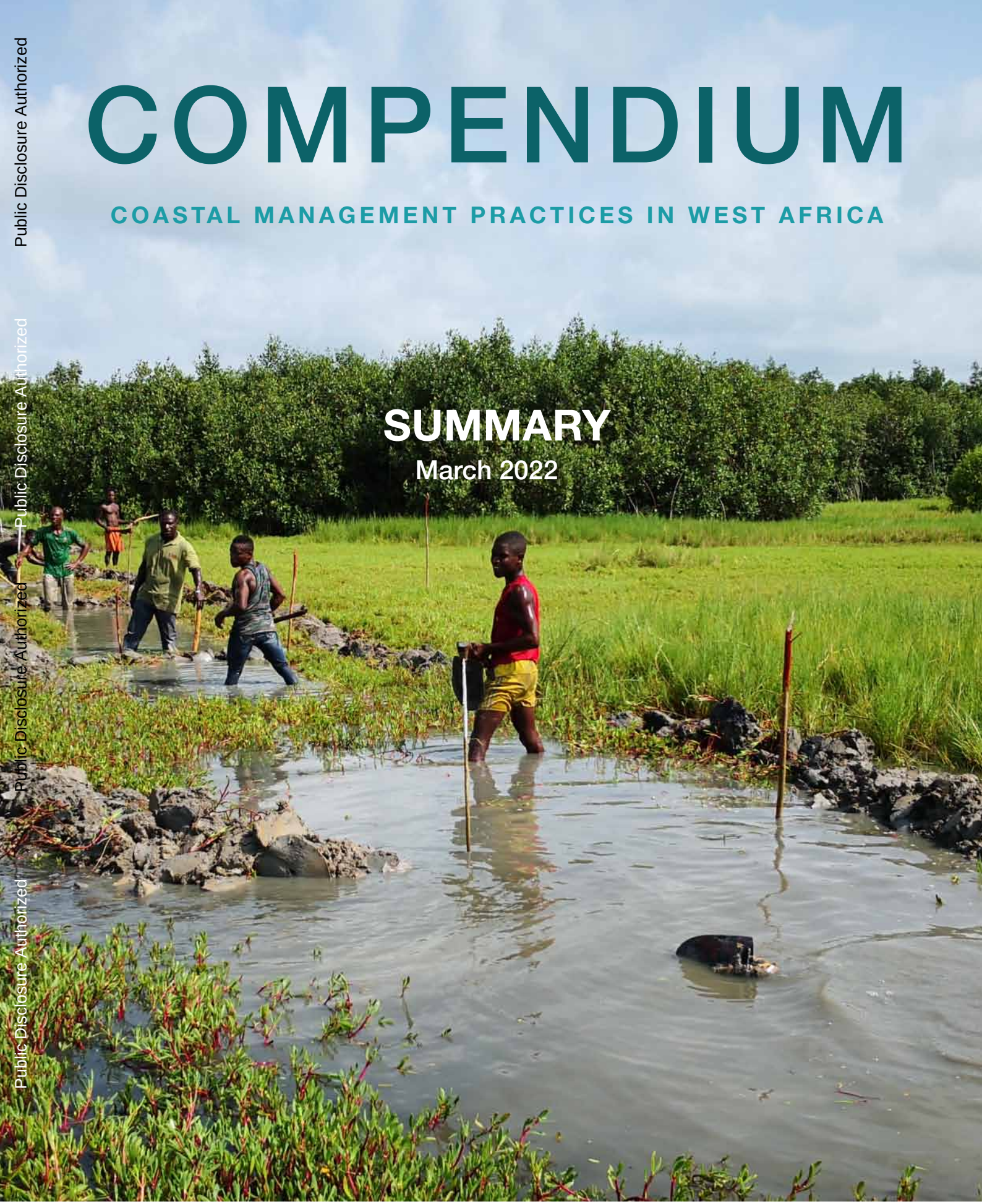
COMPENDIUM

COASTAL MANAGEMENT PRACTICES IN WEST AFRICA

SUMMARY

March 2022



IRD Institut de Recherche pour le Développement FRANCE
ACECoR
UNIVERSITY OF CAPE COAST
GFDRR
NDF NORDIC DEVELOPMENT FUND
WACA West Africa Coastal Areas Management Program
WORLD BANK GROUP

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Cover photo: Benin. Photo: Corde ONG

COMPENDIUM

COASTAL MANAGEMENT PRACTICES IN WEST AFRICA

Existing and potential solutions to control coastal erosion, prevent flooding and mitigate damage to society

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Prepared on behalf of the World Bank (WACA Program) by the French National Research Institute for Sustainable Development (IRD) and the University of Cape Coast (UCC)

ACRONYMS

EWS	Early Warning Systems
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
HES	Hard Engineering Solutions
ICZM	Integrated Coastal Zonal Management
IRD	Institut de Recherche pour le Développement (the French National Research Institute for Sustainable Development)
NDF	Nordic Development Fund
NbS	Nature-based Solutions
SES	Soft Engineering Solutions
UCC	University of Cape Coast
WACA	West Africa Coastal Areas Management Program

FOREWORD

The Compendium: Coastal Management Practices in West Africa reviews existing and possible measures to address coastal erosion, prevent flooding and mitigate its impacts on society. The Compendium proposes a critical review of the different options for managing risks, based on an analysis of the scientific literature published to-date on coastal erosion and flood risks in West Africa.

This summary presents the keys findings of the report, with indications for implementing risk management measures in a comprehensive Integrated Coastal Zone Management (ICZM) approach, and recommendations in four key points for good coastal risk management. It also introduces, in a synthetic form, the main solutions applied in West Africa for coastal zone management.

This summary is primarily intended for decision-makers and political leaders, but it is also relevant to all the stakeholders directly or indirectly concerned by the risks related to coastal erosion and flooding (officials from the civil service at all administrative levels, the private sector, nongovernmental organizations, local stakeholders and civil society).

Coastal erosion and flooding are major obstacles to regional development

In 2019, the average coastline retreat was estimated at -1.40m/year, -1.60m/year and -2.40m/year in Côte d'Ivoire, Senegal and Togo respectively. The result is an increase in population displacement and increasing material and economic loss. At the same time, the toll from flooding in major coastal West African cities regularly amounts to tens or even hundreds of deaths and missing persons, illustrated by the 'Freetown disaster', when floods of an exceptional magnitude led to the death and disappearance of 1,000 inhabitants of Sierra Leone's capital in 2017. The unusually heavy and violent rains that fell on the region in September 2020 is a reminder that **such disasters could become increasingly frequent in the future, significantly slowing down West Africa's social and economic development.**

Coastal erosion and flooding negatively affects human well-being, economic activities, existing infrastructure and ecosystem services associated with fragile environments. Coastal erosion causes coastline retreat, lowers beaches, threatens homes, roads and activities, has a particular strong impact on agriculture, tourism and fisheries sectors and also increases the risk of flooding. The most frequent consequences of floods include water point pollution, the outbreak of opportunistic waterborne disease epidemics, mosquito invasions, destruction of infrastructure and cessation of activities. While not all floods cause human damage, the destruction of property causes long-term vulnerability and also affects livelihoods.

Scientific publications show that all West African countries, from Mauritania to Nigeria, are affected by coastal erosion and/or flooding, at varying levels of severity. Some areas experience a more rapid coastal retreat or suffer more frequent and violent flooding than other areas. However, on a regional scale **it is the entire West African coastline that should be considered at risk, as coastal areas concentrate the challenges for regional development.** The population growth rate of major coastal West African cities is over 4 per cent, and home to a third of the region's population. The West African Coast is also home to large port complexes, strategic places for trade and commerce, and concentrates high productivity activities where more than half of the regional Gross Domestic Product (GDP) is produced.

Senegal. Photo: Vincent Tremeau/World Bank

Coastal area pressures set to increase

Coastal erosion and flooding are phenomena that can occur naturally, independent of human activity. As a result, erosion and flood risks are classified as 'natural risks' and the associated damages belong to the 'natural disasters' category. These designations introduce an important bias in the collective mind, where erosion and flooding are often associated with natural causes, impacting society, but without presenting a causal link between them. However, if the meteorological, geological and oceanographic characteristics of an area are obviously important in the process of erosion and flooding, scientific literature shows that **human activities and infrastructures have a strong influence on these phenomena.**

The geomorphological nature of West African coasts remains a primary vulnerability factor for the region's coastal areas. Mainly composed of loose sediments and highly mobile geomorphological formations (sandy beaches, dune belts, coastal spits and mangrove estuaries), the West African coastline is by nature unstable and rapidly changing. The coastal areas' low and flat topography accentuates the risk of flooding. And the monsoon, which generates particularly violent and dangerous torrential rains in coastal areas, can cause major floods especially when combined with tidal and pressure effects.

