust Fund
NSC	National Steering Committee
OPRC	Oil Pollution Preparedness, Response and Co-operation - Convention
ORLOA	West African Regional Coastal Observatory
ORSEC	Emergency Response Organization (Plan)
PAMZC	Adaptation to Climate Change in Coastal Areas Program
PARSI	Regional Strategic Action Plan for Investments
PCAE	Common Environmental Improvement Policy
PDGM	Mining Development and Governance Project
PENAf	Ports Environmental Network-Africa
PNIUM	National Marine Emergency Response Plan
PPP	Plans, Programs, Policies
PRCM	Regional Partnership for Conservation of Coastal and Marine Zone in West Africa
PRLEC	Regional Program for Combating Coastal Erosion in WAEMU
P-SBAS	Parallel Small BAseline Subset

PSMSL	Permanent Service for Mean Sea Level
RAMPAO	Regional Network of Marine Protected Areas in West Africa.
RMC	Regional Management Committee
ROC	Regional Orientation Committee
RSC	Regional Scientific Committee
RSMC	Regional Specialized Meteorological Center
RSO	Radar à synthèse d'ouverture
SAVE	Sand, Wave, Environment Association
SLAPIS	Local Early Warning System for Floods of the Sirba
SLR	Sea-Level Rise
SNPT	New Phosphates Company of Togo
SSP	Scientific Support Project
SWFP	Severe Weather Forecasting Program
TC	National Multi-sectoral Technical Committee
TF	Task Force
TWLE	Total Water Level Envelope
UN	United Nations Organization
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNSO	United Nations Sudano-Sahelian Office
UPEGA	Gabonese Petroleum Union
USAID	United States Agency for International Development
WA BiCC program	West Africa Biodiversity and Climate Change program
WACA	West Africa Coastal Areas Program
WACA ResIP	West Africa Coastal Areas Resilience Investment Project
WAEMU	West African Economic and Monetary Union
WARFP	West Africa Regional Fisheries Project
WMO	World Meteorological Organization

APPENDICES

APPENDIX 1 : COMMUNIQUE FINAL DE LA REUNION DES MINISTRES POUR LA VALIDATION DU BILAN 2016

UICN MOLOA UEMOA

VALIDATION OF THE RESULTS OF THE WEST AFRICAN COASTAL OBSERVATION MISSION (WACOM)

MEETING OF THE MINISTERS IN CHARGE OF THE ENVIRONMENT

Abidjan (Côte d'Ivoire), July 12, 2018

FINAL COMMUNIQUÉ

July 2018

The Meeting of the Ministers in charge of the Environment in West Africa for the validation of the results of the West African Coastal Observation Mission (WACOM) was held in Abidjan (Côte d'Ivoire) on 12 July 2018, under the chairmanship of **Mr Joseph Séka SEKA** the Environment and Sustainable Development of Côte d'Ivoire.

The meeting was attended by:

Mr Joseph Séka SEKA, Minister for the Environment and Sustainable Development of Côte d'Ivoire ;

Ms Quite DJATA, Secretary of State for the Environment of Guinea-Bissau ;

Mr Mady TALEB, Secretary General, representative of the Minister for the Environment and Sustainable Development of Mauritania;

Mr Kodjo KUDADZE, Chief of staff representing the Minister of Environment and Forest Resources of Togo;

Dr Malanding JAITEH, Technical Advisor representing the Minister of Environment, Climate Change and Natural Resources of The Gambia;

Dr Assize TOURE, Director General of the Centre de Suivi Ecologique de Dakar (Ecological Monitoring Centre of Dakar) representing the Minister of Environment and Sustainable Development of Senegal;

Honourable Anthony D. KPADEH, Director of Water Services representing the Minister of Environment, Mines and Energy of Liberia;

Mr Moussa BIO-DJARA, WACOM focal point representing the Minister of the Living Environment and Sustainable Development of Benin;

Mr Kwasi Appeaning ADDO, Associate Professor at the University of Ghana representing the Minister in charge of the Environment of Ghana;

Mr Mohamed Lamine KEITA, Director of the *Ecole doctorale Environnement marin et côtier du Centre de Recherche Scientifique* in Conakry Rogbané representing the Minister in charge of the Environment of Guinea;

Mr Foday M. JAWARD, Director of the Environmental Protection Agency representing the Minister in charge of the Environment of Sierra Leone.

The meeting was also attended by:

Mrs Zourata LOMPO/OUEDRAOGO, Chief of staff of the Commissioner in charge of the Agriculture, Water Resources and Environment Department of the WAEMU Commission;

Mr Aliou FAYE, Regional Director for Central and West Africa of the International Union for the Conservation of Nature and its resources;

Mr Richard DACOSTA, Programme Officer at the Secretariat of the Abidjan Convention.

The official opening ceremony was marked by the opening remarks by **Mrs. Zourata LOMPO/OUEDRAOGO,** Chief of staff of the Commissioner in charge of the Department of Agriculture, Water Resources and Environment of the WAEMU Commission, followed by the opening address by Mr. Joseph Séka SEKA Minister for the Environment and Sustainable Development of Côte d'Ivoire.

The Ministers discussed the "2016 Review of the West African coastline" and the report of the Experts Meeting held in Abidjan on 10 and 11 July 2018.

The Ministers validated the "2016 Review of the West African coastline" and adopted the report of the Experts Meeting, subject to comments being taken into account.

The Minsiters,

Noting that the coastline is currently home to 31% of the West African population and 51% of the urban population and that according to the various scenarios, between 74 and 83 million people will reside in West Africa's coastal zone by 2050;

Emphasizing that demographic and urban growth in a context of sustained economic growth leads to significant development of port, transport and other strategic infrastructure;

Further stressing that the economic growth of the coastline requires the protection of the marine and coastal natural capital which is the backbone of such an economy and lays the ground for a growth-conducive environment;

Recalling the fragility and diversity of the West African coastline, both in terms of dynamics and natural resources, threats and risks;

Recalling that climate change is likely to result in increased risks of deterioration of infrastructure and living conditions of West African populations, as a result of the high frequency and intensity of exceptional marine weather events;

Recognizing the need to act quickly and significantly, to protect infrastructure but also and above all the various populations, especially the most vulnerable ones, and to ensure resilient development of coastal communities, to improve their living conditions and livelihoods;

Considering the existence of proven scientific expertise at national and regional levels in West Africa to support coastal risk management;

Expressing their gratitude to the Government of the Republic of Côte d'Ivoire for hosting this meeting for the validation of the results of the West African Coastal Observation Mission (WACOM)

Call upon the States:

1. to commit to developing their blue economies and encouraging sustainable and resilient growth in response to climate change in their coastal and marine sectors;
2. to strengthen regional collaboration and coordination in the management of West African coastal area and to assess their actions in this field from a regional perspective;
3. to ensure better coordination between the various stakeholders, sectors and institutions by diversifying the technical and financial cooperation mechanisms relating to coastal risk reduction and in the definition of investment priorities, in particular regional cooperation but also the development of decentralized cooperation.

Call upon the technical and financial Partners:

1. to uphold and strengthen efforts to monitor coastal hazards at national and regional levels;
2. to keep up their efforts to coordinate interventions in the countries' multisectoral investment programmes.

To this end, they make the following recommendations:

To the States:

- Transform WACOM into a "Regional Observatory" supported by dedicated funds;
- Strengthen training institutions for managers and specialists to improve skills in the management of the marine and coastal environment;
- Set up or strengthen the national validation, control and follow-up structures in charge of coordinating policies defined for the development of coastal areas, in conjunction with sub-regional programmes, such as WACOM.
- At the national level, develop an advocacy strategy in order to minimize major anthropogenic activities to enable better coastal management;
- Encourage the creation of a consortium of West African experts to support coastal risk management;
- Promote nature-based strategies and solutions to address coastal hazards.

To the WAEMU Commission

- Support the transformation of WACOM into a regional Observatory;
- Ensure consistency of the interventions and investments by the technical and financial partners, in accordance with the relevant requirements of the West African coastal management scheme;
- Promote the implementation of multilateral agreements relating to the marine and coastal environment;
- Develop a regional strategy for the development, protection and integrated management of coastal areas based on the results of the 2016 coastal review;
- Operationalize the Scientific Committee to enable it to fully fulfill its mandate;
- Strengthen advocacy for the mobilization of financial resources for coastal risk management;
- Set up or strengthen frameworks for exchanges and collaboration between political, scientific and stakeholders with a view to improving governance of the marine and coastal environment;

To WACOM:

- Develop a strategy for the dissemination and ownership of the results;
- Develop an advocacy strategy with the decision-makers in order to ensure better ownership and effective implementation of the West African coastal management scheme;

The Ministers expressed their satisfaction with the outcome of the meeting and congratulated the WAEMU Commission, the International Union for Conservation of Nature and the *Centre de Suivi Ecologique de Dakar* (Ecological Monitoring Centre in Dakar)

At the end of the meeting, the Ministers expressed their gratitude to **His Excellency Mr. Alassane OUATTARA**, President of the Republic of Cote d'Ivoire, to his Government and to the Ivorian people for the fraternal welcome and benevolent attention they received during their stay.

Done in Abidjan, July 12, 2018

For the ministerial meeting

For the Minister for the Environment and Sustainable Development of Côte d'Ivoire
Chairperson of the ministerial meeting

Mrs. Nasséré KABA

APPENDIX 2: INDICATORS VALIDATED FOR A SHORT TERM FOLLOW-UP AT THE REGIONAL SCALE

Hazard Component	Theme	Category	Subcategory	Indicator
Stakes	Human	Population	Residing	Number of inhabitants/density
	Housing	Residential	Settlements	Number of residential settlements
	Economic	Industries	Potentially polluting	Existence and number of industries
	Heritage	Environmental	Habitats: mangroves, wetlands	Surface evolution
	Equipment and management works	Prevention	Protection facilities	Number of works
Hazards	Erosion	Coastline location	-	Coastline progress (erosion, stability, progradation)
		Beach evolution	-	Topographic profiles
	Submersion	Submersion types	-	By overflows, by crossing the sea packs, by breaking the protection
		Flood-prone and submersible areas	-	Surface area (ha)
	Natural predisposing factors	Exposure to the generating factors	-	Coastal direction relative to swells/currents/winds
	Weather and sea forcing	Sea state	Swell	Significant height/period
	Anthropogenic erosive forcings	Sediment extraction	Onshore	Location and annual quantities
	Pollution	Physical, chemical, biological	-	Mining
	Estuarine and lagoon areas flooding	Water height	-	Records of humidity traces
	Climate change	Sea level rise	-	• Rise in cm/ decade/century projections

APPENDIX 3: LIST OF PRIORITY INDICATORS SELECTED BY WARCO MEMBER STATES

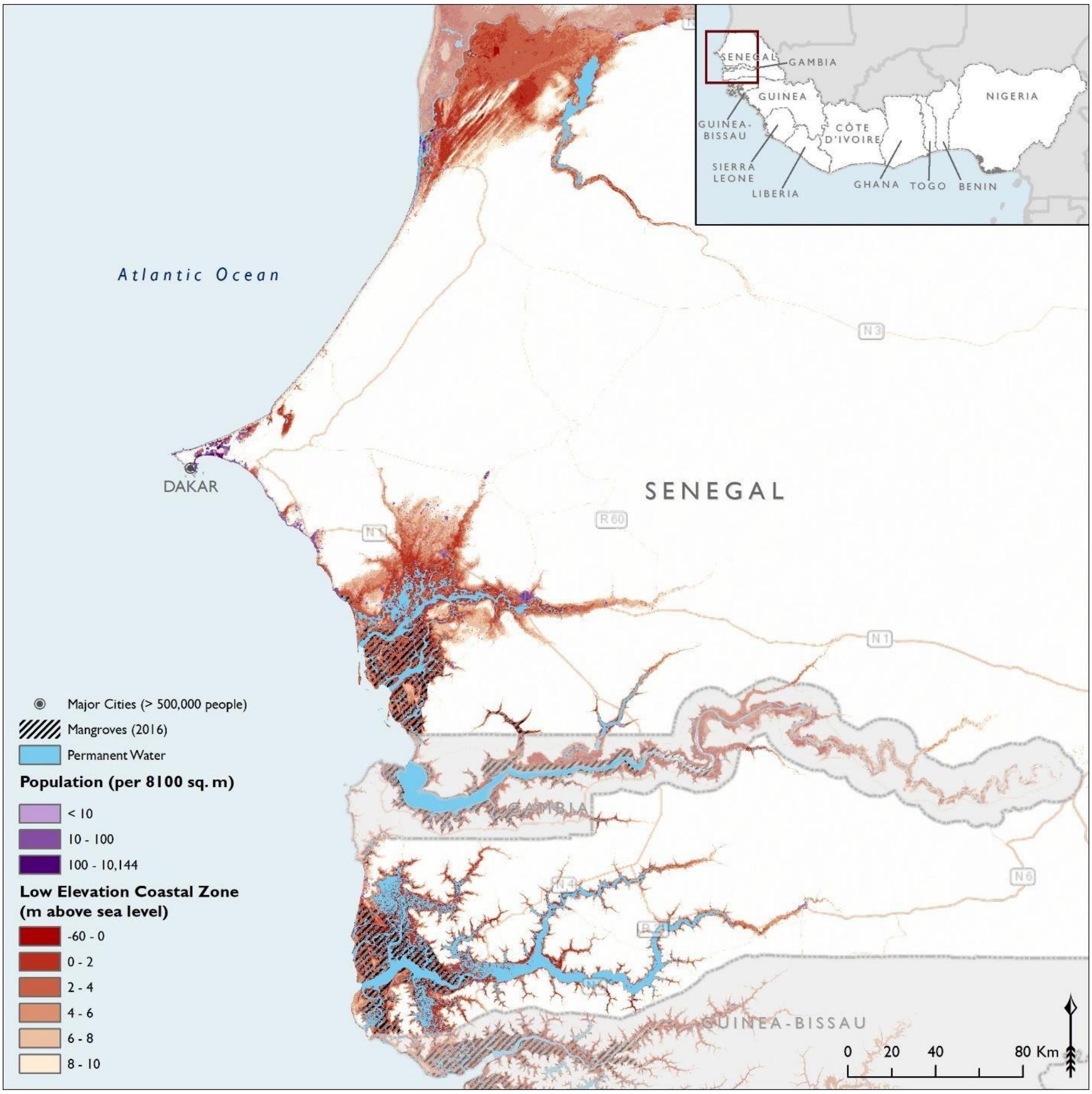
Hazard Component	Theme	Category	Subcategory	Indicator
Stakes	Human	Population	Residing	Number of inhabitants/density
				Number and size of households
				% of vulnerable persons (- 10 years/+ 60 years)
	Housing	Residential	Settlements	Number of residential settlements
	Economic	Industries	Potentially polluting	Existence and number of industries
		Fishery	Artisanal	Annual tonnages and types of vessels/home sites
			Commercial	Annual tonnages and types of vessels/home sites
	Heritage	Environmental	Habitats (mangroves and wetlands)	Surface areas/evolution
			Environmental protection measures	Threatened/protected species/surface areas of protected natural environments (reserves, forests, MPAs…)
	Equipment and management works	Safety and rescue	Hospitals, relief centers, shelters	Number/accommodatio n capacity
		Prevention	Protection facilities	Number
Hazards	Erosion	Coastline location		Erosion/progradation
		Topographic profiles		Losses/gains
		Surface are between successive coasts		Location/losses, gains
		Sediment budgets	Sediment transit	Losses/gains/evolution direction and speed
		Mass movements		Movement types (rockfall, collapse, landslide), movement volumes, number of movements
	Submersion	Coast types	Sandy, muddy	Linear (km)
			Rocky	
			Cliffs	