The shortage of sediment caused by dam construction is one of the main causes of erosion in West Africa. As rivers are a primary source of sediment supply for the coastlines, dam construction on the main rivers considerably depletes the sedimentary balance of West African coasts, trapping sediments carried by rivers upstream from the deltas. Conversely, wave dynamics, swells and currents cause sediments to move along the coastline in a west-east direction. **The construction of large port complexes destabilized this sedimentary drift, causing sediment accumulations upstream and a deficit downstream.** Certain defense works protecting against waves can also have the same effect.

Coastal ecosystems degradation aggravates the extent and severity of erosion and flooding events. Deforestation and wetlands loss due to urbanization development and other activities particularly agriculture, trigger erosion and flooding. Indeed, mangroves retain sediment and slow down erosion processes, and wetlands serve as 'buffer zones' reducing energy and flood volumes.

Poorly controlled urban growth resulted in soil sealing and an extension of urbanization in flood-prone areas. A shortage or failure of rainwater drainage and sewerage systems and solid waste's obstruction of drainage systems are recognized factors which aggravate flooding. In general, planning policies failure in the face of urban population growth increases coastal populations' vulnerability to flooding.

Acceleration in rising average sea levels, rainfall pattern disruption and aggravation in extreme weather and marine events are **all consequences of climate change that tend to increase already existing threats.**

It is in this context that forecasting models predict increasingly strong population growth in coastal areas, due in part to current population numbers but also to inland population migrating towards the coast. Many migrants are fleeing insecurity in countries experiencing conflict, as well as the consequences of the great drought in the 1970s and 1980s. The prospect of greater employment opportunities and the lure of an urban and more modern way of life in large coastal conurbations, provide strong attractive factors for migration. According to projections, the rise in average sea levels will strongly affect West Africa by 2060 because **the region is home to low-lying coastal areas where the highest population growth rate in the world is expected.**

The magnitude of current erosion and flooding events combined with extreme concentrations of settlements and activities along the West African coast, increase the risks to dangerous levels and threaten the entire region's development in the long term. Risk management actors in West Africa are provided with a myriad of options for action to fight coastal erosion and prevent flooding.

Hazards and vulnerability in coastal social-ecological systems

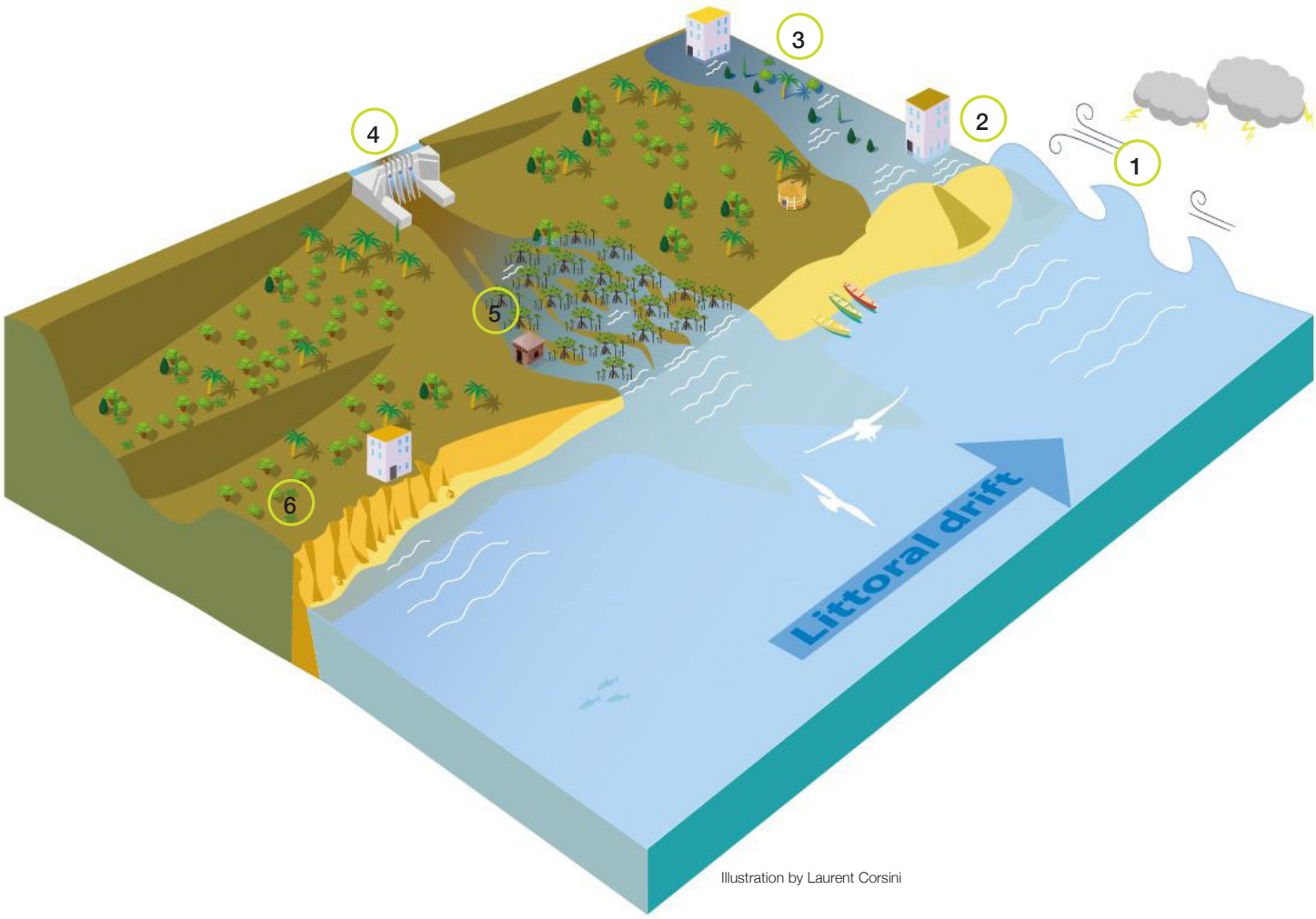


Illustration by Laurent Corsini

1. Rising sea level and storms cause overtopping
2. Beach and dune overtopping by the highest waves
3. Flooding of residential areas
4. Long-standing large dam, managed in such a way that it cannot reduce river flooding at the end of the rainy season
5. Flooding of estuarine agricultural areas by a combination of river flooding and high sea level
6. Erosion of cliffs endangers buildings

Status of management practices deployed in West Africa

Heavy engineering, soft and nature-based solutions, coastal risk prevention and management measures

Management measures applied so far in West Africa mostly rely on 'heavy engineering' measures (or grey infrastructure), which involves erecting structures to artificially stabilize the coastline. The benefits of these measures make it possible to break wave energy, retain sediments and prevent flooding in low-lying areas. Groynes are the most used coastal defense structure in West Africa and mostly consist of piles of rocks arranged perpendicular to the coast to retain sediment upstream of the wall. Breakwaters, jetties, revetments, and dykes can also be seen from Senegal to Nigeria. While cliff stabilization methods could be used in some instances, for example at the tip of the Cape Verde Peninsula in Dakar, there is insufficient discussion for this option in available literature. Additionally, scientific literature does not provide any examples of storm surge barrier use in West Africa.

Breakwater construction can be remarkably effective and appropriate in instances when the risks are high. For example, Benin, Côte d'Ivoire, and Togo whose coasts are highly vulnerable to erosion, set up major breakwater construction projects to protect strategic areas such as the Abidjan port. However, building such structures comes with high costs and not within reach of all territories while maintenance costs and the technical skills required to maintain these structures are grossly underestimated. It was the addition of construction and maintenance costs that led, for example, to the abandonment of a serial groyne construction project near Cotonou in the early 2000s. Because these massive structures are expensive and particularly visible on the landscape, they are perceived as a solid long-term solution. However, evidence proves different and poorly maintained revetments can collapse within just 15 years of use, as was the case in Jamestown, Ghana. The revetment in Jamestown was replaced with less resource-intensive and technologically advanced gabion-based revetment consisting of steel cages filled with rock, which proved successful. Thus, the best management option is not necessarily the most expensive, or the most high-tech, but the option that best takes into account the specificities of each risk context. It is prudent to recall these structures' undesirable effects in artificially stabilizing the coastline, disrupting the natural movement of sediments with waves and currents while most of this type of infrastructure, causes accretion upstream and leads to coastal erosion downstream.