Hazard Component	Theme	Category	Subcategory	Indicator
		Submersion types		By overflows, by crossing the sea packs, by breaking the protection
		Submersion dynamics	Coastal currents Tidal currents Tide magnitude	Speed of the currents/speed of the water rise/submersion duration
		Flooded areas	Coastal/marine marshes	Surface area (ha)
		Water levels in the houses	Flooded coastal infrastructure	Number of houses affected/height
		Lengths of coastlines affected	Characterization of the linear affected	Linear/km
	Natural predisposing factors	Topography (coast and backshore)		Landform evolution
		Bathymetry		Ocean depth and landform
		Morphometry (study and analysis of structural shapes)		Beach width/length/area/slope/ vegetation cover/bathy foreshore/length and width of barrier beach
		Exposure (To the generating factors)		Coastal direction relative to swells/currents/winds
	Weather and sea forcing	Sea state	Swell	Height/period
		Currents	Onshore	Directions/forces
			Offshore	
		Winds		Forces/directions
	Anthropogenic erosive forcings	Sediment extraction on the coastal strip	Mining and quarrying	Annual quantities
		River and lagoon sediment extraction	Sandy	
	Pollution	Physical (solids suspended, waste)		Mining
		Chemical (inorganic and organic components)		
		Biological (bacteria...)		
	Estuarine and lagoon areas flooding	Water height		Increase in centimeters
		Flooded areas		Low areas location
		Flow monitoring		Increase/decrease/return to normal (in m^3/s)
	Climate change	Sea level rise		Rise in cm/ decade/century projections

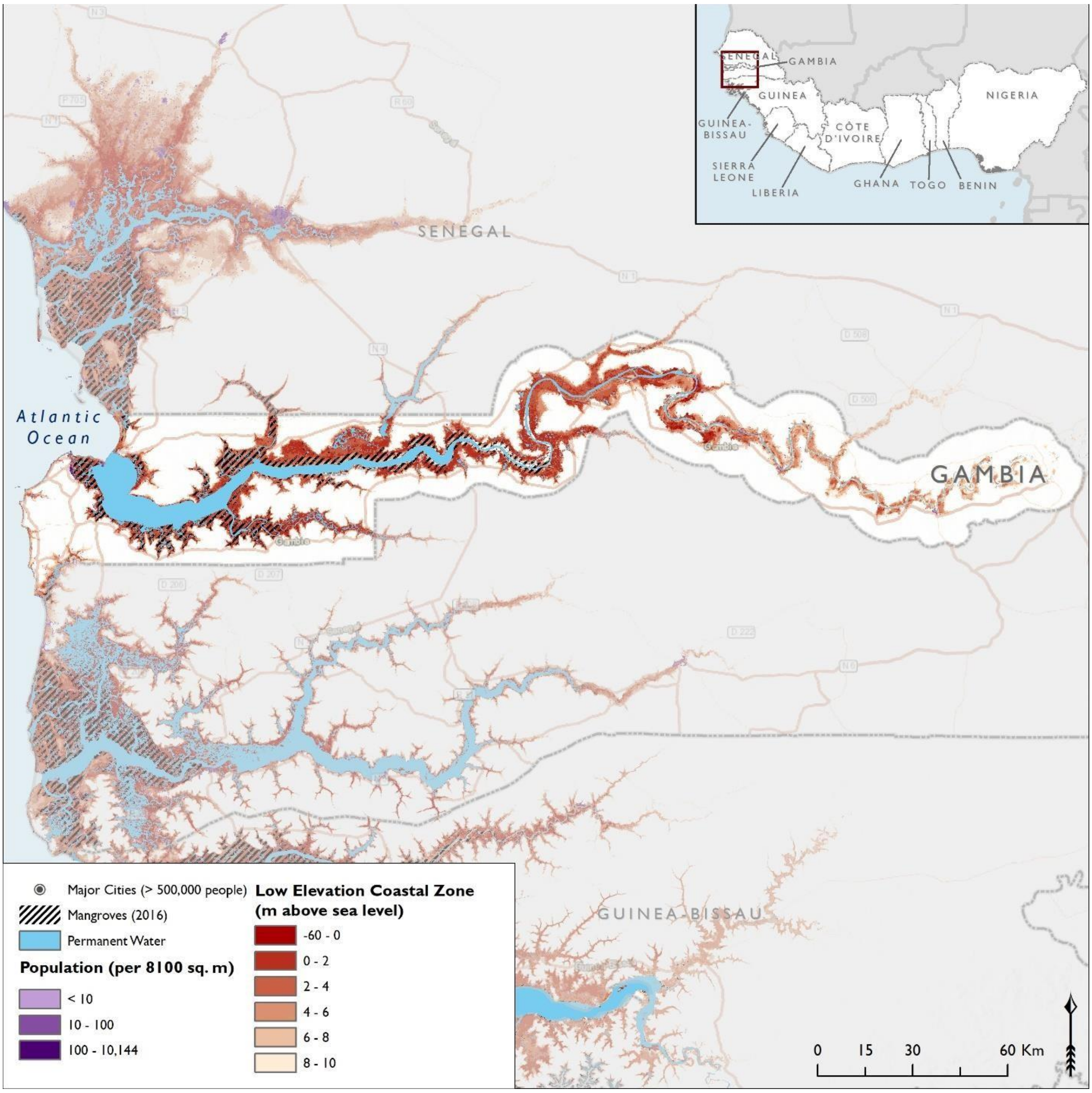
Hazard Component	Theme	Category	Subcategory	Indicator
		Ocean acidification		Sea mining (pH)
		Droughts (rainfall)		Number of days
		Extreme events' occurrence and/or intensity		Number/year/decade, damage caused
		Monsoon effects		Rainfall heights/duration of events
Risk Representations and Management Methods	Representations	Risk knowledge on the territory	Risk awareness by public services	Devices established/dissemination method
			Knowledge of prevention and protection instructions	Considered natural risks by populations
			Population awareness raising	Considered natural risks by populations
		Hazard-related events memory and experience		Number of storms/natural disasters
		Knowledge and confidence level in management and response organizations		The population's level of knowledge
	Management	Safety and rescue	Warning system	Measures established (communal backup plan, rapid submersion plan, risk prevention plan)
			Backup plans implementation	
		Prevention	Construction and architectural standards	Altitude of the first floor, single-storey buildings, evacuation potential, total number of buildings, elevation of floors), distance to a place of refuge
			Industrial safety standards	
			Protection facilities	Inventory/typology/mapping
			Relocation measures	Existence or not of a strategic backup plan
		Personal response methods and techniques developed		Evacuation systems, places of refuge, pumping systems
	Public policies	Number of countries with a controlled urbanization policy		Objectives of the projects/relevant audience/number of persons concerned/relevant areas
		Amounts of grants		Annual amounts/programs duration

APPENDIX 4 : LOW ELEVATION COASTAL ZONES

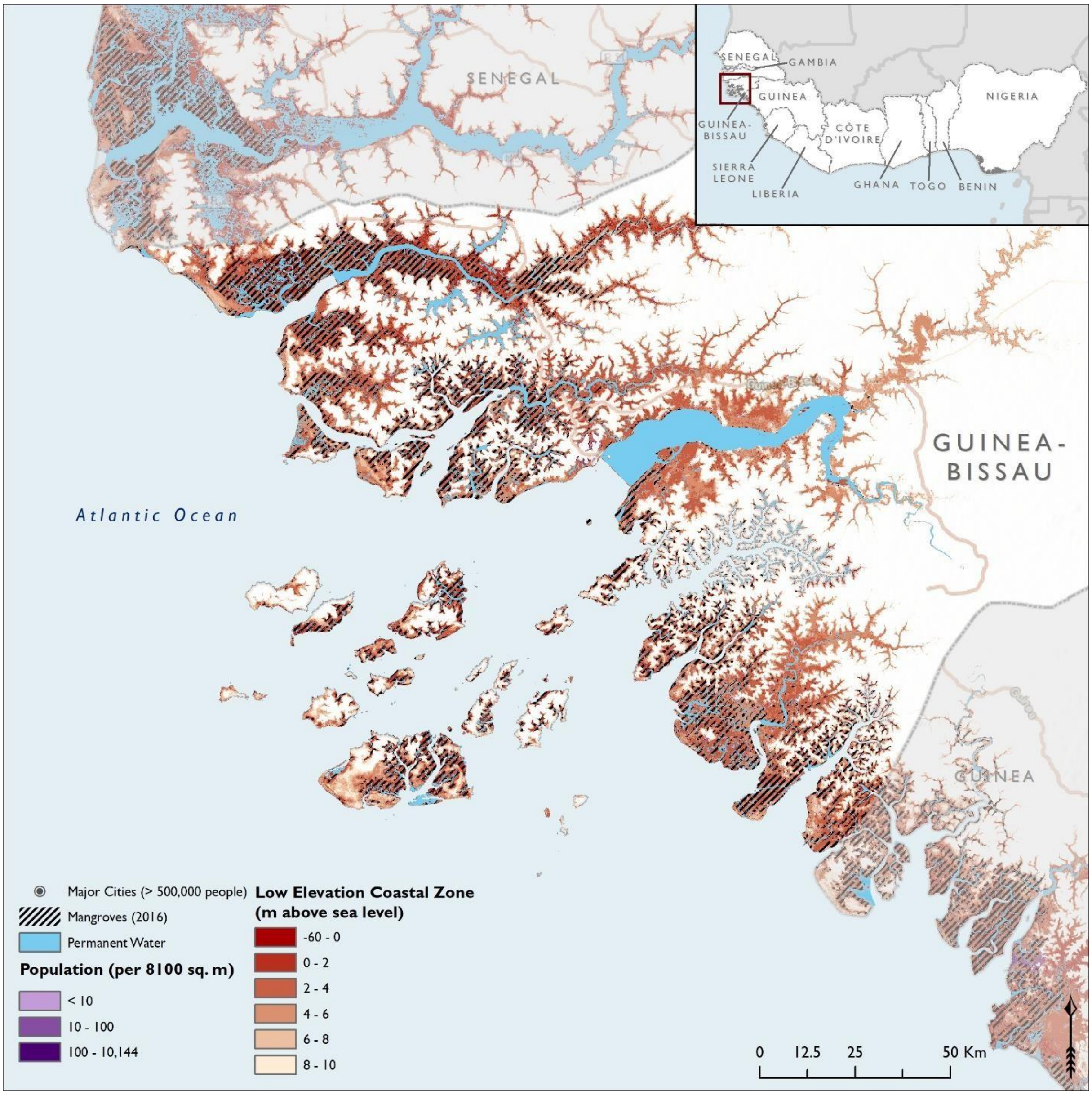
Low elevation coastal zones in Senegal



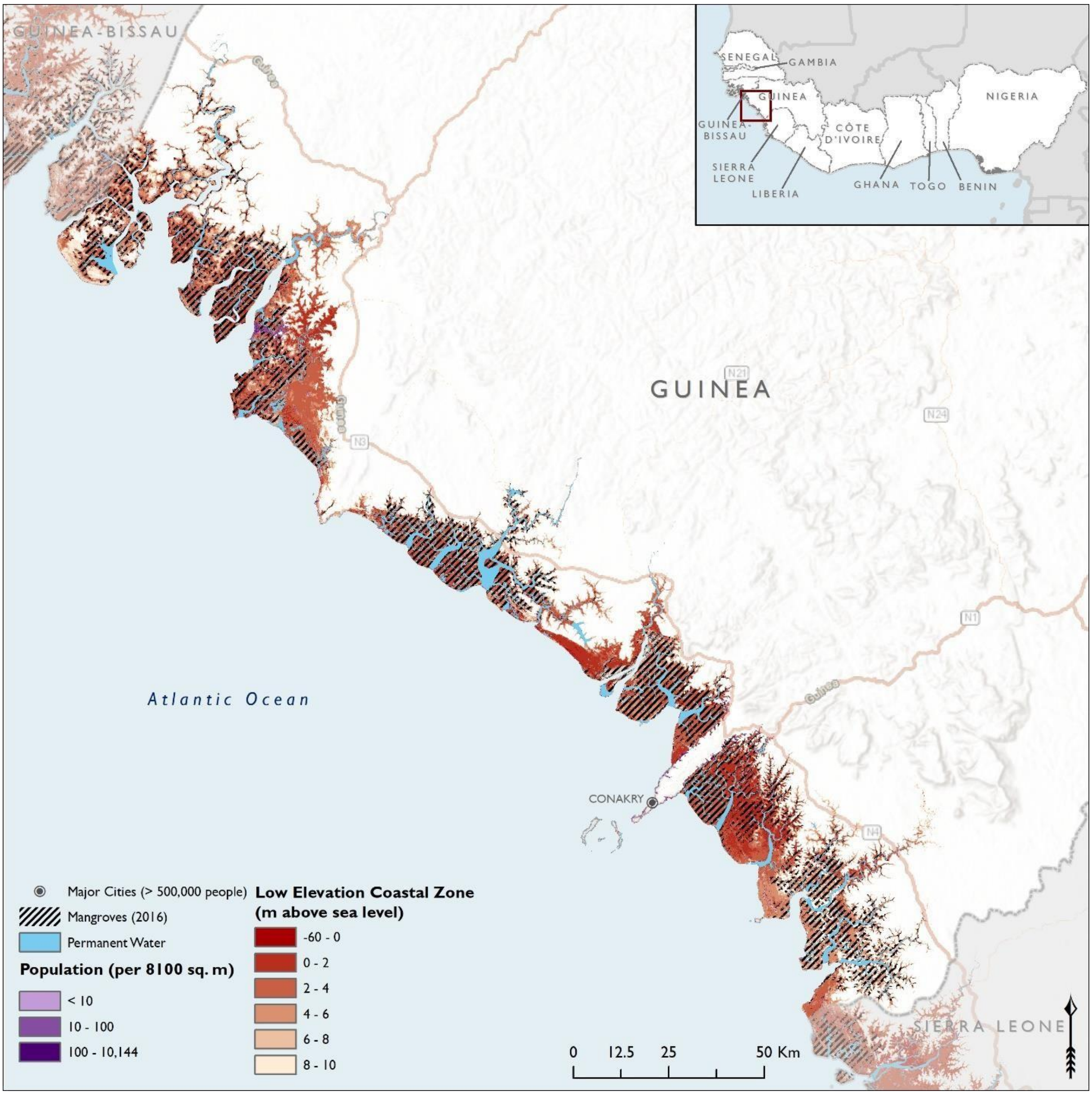
Low elevation coastal zones in the Gambia