Less environmentally intrusive engineering measures are also used to combat coastal erosion and flooding in West Africa. These measures are mainly based on natural coastal structure restoration, allowing the dissipation of wave energy, and providing a natural barrier to combat flooding, providing beach nourishment, dune replenishment and restoration of wetlands such as mangroves and salt marshes. Apart from mangrove reforestation sites, which are numerous in West Africa and particularly in Senegal, **these solutions are still poorly developed in the region.** The Nouakchott dunes in Mauritania have been successfully rehabilitated, but at a fairly high cost. The Gambia (Kololi beaches) and Nigeria (Victoria Island,Lagos) opted for beach nourishment, which also requires maintenance, as erosion processes continue and carry away new sediment. This management option can be combined with the construction of groynes to limit coastal erosion more sustainably.

Finally, there are no cases in West Africa of integrated river sediment management at a watershed scale. The aim is for a global vision of all the processes affecting beach sediment balance, taking into consideration the entire chain of sediment transport from the basin to the coast. Currently, dams capture almost all sediment carried by rivers, however, scientific studies show the primordial importance of river inputs which allow a natural replenishment of beaches and play a major role in fighting coastal erosion. Recent engineering solutions allow the passage of sediments through dams, but these solutions are costly. **Integrated river sediment management aims to maintain sediment balance over the entire watershed and conduct impact studies for each river development project.** However, this requires advanced scientific expertise and cooperation between institutions. Despite the obstacles, this type of management should be considered, especially in large estuaries such as the Senegal River where human and economic challenges are high.

In addition to engineering solutions deployed in the field, **disaster prevention and management measures are options aimed at developing knowledge around risks while applying practices to mitigate the impacts of hazards on populations.** Early warning systems (EWS) and risk mapping are fundamental preventative measures in large coastal cities, such as Dakar or Cotonou; and while flood risk mapping is a relatively popular exercise in West Africa, the entire regional territory is not covered. By identifying high-risk areas, it is possible to plan land use and avoid increasing the risks in vulnerable areas – the aim of public policies for zoning coastal activities and urban planning. Plans can define a minimum distance of constructions from the sea, as applied in the tourist locality of Grand Bassam in

Côte d'Ivoire. In more exposed areas, the relocation of people and goods is necessary. Relocation operations were carried out in Grand-Lahou and near Abidjan, Côte d'Ivoire, while others are underway, for example in the Guet N'Dar district in Saint-Louis, Senegal. However, measures to organize the retreat of populations from the shoreline or to prohibit construction in exposed areas require good technical knowledge, strong institutional capacity on the part of the public authorities to enforce plans and the establishment of dialogue with local communities.

Partly because of the difficulties related to the implementation of soft engineering techniques and the multisectoral nature of coastal planning, **Hard Engineering Solutions (HES),** widely favored by communities, **were privileged over other prevention and risk management measures in West Africa.** While protective infrastructure can be highly effective, the excessive importance given to grey infrastructure caused a rethink because of the unaffordable high cost and collateral effects. There is now a preference for an appropriate combination of hard and soft solutions according to the characteristics of each site, to achieve sustainable measures with less impact on the environment.

Hard-engineering solutions

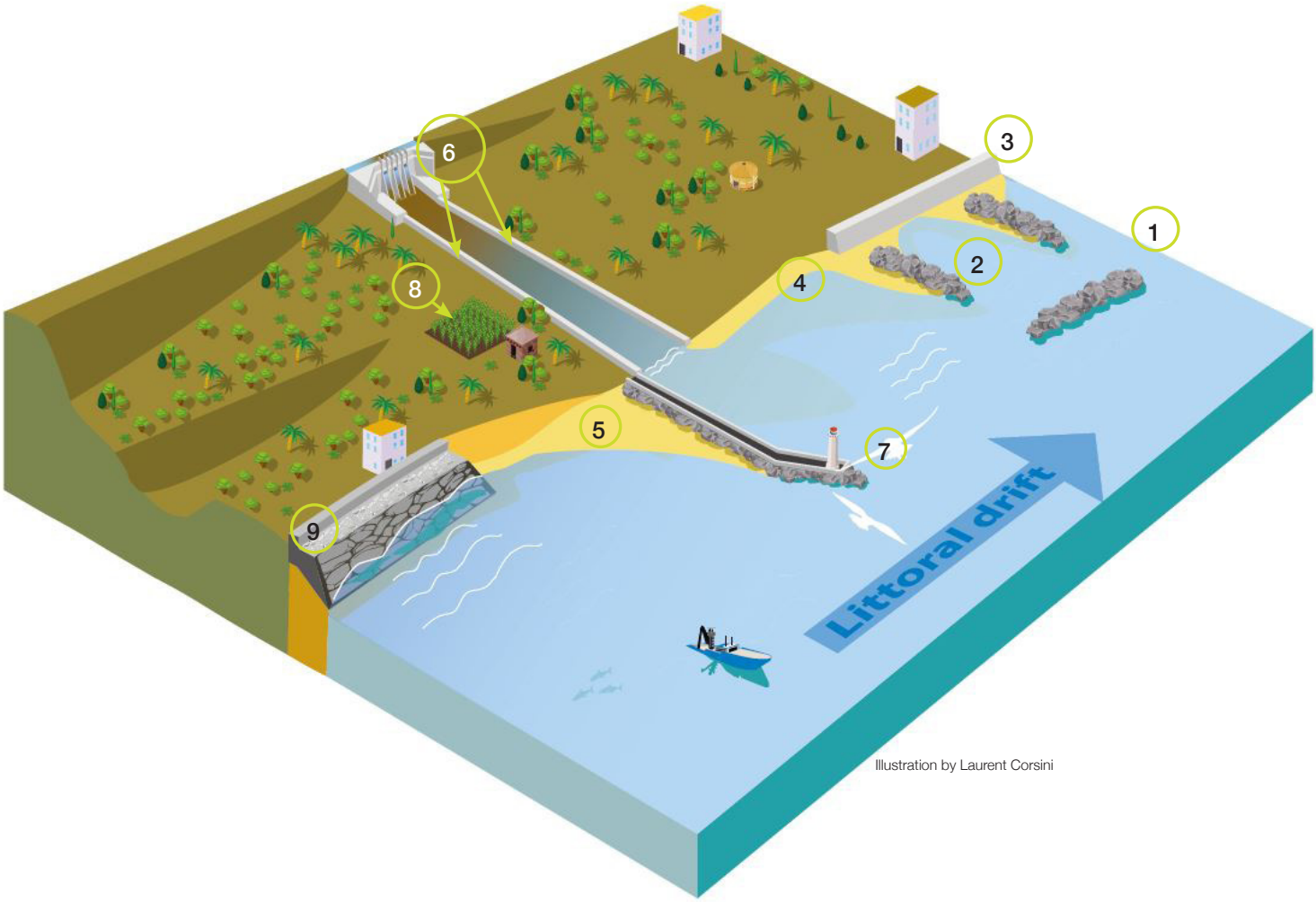


Illustration by Laurent Corsini

1. Breakwater
2. Groynes
3. Seawall preventing flooding event
4. Shrinking beaches due to lack of sediment supply
5. Accretion
6. River embankment
7. Jetty to prevent silting of the estuary
8. Water-controlled irrigated agriculture replaces flood agriculture and mangroves
9. Cliff stabilisation

Nature-based solutions

Nature-based solutions (NbS) have emerged as an innovative approach for sustainable coastal zone management. Best described as actions relying on well-functioning ecosystems to address social challenges through services provided by nature, NbS protect biodiversity while ensuring communities' security and prosperity. More than a specific category of management measures, **NbS is a general principle of thinking and action where ecosystem services are fully integrated into coastal zone management planning. This principle of action fits particularly well with that of Integrated Coastal Zone Management (ICZM),** since the application of NbS requires a specific environmental and cultural context focus, stakeholder consultation and equitable redistribution of ecosystem services over the long term. Mangrove restoration is the main NbS method applied in West Africa.

In comparison to more cumbersome infrastructure measures, the advantages of NbS are evident with fewer collateral effects and lower implementation and maintenance costs. NbS is not suitable for all situations and may not be sufficient to limit risks, however it can be combined with more traditional risk management options, such as dykes. While NbS appear to be a sustainable, gentle, and inexpensive way of managing risks, planning options should not succumb to a Manichean view of risk management by banning actions that do not comply with this principle. The main goal of a risk management plan remains the effectiveness of protective measures to ensure the safety of communities and limit damage, in the short, medium, and long term.