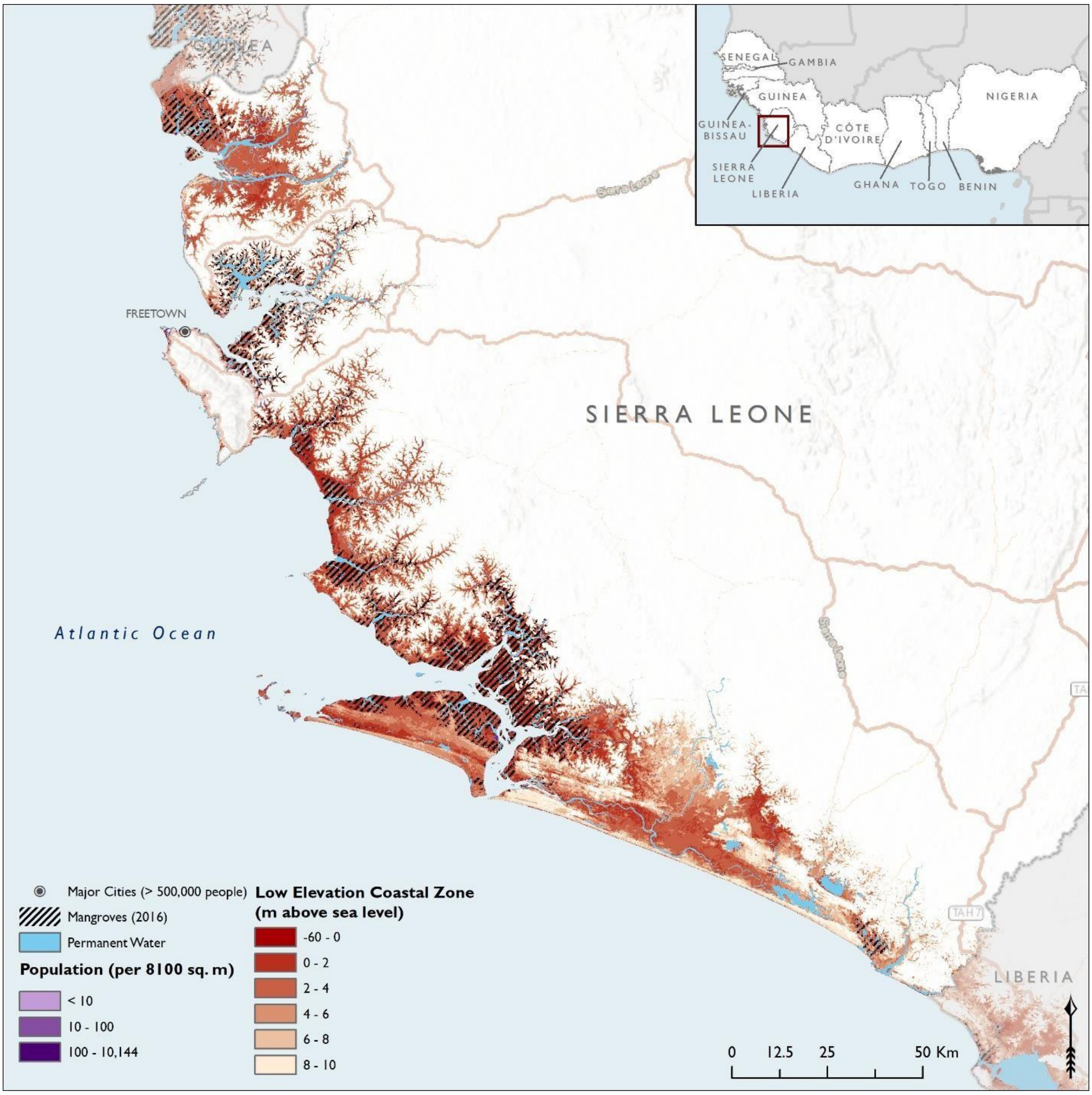
Low elevation coastal zones in Guinea-Bissau



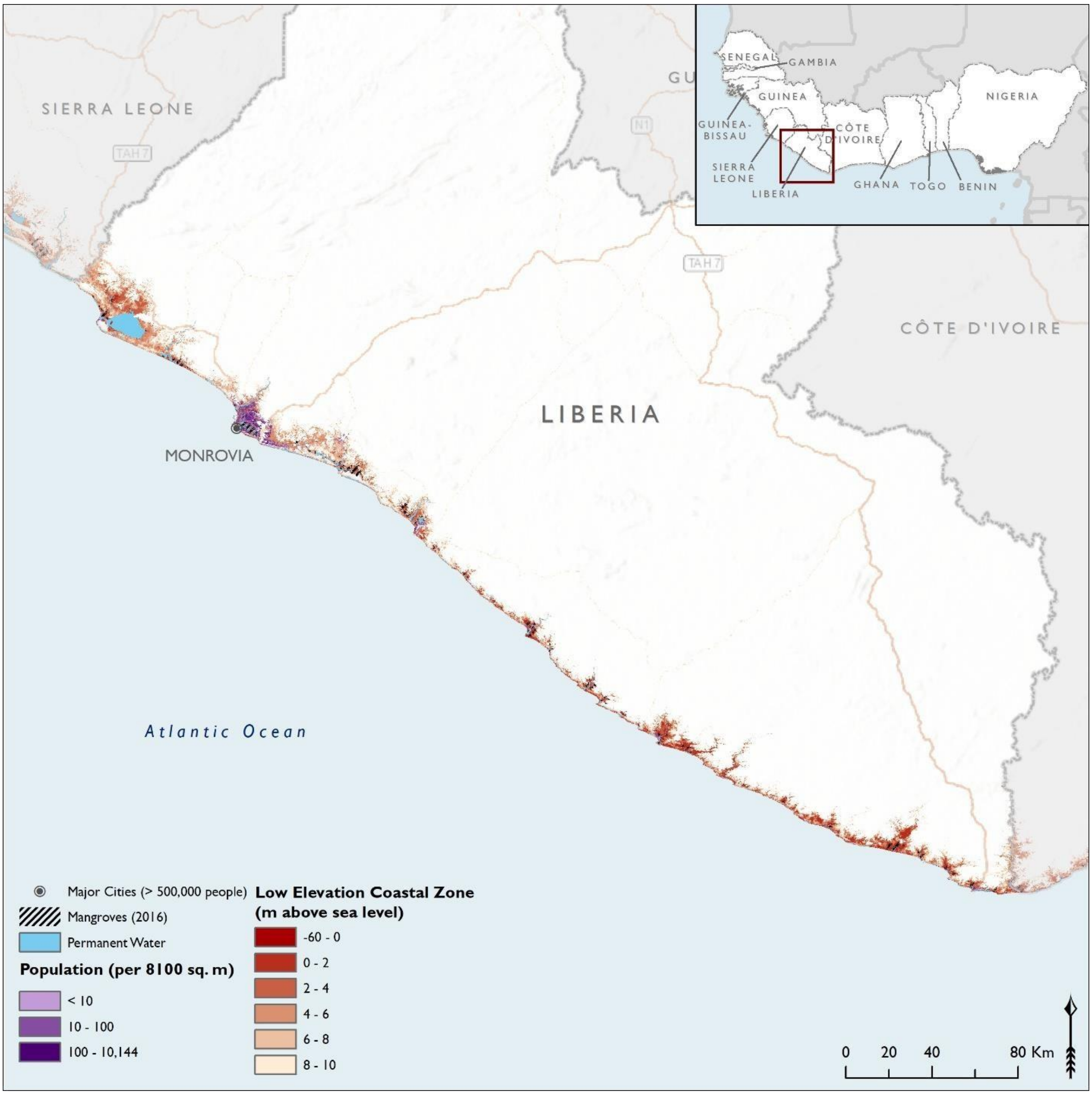
Low elevation coastal zones in Guinea



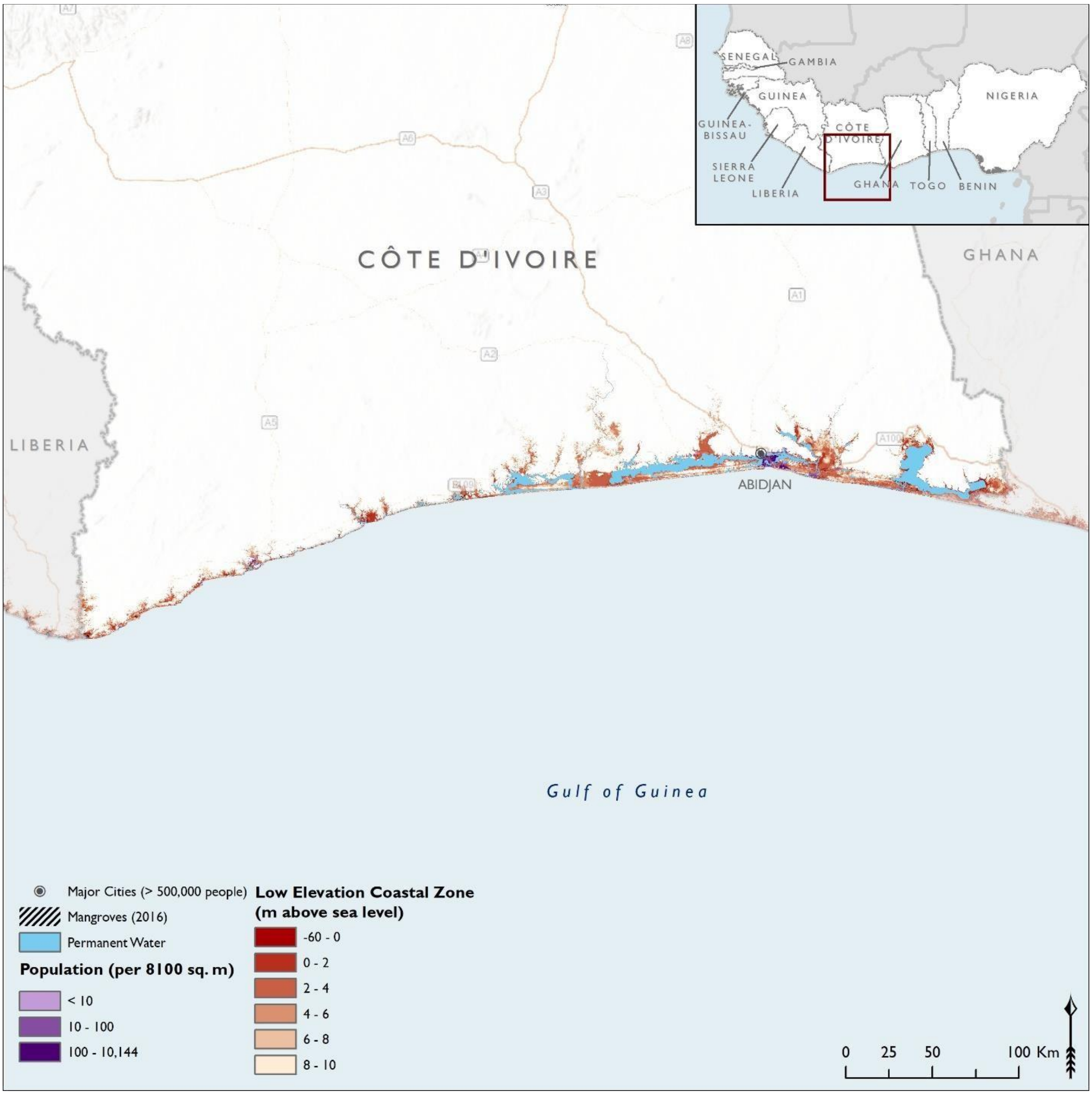
Low elevation coastal zones in Sierra Leone