Soft-engineering, coastal planning and risk management solutions

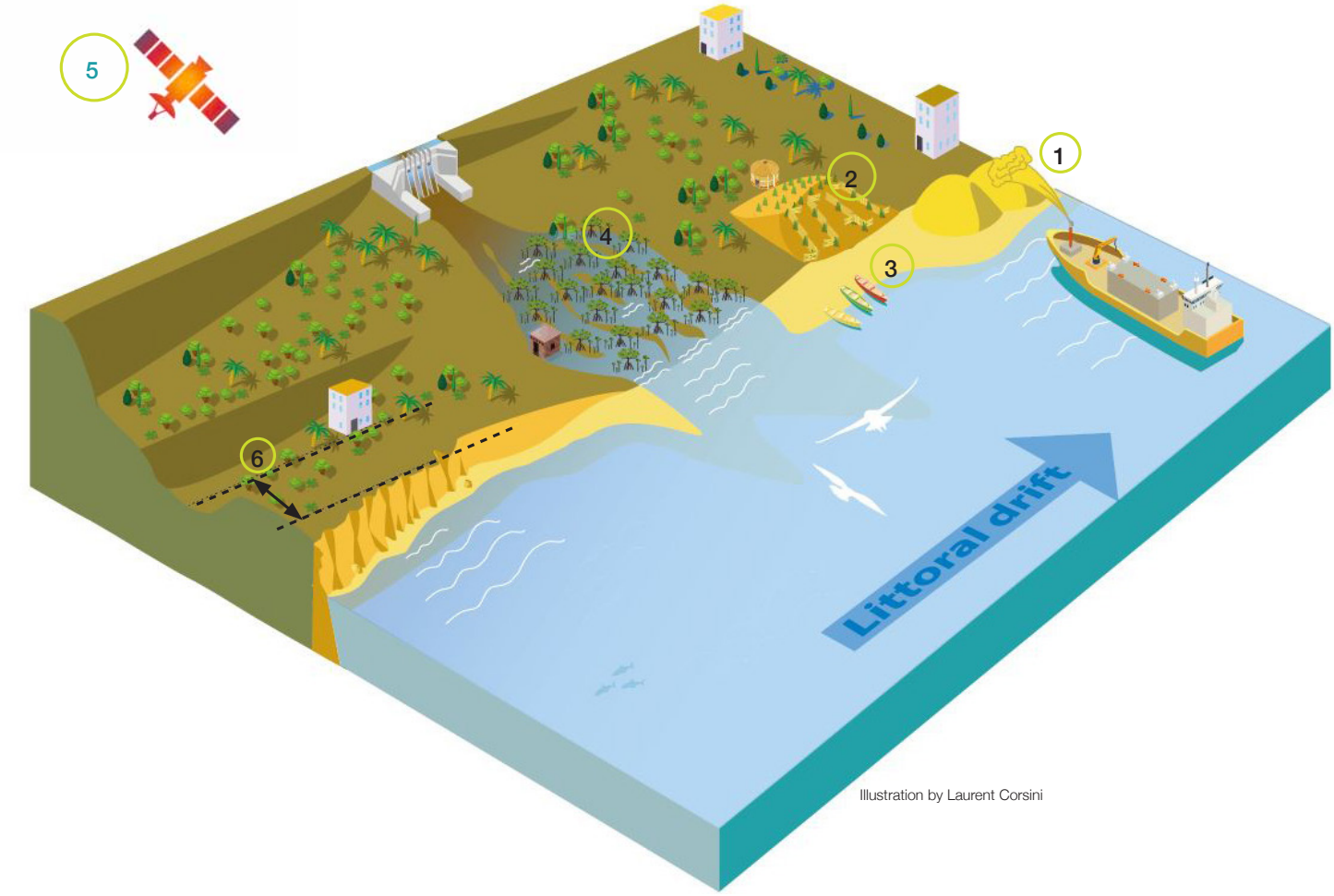


Illustration by Laurent Corsini

1. Nourishment of the beach to give it back its natural shape
2. Dune restoration through the plantation of trees
3. The beach regains its width through the normal supply of sediment
4. Natural flooding in estuarine areas allows the traditional rice-crop system and the rehabilitation of the wetlands and mangroves
5. A flood early warning system using satellites allows people to leave the agricultural camp in time in case of flooding
6. Setback and relocation to prevent the danger of building damage and collapses

Implementing integrated management plan against coastal risks

In order to determine the measures best suited to each local risk context and to ensure appropriate functioning, it is necessary to draw up a management plan to define objectives, schedule the plan's deployment and monitor results.

It is recommended to develop an integrated management plan and avoid a risk management plan independent of other territorial public policies. ICZM considers the coastline as a system whose elements are interdependent and cannot be modified without a knock-on effect elsewhere. **ICZM promotes a cross-cutting approach to coastal zone management,** taking into account the interests of a multiplicity of stakeholders and considering the social, economic, and environmental challenges of the territory on an equal footing. ICZM also emphasizes the importance of the land-sea continuum, insofar as land-based activities can have grave consequences on the marine environment and ocean dynamics influence the occupation of the coastline, particularly in the context of strong coastal risks. Finally, ICZM relies on the anticipation of risks and the sustainability of its management approach, recommending that different geographical and time scales are considered and that a concerted approach is established between stakeholders. **ICZM corresponds in a way to the application of the principles of sustainable development in coastal areas.**

The integrated approach promoted by ICZM emphasizes the specificity of each territory and the complexity of the processes that take place. Nevertheless, the following main organizing principles can be identified to take into account coastal risks in an integrated management plan.

KEY PRINCIPLES FOR INTEGRATED COASTAL ZONE MANAGEMENT

1. Establish a territory diagnosis and estimate the risks

- Define and bring together stakeholders.
- Define the study's boundary, keeping in mind interweaving of geographical scales and administrative levels.
- Collect data on existing hazards and the probability of occurrence in the near and distant future.
- Collect data on the demographic, economic, socio-political, environmental and the territory's morphological characteristics. It is also important to measure disaster risk and preparedness and response capacity limits of local authorities and civil society.
- Based on data analysis, prioritize the area and human, economic or natural stakes according to a vulnerability estimate focused on erosion and flood risks. The aim is to prioritize the areas for protection.
- Define, in a participatory manner, management plan's objectives.

2. Propose several scenarios

- Identify a combination of measures to achieve the defined objectives. The objectives defined in Phase 1 can be achieved, depending on the means available to the community and the preferred stakeholder methods where it is often necessary to put in place actions, that allow for complementary efficient risk management.
- Establish several scenarios based on these combinations; identify technical, financial and human resources required to implement chosen measures, plan deployment schedule, pre-existing constraints, benefits for the community, negative impacts on the territory, and indicators to monitor and evaluate the objectives. Scenarios must consider several time scales to integrate changes in risk factors such as population growth, climate change, etc.
- Adopt a main scenario. Scenarios can be discussed upstream by experts and then submitted to all stakeholders. Various technical tools can be used to present the scenarios: mapping, modeling, SWOT analysis, etc.

3. Deploy the management plan in the field

- Strengthen institutional capacity, if necessary
- Build defense infrastructure and develop tools and public policies for risk prevention and disaster management.

4. Evaluate integrated management plan effectiveness

- Collect monitoring data on a regular basis.
- Evaluate objective achievements through indicators.
- Adjust the actions as necessary.
- Make a complete periodic review of progress and the action's effectiveness, and adapt the plan if necessary.

Recommendations for good coastal risk management

Good coastal risk management is considered to be a set of effective measures for the protection and development of human, economic and natural assets in coastal zones. The measures should be decided and implemented in a concerted way between the territory's actors and in line with the objectives of existing territorial public policies. The use of communities' local knowledge, interdisciplinary scientific studies and technicians' operational know-how promotes the acceptability, efficiency and sustainability of management solutions envisaged. Finally, a global, systemic approach to the coastline is preferable, considering that coastal zones are interfaces between activities and terrestrial and marine environments, and are therefore complex places to be analyzed at different scales.

Aware of the pragmatic difficulties that such a theoretical approach raises, the authors identified four key points, decisive in initiating good management of coastal risks:

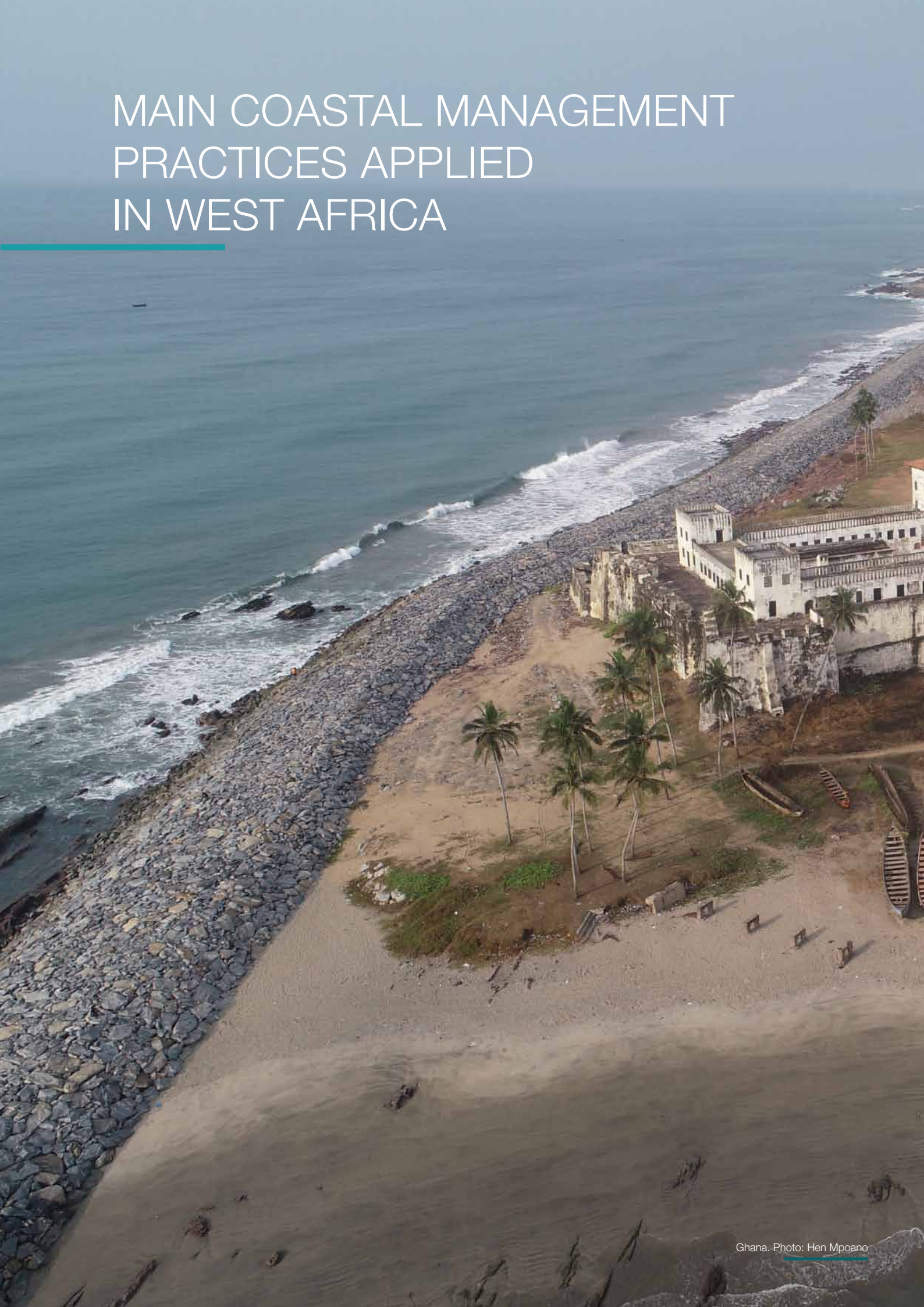
1. **Consider at least two geographic scales to analyze risks and implement measures.** Risks often originate as a result of global or regional dynamics and local factors of vulnerability. When considering risk in a management plan, it is necessary to take into account interweaving geographical measures in hazard formation and risk construction, as well as administrative capacity in development and implementation of territorial public policies.

2. **Identify all actors involved in risk management and offer opportunities for stakeholders to participate in development of the management plan.** This involves sharing the conclusions' preliminary studies including territory diagnosis, define the management plan objective in a collaborative manner and decide on varying management options that can be applied (choice of final scenario). This participatory approach should be continued during the implementation phase, particularly to ensure the communities' support for plans.

3. **Adopt a flexible management plan where objectives can be re-evaluated, and activities adjusted according to risk environment evolution.** Some options could include a combination of short-term effectiveness, for example, protecting infrastructures with a dyke, with long-term effectiveness, by relocating this infrastructure. With demographic and economic change taking place in West Africa, it is recommended to provide for alternative solutions adapted to different levels of risk when developing the management plan. It is essential to rely on projections established by scientists for this purpose.

4. **Rely on data from observatories and scientific programs** to evaluate activities' effectiveness, identify possible environmental or sociological obstacles, and more broadly, monitor the coastline's evolution. On a regional scale, an observation network should be activated where data centralization and open data sharing is available, and the existing educational system should be strengthened in Masters, PhDs and thematic workshops.

MAIN COASTAL MANAGEMENT PRACTICES APPLIED IN WEST AFRICA



Ghana. Photo: Hen Mpoano

Breakwaters in Saly, Senegal. Photo: Senegal World Bank funded Tourism Project (PDTE)

Solution n°1: Breakwaters

Category

Hard engineering solutions [X]
Soft engineering solutions [ ]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria:

Yes [ ]
Maybe, under certain conditions [ ]
No [X]

Substance and Purpose

Offshore breakwaters are shore-parallel hard engineering protection structures situated just offshore of the surf zone and designed to intercept and reduce incoming wave energy at the shoreline, thus reducing erosion. This ensures accumulation of sediment in the lee of the structure, leading to widening of the beach.

Main environmental requirements & institutional context

Breakwaters are expensive, requiring a high level of technical knowhow. Appropriate only in certain current and wave conditions.

Combining with other solutions

Breakwaters aim to be sufficient as a stand-alone method to protect a stretch of coastline. Nevertheless, may be combined with other type of defense structures such as jetties.

Assets, advantages and strengths particular to the West Africa coastal area

The shorter breakwater construction in series allows some wave action at the coast, beneficial for recreation. The breakwater protective function can be maintained for many years, requiring only basic monitoring and maintenance if appropriately planned, designed and constructed.

Constraints, weaknesses and difficulties particular to the West Africa coastal area

A preliminary survey to understand the area's wave dissipation is required.

Groynes in Saly, Senegal. Photo: Senegal World Bank funded Tourism Project (PDTE)

Solution n°2: Groynes

Category

Hard engineering solutions [X]
Soft engineering solutions [ ]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [ ]
No [X]

Substance and Purpose

Groynes are narrow, shore-perpendicular, hard structures designed to interrupt longshore sediment transport by trapping a portion of the sediment which is otherwise transported along shore. Groynes are generally solid, durable structures and considered a protection measure to address coastal erosion.

Main environmental requirements & institutional context

Appropriate for drift-aligned coasts where erosion difficulties are generated by gradients in the longshore transport. Groyne field construction requires a good degree of expertise.

Combining with other solutions

Groynes complement other solutions such as seawalls, revetments, beach nourishment and dune construction by reducing wave energy at these structures.

Assets, advantages and strengths particular to the West Africa coastal area

The advantages of groynes are mainly related to their ability to trap sediment, thereby leading to beach widening with consequent benefits of reduced erosion.

Constraints, weaknesses and difficulties particular to the West African coastal area

The primary disadvantage of groynes is the interruption of longshore drift to promote beach widening on one section of coastline, which is likely to cause sediment starvation and erosion further downstream. Groynes don't add sediment to the shoreface but rather distribute available materials differently. As such, groyne construction is perhaps most effective when complemented with beach nourishment.

Jetties in Elmina, Ghana. Photo: Donatus Bapentire Angnuureng/UCC

Solution n°3 : Jetties

Category

Hard engineering solutions [X]
Soft engineering solutions [ ]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [ ]
No [X]

Substance and Purpose

Jetties are larger, extend to greater offshore distances than groynes and constructed from a wide variety of materials including rock armour, concrete, dolos, tetrapods and steel piling. They are constructed at the banks of tidal inlets and river mouths to trap a portion of the longshore sediment transport, stabilising the inlet and preventing channel siltation, ensuring navigation.

Main environmental requirements & institutional context

Costly to construct, hence limited to developed coastlines with infrastructure (harbours).

Combining with other solutions

It may be practical to combine jetty construction with a sediment bypassing scheme, where sediment trapped by the jetty is dredged from its updrift side and deposited on the downdrift side of the tidal inlet/river mouth. This would maintain a degree of longshore sediment supply.

Assets, advantages and strengths particular to the West Africa coastal area

Jetties are long term solutions to coastal protection and can be very beneficial in areas where the coastline is developed with infrastructure and property. The principal advantage is to ensure the continuous passage of ships through a tidal inlet or river mouth where there are significant benefits for development and commerce

Constraints, weaknesses and difficulties particular to the West African coastal area

As jetties can be long structures, considerable amounts of sediment can be trapped on the updrift side, which can lead to major coastline setbacks on the downdrift side.

Revetment in Benin. Photo: IUCN

Solution n°4 : Revetments

Category

Hard engineering solutions [X]
Soft engineering solutions [ ]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [ ]
No [X]

Substance and Purpose

Revetments are shore-parallel, sloping structures, constructed landwards of the beach to dissipate and reduce wave action. These structures typically protect a soft landform such as a dune area or coastal slope and often solid structures. Revetments are employed on the seaward edge of coastal sections vulnerable to erosion, such as dunes, soft cliffs or other defence measures.

Main requirements (regarding the environmental or institutional context)

Very expensive.

Combining with other solutions

Other defence solutions including groynes, breakwaters for reinforcement.