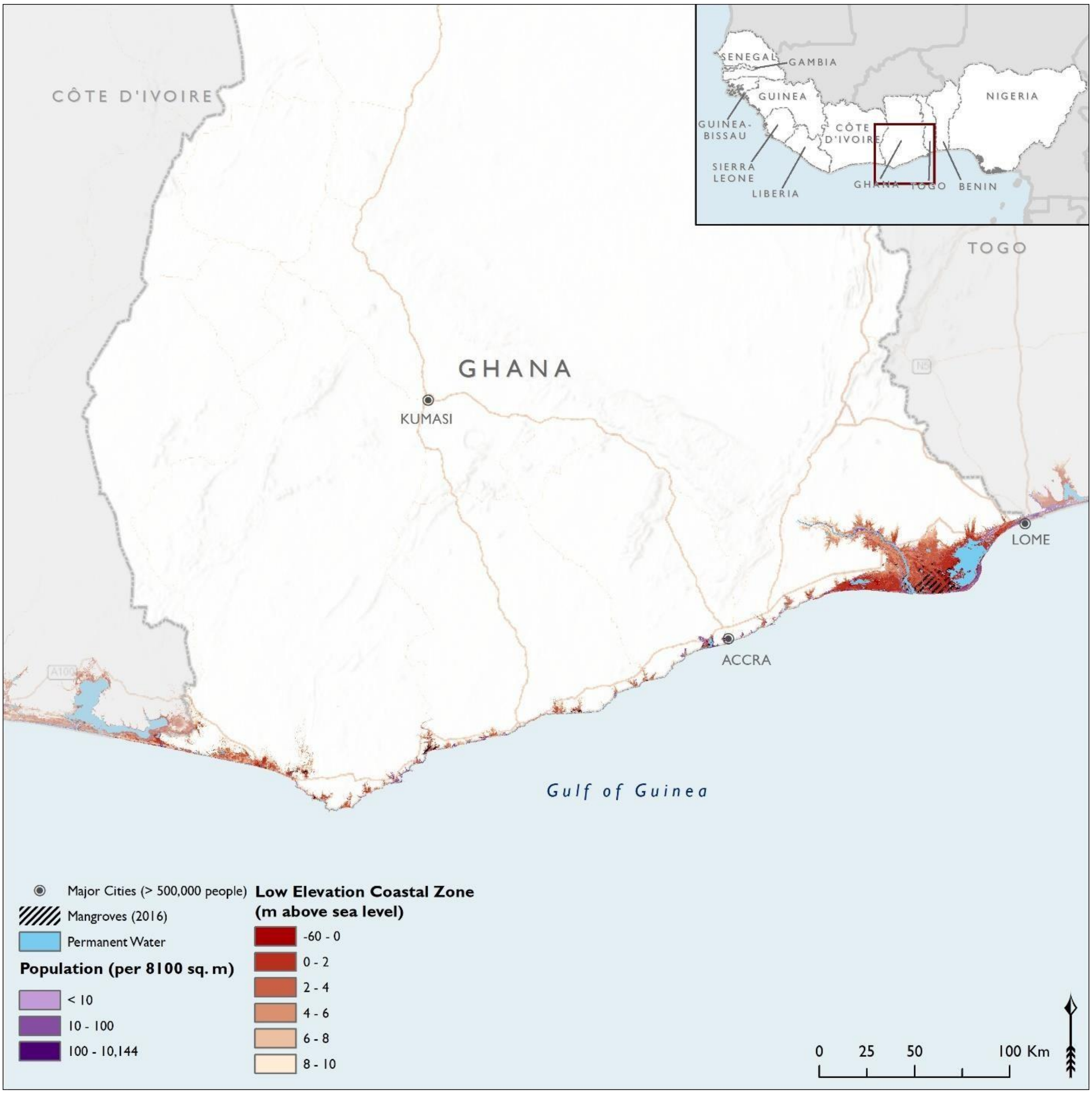
Low elevation coastal zones in Liberia



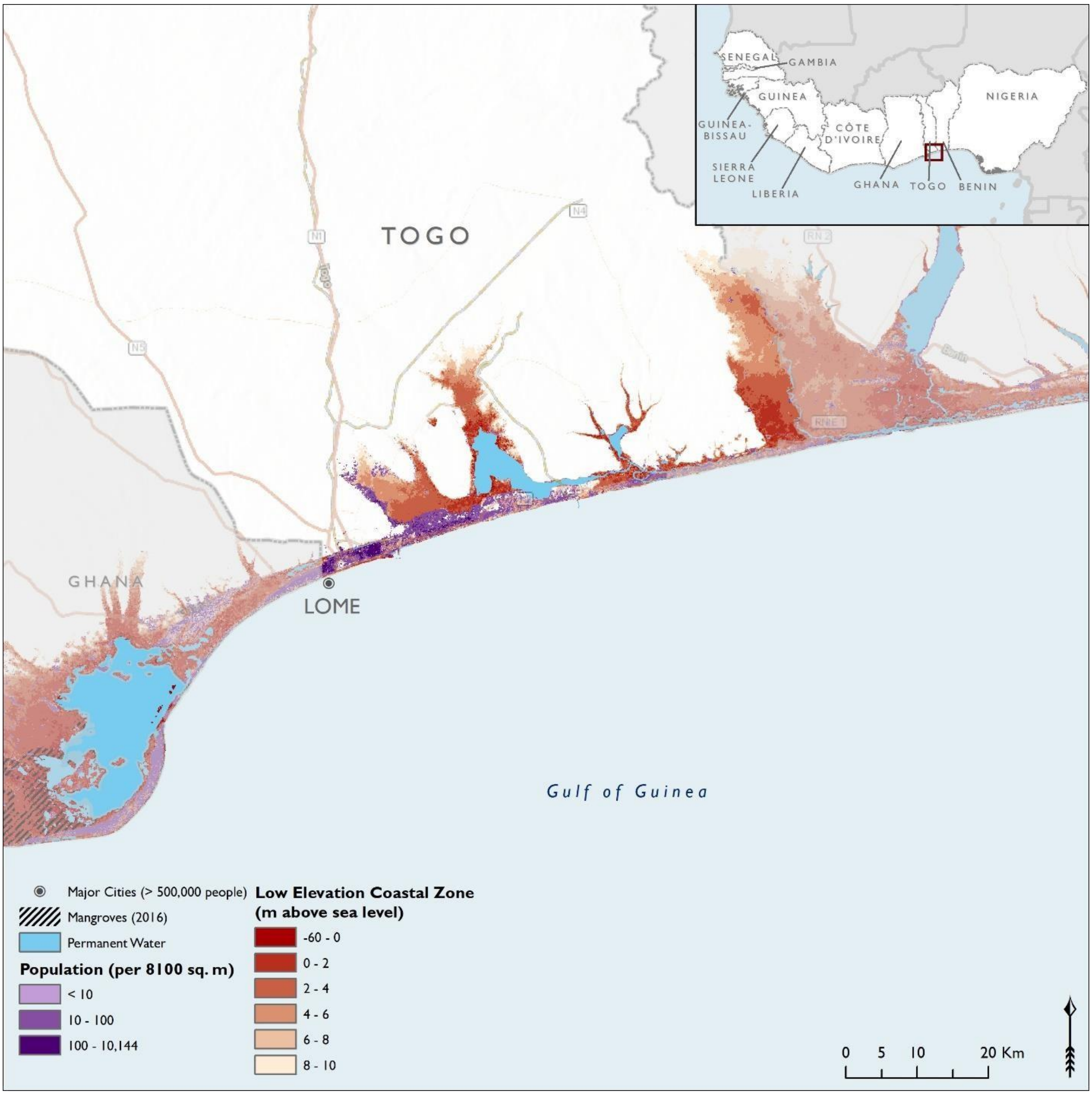
Low elevation coastal zones in Côte d'Ivoire