Assets, advantages and strengths particular to the West African coastal area

Depending on the local conditions, it may result in increased accretion and a flatter beach profile, thus a stabilised shoreline.

Constraints, weaknesses and difficulties particular to the West African coastal area

Takes up space and may impede access to the sea (for some activities). Even solid, it is not a lifelong project.

The old seawall of Saint-Louis, Senegal, Photo: Bruna Alves/IRD

Solution n°5 : Seawalls

Category

Hard engineering solutions [X]
Soft engineering solutions [ ]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [ ]
No [X]

Substance and Purpose

Seawalls are built parallel to the shore and aim to hold or prevent soil sliding, while providing protection from wave action. Their primary function is to prevent further shoreline erosion. The secondary function is defence against coastal floods. Seawalls are usually used in areas where further shoreline erosion will result in extreme damage, for instance, when roads and buildings are about to fall into the sea.

Main environmental requirements & institutional context

Very expensive. Requires a solid foundation (rocky) for durability over the long term.

Combining with other solutions

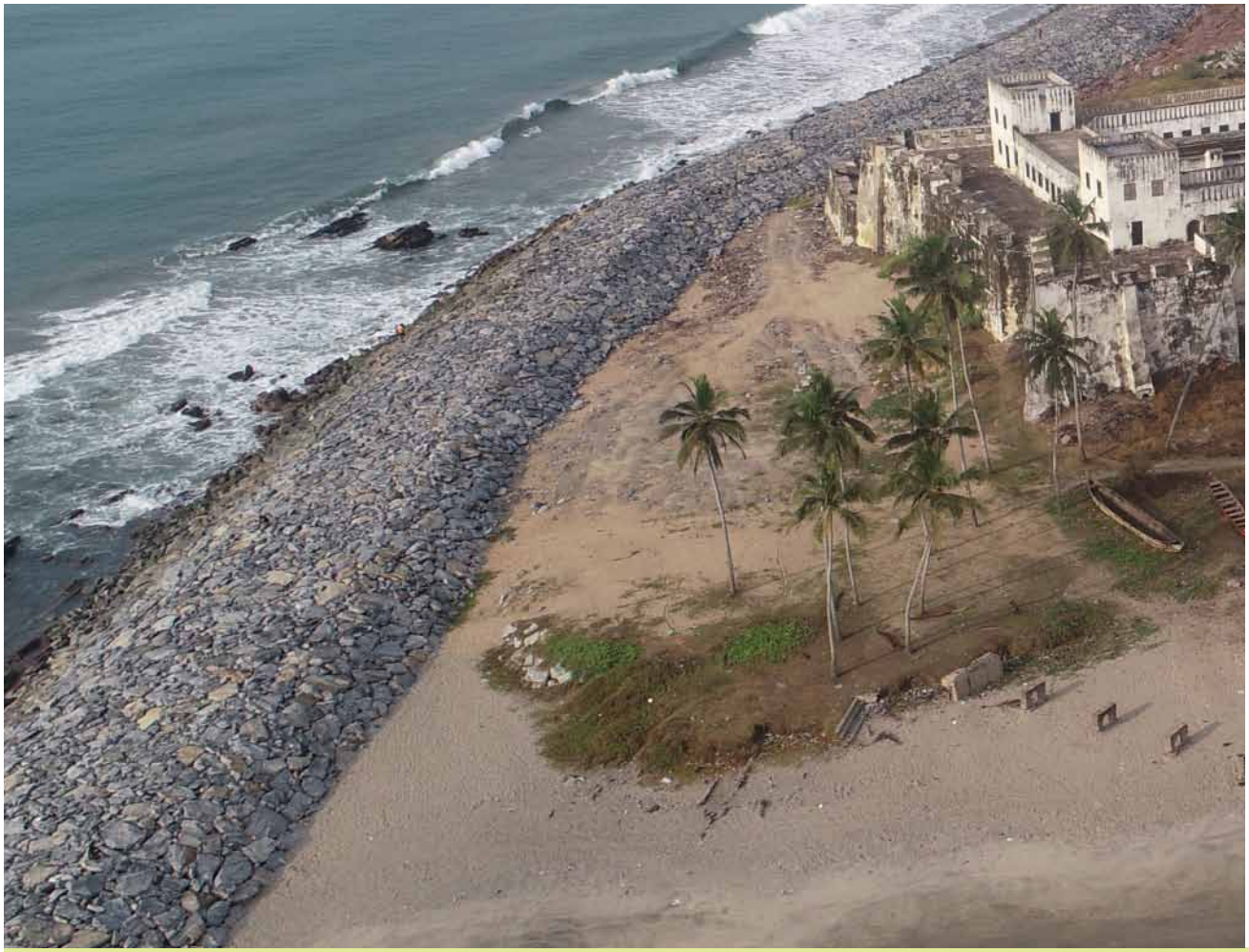
Currently, the use of seawalls for coastal erosion prevention are constructed in tandem with groynes. This has resulted in the stability of the seawalls as well as preventing overtopping waves.

Assets, advantages and strengths particular to the West African coastal area

A perfect seawall can provide a high level of protection against coastal flooding and erosion. When well-maintained and appropriately designed, seawalls do not use a large amount of space and will fix the boundary between the sea and land to ensure no further erosion occurs.

Constraints, weaknesses and difficulties particular to the West African coastal area

Seawalls may lead to a general reduction of available sediment in the coastal cell, downdrift erosion for example flanking erosion, basal scour (due to wave-energy focusing on the base of the wall), and beach down-draw.



Dyke on Elmina Coast, Ghana. Photo: Hen Mpoano

Solution n°6 : Dykes

Category

Hard engineering solutions [X]
Soft engineering solutions [ ]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [ ]
No [X]

Substance and Purpose

Dykes are designed in such a way that they provide stability under normal and extreme conditions. Structures 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. They are not intended to preserve beaches.

Main environmental requirements & institutional context

Dykes are common practices in low-lying coastal areas and are often the cheapest hard defence practice when coastal land is less valuable.

Combining with other solutions

Dykes aim to be sufficient and stand-alone to protect a stretch of coastline.

Assets, advantages and strengths particular to the West African coastal area

The sloped seaward edge of a dyke leads to greater wave energy dissipation and reduced wave loadings on the structure compared to vertical structures. This is achieved as the seaward slope forces waves to break as the water becomes shallower.

Constraints, weaknesses and difficulties particular to the West African coastal area

Dykes require high volumes in order to resist high water pressures on the seaward face. As a result, construction uses large volumes of building materials, including sand, clay and asphalt, which can be costly. Applying dykes in the shallow slopes requires significant land area and facilitating wave energy dissipation results in a large footprint during construction – all of which are further disadvantages.

Cliff stabilisation in Gorée Island, Senegal. Photo: Madjiguene Seck/ World Bank

Solution n°7 : Cliff stabilisation

Category

Hard engineering solutions [X]
Soft engineering solutions [ ]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [X]
No [ ]

Substance and Purpose

Cliff stabilisation relates to measures carried out to minimise erosion of sloping soft rocky coasts. These landforms are susceptible to erosion due to relatively non-compacted sediments which are particularly vulnerable to erosive forces such as waves, winds, tides, nearshore currents, storms and rising sea levels. The ultimate goal is to stabilise the coastline.

Main environmental requirements & institutional context

The cost of cliff stabilisation depends on local conditions, individual situations and likely to be associated with revetment construction. The preference for cliff stabilisation is to seek the least expensive and most durable method, based on natural processes.

Combining with other solutions

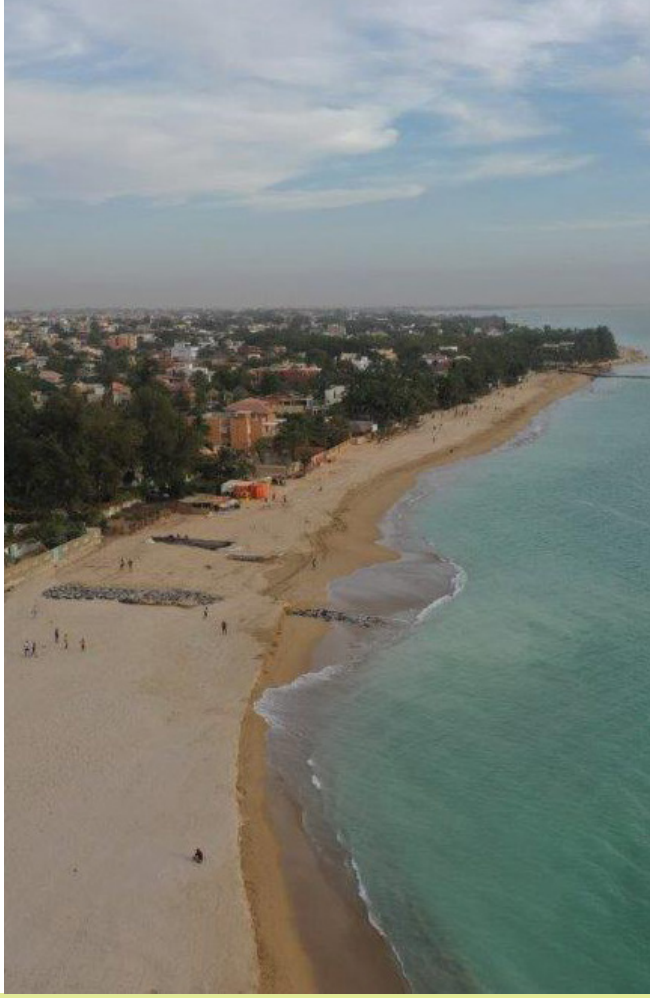
Revetments may be used to protect certain fragile parts of the cliff and to channel runoff water into covered or paved drains.

Assets, advantages and difficulties particular to the West African coastal area

A stabilised shoreline with the landscape preserved almost in its original form.

Constraints, weaknesses and issues particular to the West African coastal area

Stabilisation interferes with natural coastal dynamics where smoothing and slope re-grading causes land loss and may cause erosion in the long run.



Beach nourishment in Saly, Senegal. Photo: Senegal World Bank funded Tourism Project (PDTE)

Solution n°8 : Beach nourishment

Category

Hard engineering solutions [ ]
Soft engineering solutions [X]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [X]
No [ ]

Substance and Purpose

Beach nourishment is a coastal protection approach which involves the artificial addition of sediment of suitable quality for beaches with sediment deficit. Nourishment involves beach recharge, fill, replenishment, re- nourishment and feeding.

Main environmental requirements & institutional context

Availability of mined gravel or sand; availability of a specially equipped boat or powerful trucks with spears; availability of funds over a long period of time.

Combining with other solutions

Can be used as a solution stand-alone or integrated with hard structures as part of strategic shore protection efforts. More specifically, it can be used to compensate the drawback effects of groynes including sediment starvation and downdrift erosion.

Assets, advantages and strengths particular to the West African coastal area

The result of beach nourishment is to keep the sandy beach at a width that provides protection from storms. Beach nourishment enhances the dissipation of wave energy through its ability to maintain or reshape the beach profile. A wide, flat beach dissipates a considerable amount of wave energy while a narrow, steep beach reflects incoming wave energy, resulting in increased erosion.

Constraints, weaknesses and difficulties particular to the West African coastal area

The beneficial effect of beach feeding is temporary, so it should be repeated every two or three years, making this solution a costly option in the long term. The mining of gravel or sand may cause some environmental damages.

Dune Rehabilitation in Mauritania. Photo: Modestine Victoire Bessan/IUCN

Solution n°9 : Dune construction/rehabilitation

Category

Hard engineering solutions [ ]
Soft engineering solutions [X]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [X]
Maybe, under certain conditions [ ]
No [ ]

Substance and Purpose

Dune rehabilitation is the restoration of natural or artificial impaired dunes, to gain the greatest coastal protection benefits. Naturally occurring sand dunes are wind-formed sand deposits produced through a sediment store in the zone just landward of normal high tides. Artificial dunes are engineered structures created to mimic the functioning of natural dunes whose construction and rehabilitation are aimed at reducing coastal erosion and flooding in adjacent coastal lowlands.

Main environmental requirements & institutional context

One linear meter of mechanical dune stabilisation is up to US$6.97 (estimate from Nouakchott project, 2000 to 2007).

Combining with other solutions

Dune rehabilitation is often accompanied by a planting and reforestation, for longer lasting dunes.

Assets, advantages and strengths particular to the West African coastal area

The beauty of the landscape is preserved or enhanced.

Constraints, weaknesses and difficulties particular to the West African coastal area

Dunes occupy a lot of land and generally unsuitable for frequent human or herd visits.

Benin. Photo: Cerde ONG

Mangrove restoration in Benin. Photo: Corde ONG

Solution n°10 : Wetlands and mangroves restoration

Category

Hard engineering solutions [ ]
Soft engineering solutions [X]
Coastal planning & risk management techniques [ ]

Compliance with nature-based solution criteria

Yes [X]
Maybe, under certain conditions [ ]
No [ ]

Substance and Purpose

Wetland restoration is the rehabilitation of previously existing impaired wetland. The term wetland refers to a diverse range of shallow water and intertidal habitats. One well- known type of coastal wetland is the mangrove forest. Mangroves contribute to wave attenuation via sediment trapping. As currents and waves are attenuated by plants, sediment particles may be deposited.

Main environmental requirements & institutional context

Requires modest funds but importantly requires community approval and participation to avoid wood harvesting.

Combining with other solutions

Wetlands and mangrove restauration systems aim to be sufficient and stand-alone to protect a stretch of coastline, more specifically in estuarine areas and muddy coasts.

Assets, advantages and strengths particular to the West African coastal area

The landscape's beauty and the biodiversity are preserved. Ecosystem functions are maintained with soil stability, climate regulation, and improved water quality.

Constraints, weaknesses and difficulties particular to the West African coastal area

The choice of areas to be replanted must be carefully chosen to ensure usual land tenure and traditional activities are unaffected.

Solution n°11 : Flood early warning systems

Category

Hard engineering solutions [ ]
Soft engineering solutions [ ]
Coastal planning and risk management techniques [X]

Compliance with nature-based solution criteria

Yes [X]
Maybe, under certain conditions [ ]
No [ ]

Substance and Purpose

An early warning system is a way of detecting threatening events in advance. This enables public warnings to be issued at the same time so actions can be taken to reduce the adverse effects of an event. This type of hazard needs to be considered as a priority in West African coastal areas where the primary objective is to reduce exposure to coastal flooding through promoting effective temporary evacuation.

Main environmental requirements & institutional context

Early warning technologies are relatively low-cost, requiring regular collection of local rainfall, stream level, and streamflow data, achieved through routine monitoring.

Combining with other solutions

Flood early warning systems can be combined with any other coastal defence solution, effective in complementing flood risk mapping.

Assets, advantages and strengths particular to the West African coastal area

This planning approach is straightforward and feasible and its implementation in West Africa will minimize fatalities.

Constraints, weaknesses and difficulties particular to the West African coastal area

For effective rollout of early warning systems, communities require training as well as permanent and rigorous monitoring of meteo-oceanic phenomena by dedicated services.

Solution n°12 : Risk mapping, flood risk mapping

Category

Hard engineering solutions [ ]
Soft engineering solutions [ ]
Coastal planning and risk management techniques [X]

Compliance with nature-based solution criteria

Yes [X]
Maybe, under certain conditions [ ]
No [ ]

Substance and Purpose

Flood mapping is designed to increase awareness of the likelihood of flooding among the public, local authorities and other organisations. By combining data on flood probabilities (flood mapping) with data on human, economic and natural issues, GIS enables the production of flood risk maps, which should be integrated into coastal planning procedures.

Main environmental requirements & institutional context

Advanced and accurate flood maps are based on complex numerical models. However a lack of observed/field data on extreme events requires the use of numerical modelling to forecast possible outcomes, with inputs from qualified experts for implementation.

Combining with other solutions

Flood risk mapping can be combined with any coastal defence solution. It is particularly useful for flood early warning systems and plays a central role in all planning activities.

Assets, advantages, and strengths particular to the West African coastal area

Risk and flood mapping is an essential tool for effective integrated coastal zone management.

Constraints, weaknesses and difficulties particular to the West African coastal area

This exercise is costly in terms of data requirement and expert time.

Solution n°13 : Coastal setbacks

Category

Hard engineering solutions [ ]
Soft engineering solutions [ ]
Coastal planning and risk management techniques [X]

Compliance with nature-based solution criteria

Yes [X]
Maybe, under certain conditions [ ]
No [ ]

Substance and Purpose

Coastal setbacks are a prescribed distance to a coastal feature such as the line of permanent vegetation, within which all or certain types of development are prohibited. A setback may dictate a minimum distance from the shoreline for new buildings or infrastructure facilities or may state a minimum elevation above sea level for development. The setback area provides a buffer between a hazard area and coastal development.

Main environmental requirements & institutional context

The communities' understanding and compliance to agree not to build inside the prohibited zone.

Combining with other solutions

Coastal setback can be combined with any coastal defence solution. Good complementarity with flood risk mapping and coastal zoning.

Assets, advantages and strengths particular to the West African coastal area

Setbacks provide a highly effective method of minimising property damage due to coastal flooding and erosion, by removing structures from the hazard zone. They help to maintain the natural appearance of the coastline and preserve natural shoreline dynamics. Setbacks also help to maintain shoreline access by preventing development immediately on the seafront.