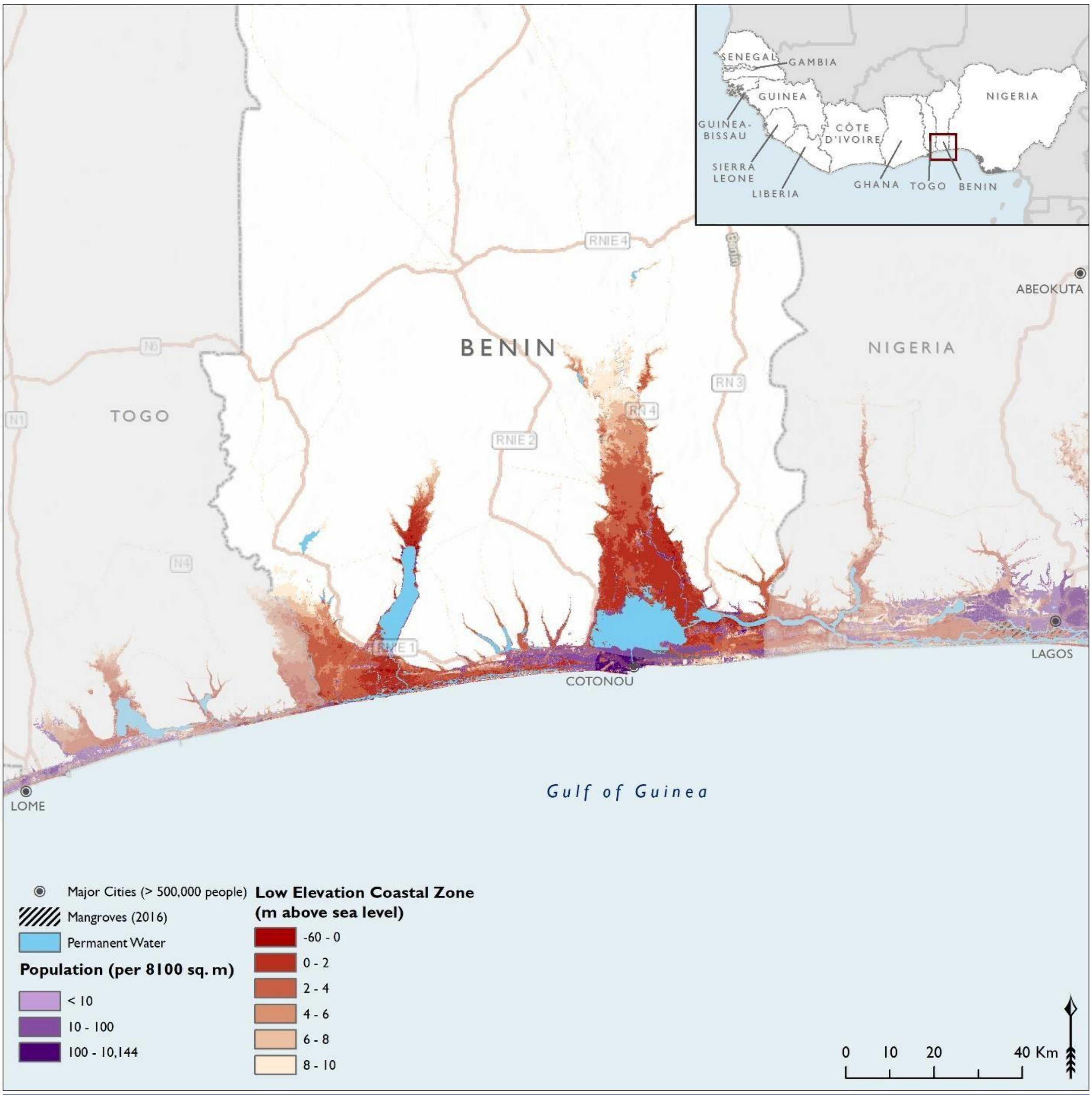
Low elevation coastal zones in Ghana



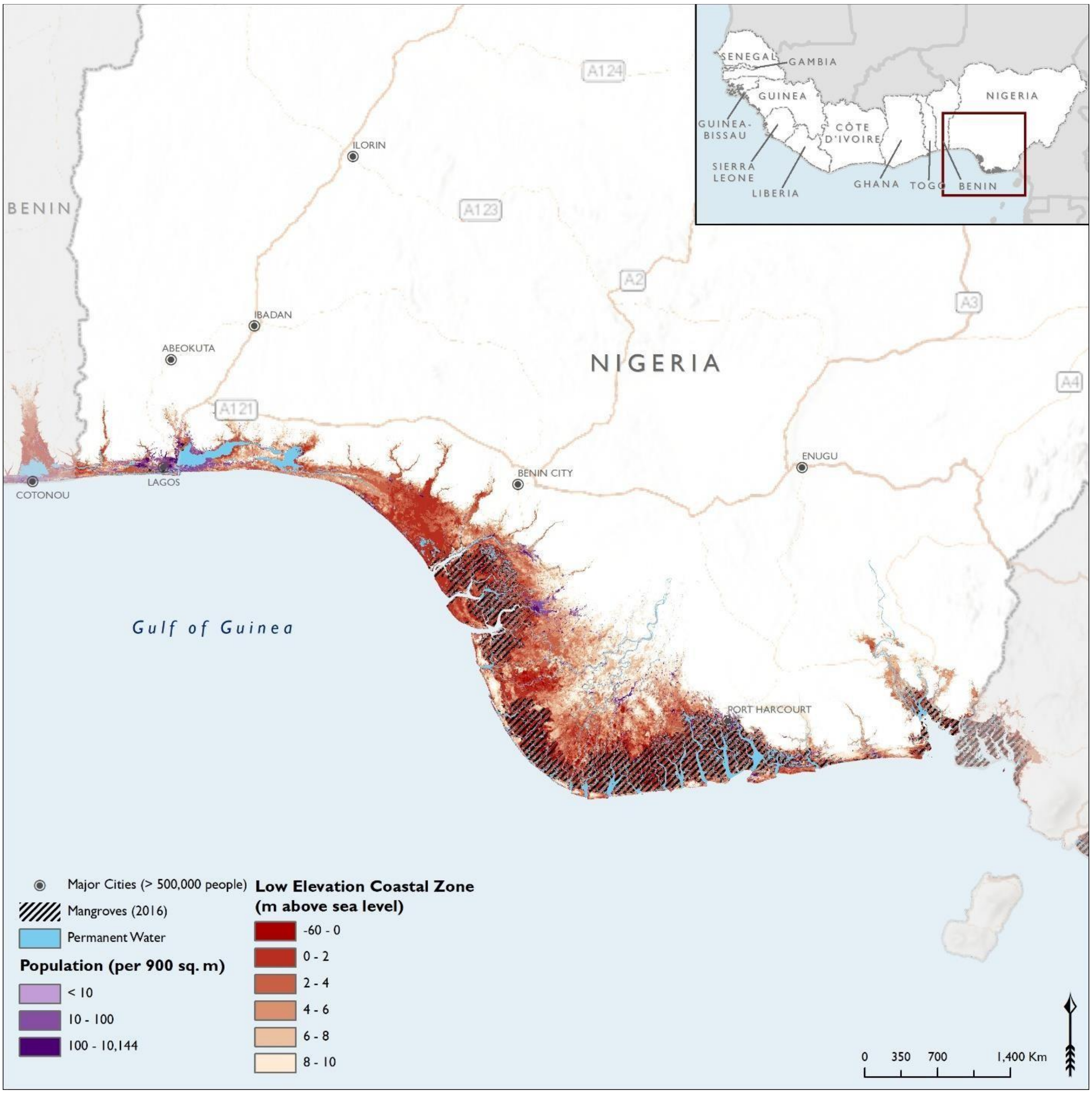
Low elevation coastal zones in Togo



Low elevation coastal zones in Benin



Low elevation coastal zones in Nigeria



APPENDIX 5 : METHODOLOGICAL GUIDE FOR HAZARD AND VULNERABILITY CHARACTERIZATION (OFF-PRINT)

APPENDIX 6 : LIST OF CONTRIBUTORS (OFF-PRINT)