Constraints, weaknesses and difficulties particular to the West African coastal area

Does not fit with the spontaneous colonisation pattern of coastal regions.

Solution n°14 : Managed realignment

Category

Hard engineering solutions [ ]
Soft engineering solutions [ ]
Coastal planning and risk management techniques [X]

Compliance with nature-based solution criteria

Yes [ ]
Maybe, under certain conditions [X]
No [ ]

Substance and Purpose

Managed realignment commonly includes setting back the line of an actively maintained coastal defence to a new line, landward of the original or preferably, to elevated ground. This will increase the creation of intertidal habitat between the old and new defences.

Management realignment is therefore the deliberate process of changing flood defences to allow flooding of a defended area.

Main environmental requirements & institutional context

Appropriate in coastal areas with established coastal defences, low-lying land, desire to improve flood or coastal defence systems, sustainability-oriented coastal management attitude, need to create intertidal habitats, and where the society is aware of the benefits of managed realignment.

Combining with other solutions

Usually managed realignment requires a combination of hard and/or soft solutions (such as seawalls, dykes, tidal marsh or dune rehabilitation) with coastal planning and risk management techniques (flood risk mapping, coastal zoning, relocation).

Assets, advantages and strengths particular to the West African coastal area

The approach can adequately protect a coastal area or infrastructure from erosion and flood risks.

Constraints, weaknesses and difficulties particular to the West African coastal area

It can be expensive and has to the potential to generate high political and social controversy particularly when it involves relocating residents and subsequent confrontation with landowners.

Solution n° 15 : Coastal zoning

Category

Hard engineering solutions [ ]
Soft engineering solutions [ ]
Coastal planning and risk management techniques [X]

Compliance with nature-based solution criteria

Yes [X]
Maybe, under certain conditions [ ]
No [ ]

Substance and Purpose

Coastal zoning is a land use system for regulating development activities, dividing coastal areas into designated zones with different purposes and restrictions. Coastal zoning has the ability to manage multiple uses of the same coastal area to benefit all users with the potential to allow multiple users to benefit from services provided by coastal areas.

Main environmental requirements & institutional context

Coastal zoning is a nature/community-based management practice that requires institutional capacity development, data surveillance and knowledge of the coastal area.

Combining with other solutions

Just as flood and risk mapping was the cornerstone of the diagnostic stage of ICZM, coastal zoning is the key tool for implementation of an ICZM plan. Coastal zoning is by nature intended to organise the use of different types of solutions.

Assets, advantages and strengths particular to the West African coastal area

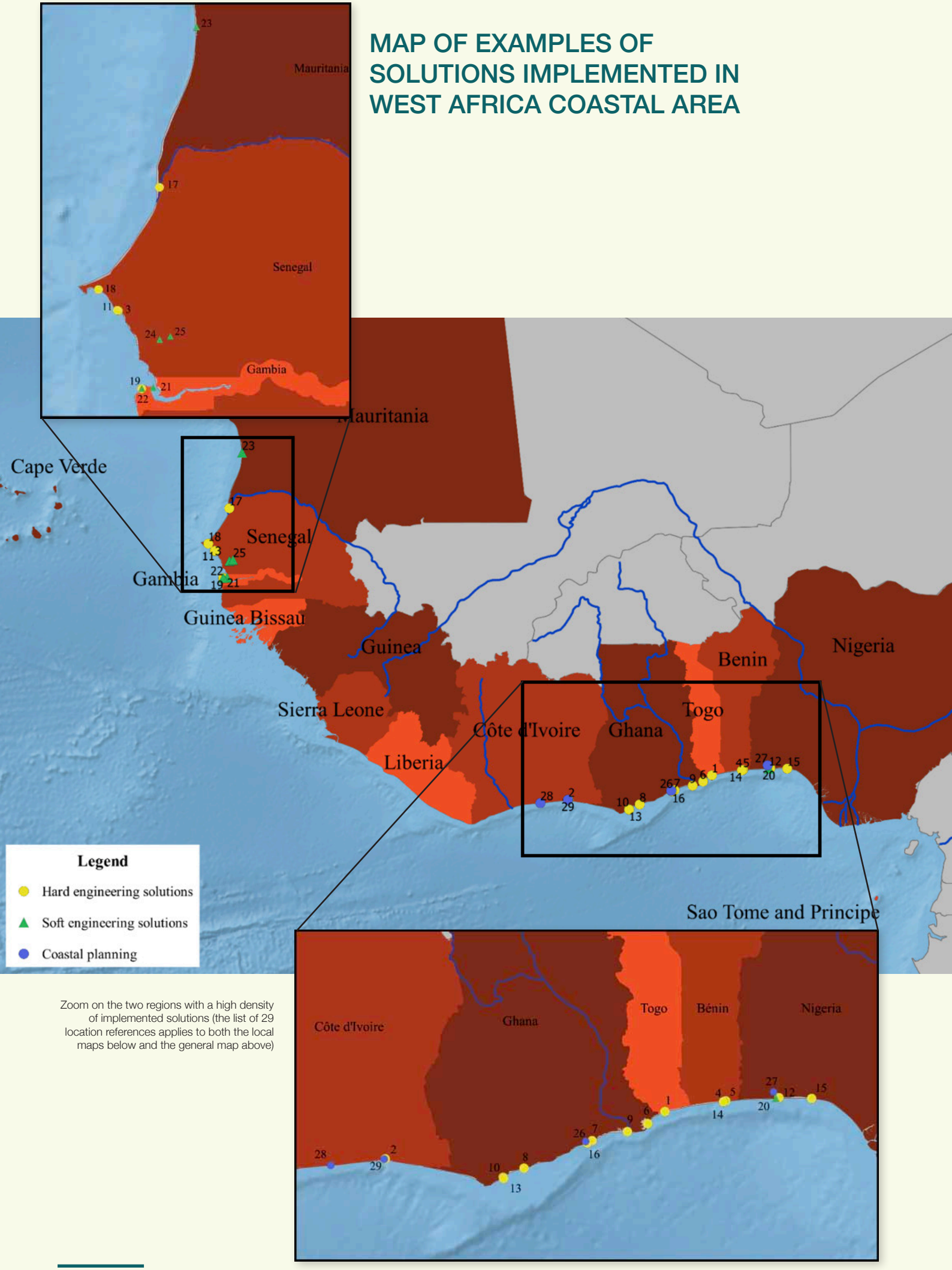
Coastal zoning schemes can help maintain local coastal livelihoods, biodiversity and broader economic activities for the benefit of all communities and stakeholders

Constraints, weaknesses and difficulties particular to the West African coastal area

The cost of implementing a zoning system largely depends on the complexity of the system, the different governance regulations and the size of the coastal area in question.

Senegal. Photo: Vincent Tremeau/World Bank

MAP OF EXAMPLES OF SOLUTIONS IMPLEMENTED IN WEST AFRICA COASTAL AREA



Zoom on the two regions with a high density of implemented solutions (the list of 29 location references applies to both the local maps below and the general map above)

N°	LOCATION	TYPE OF SOLUTION
1.	Lomé	Offshore Breakwater
2.	Abidjan	Offshore Breakwater
3.	Petite côte	Offshore Breakwater
4.	Cotonou	Offshore Breakwater
5.	Cotonou	Groynes
6.	Keta	Groynes
7.	Sakumono	Groynes
8.	Elmina	Groynes
9.	Ada	Groynes
10.	New Takoradi	Groynes
11.	Petite côte	Groynes
12.	Lagos	Groynes
13.	Elmina	Jetties
14.	Cotonou	Jetties
15.	Lagos	Jetties
16.	Accra	Revetments
17.	Saint-Louis	Revetments
18.	Rufisque	Seawall
19.	Serekunda	Seawall
20.	Lagos	Beach nourishment
21.	Banjul	Beach nourishment
22.	Kololi	Beach nourishment
23.	Nouakchott	Dune rehabilitation
24.	Djimda (Fatick)	Wetland restoration
25.	Guagué Sherif	Wetland restoration
26.	Accra	Early flood warning system
27.	Lagos	Early flood warning system
28.	Grand-Lahou	Relocation
29.	Abidjan	Relocation


Credit: Hen Mpoano

West Africa Coastal Areas Management Program

For more than a decade, the West African coastal countries have suffered from the adverse effects of coastal erosion exacerbated by climate change, jeopardizing the high socio-economic, environmental, and cultural potential of their coastal zones. If nothing is done, the vulnerability of the socio-economic infrastructure, natural resources and coastal populations will only grow, leading to an ever-increasing loss of wealth in the region.

The West Africa Coastal Areas Management Program (WACA) is a convening platform that assists West African countries in sustainably managing their coastal areas and enhancing their socio-economic resilience to the effects of climate change, facilitating access to technical expertise and financial resources.

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