POLICY BRIEF

Cost of Coastal Environmental Degradation, Multi Hazard Risk Assessment and Cost Benefit Analysis

Key Messages

- Coastal environmental degradation as a result of erosion and flooding poses a significant threat to the West African coastal environment, its people and its assets; the threat will increase in coming years due to the impact of climate change.
- The knowledge base on causes and consequences of coastal environmental degradation in West-Africa needs to be broadened and remediation solutions must be proposed and assessed.
- In order to support informed and ultimately sustainable decision-making, a methodology enabling the calculation of the cost of environmental degradation and the evaluation of the cost-efficiency of DRR and CCA measures is proposed.
- The general validity and utility of the methodology has been demonstrated. It offers an operational framework that can be further improved by integrating better data or information as it becomes available.
- The methodology has been applied to pilot sites in Benin, Côte d'Ivoire, Ghana and Togo. Results suggest that cost-effective measures or combinations of measures can be found to limit the damages due to coastal erosion and flooding at these locations The first quick-scan analysis indicates that the benefits (i.e. risk reduction) of planned retreat and accommodation measures outweigh its costs and that early action (i.e. limiting development in areas at risk) will further improve the benefit-cost ratio.
- Further application of the methodology shall be promoted in order to optimize resources spent on coastal risk management.
- The integration of other hazards, such as river flooding, in the methodology would lead to an improved selection of DRR and CCA measures, suiting the needs of the population with increased adequacy.
- Coastal zone management requires an 'all-of-society' approach. The inclusion of stakeholders in the process will ensure that the local knowledge is valued as a complement to scientific knowledge and will guarantee that selected CCA and DRR measures suit the needs.
- Coastal processes such as erosion and flooding do not stop at national borders. The West African coastal zone can be seen as a unique system. Therefore, a regional approach to coastal management and implementation of DRR and CCA measures will be required.

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Coastal environmental degradation in Benin, Côte d'Ivoire, Ghana and Togo

The West African coastal area hosts large infrastructure, major industries, tourism, agriculture and fishing activities as well as human settlements and communication routes. These rapidly urbanising areas drive national economic growth and provide the livelihoods to many.

However, demographic pressures and increasing exploitation of coastal resources have led to rapid coastal environmental degradation. Coastal ecosystems in West Africa now face a range of challenges, including coastal erosion and flooding, overexploitation of natural resources, marine and coastal pollution, loss of biodiversity and of ecosystem services, rapid urbanization and unsustainable land use, and overall poor environmental governance.

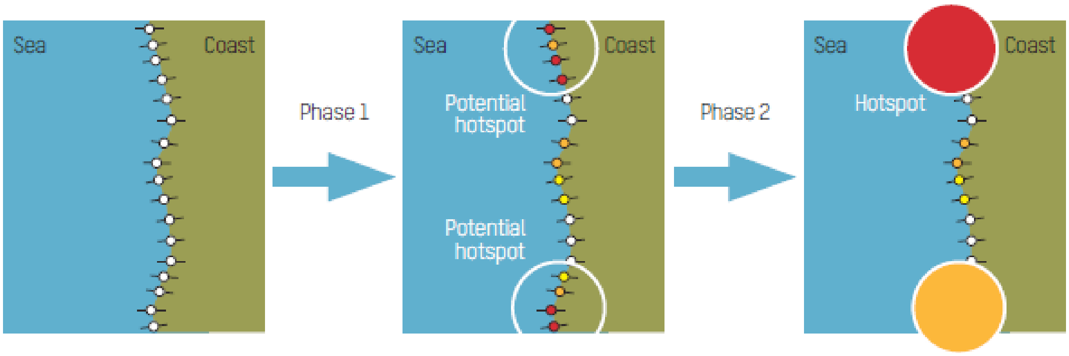
In order to address these challenges, the knowledge base on causes and consequences of coastal environmental degradation in West-Africa needs to be broadened and remediation solutions must be proposed and assessed.

The present study aims at contributing to informed and ultimately sustainable decision-making in the field of DRR and CCA measures, by proposing a methodology enabling the calculation of the cost of environmental degradation and the evaluation of the cost-efficiency of DRR and CCA measures. This methodology has been tested on one pilot in each of the participating countries: Benin, Côte d'Ivoire, Ghana and Togo.

The methodology

The proposed methodology is inspired by the Coastal Risk Assessment Framework which has been developed an applied to coastal zones in Europe, and has been adapted to coastal erosion and flooding in the West African context. It can be decomposed in 2 phases, aiming at answering the 2 following questions:

- Where to invest first? – Phase 1
- Which measures to be preferred? – Phase 2



Phase 1: Identification and ranking of the hotspots ("What's the priority? Where to invest first?")

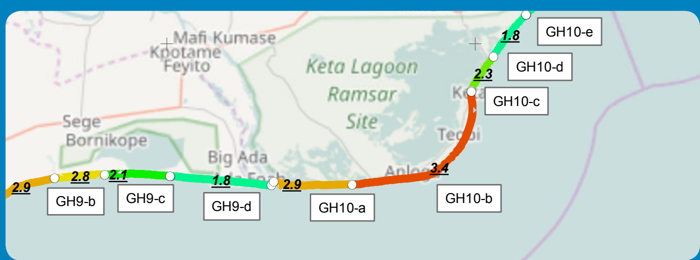
This step helps prioritizing the action by ranking hotspots along the coast in terms of their vulnerability. This is done through the calculation and ranking of coastal indices of pre-identified coastal sectors. Coastal indices reflect both the severity of the hazards (coastal erosion and flooding) and the extent of the exposure (population and assets in the area).

BOX 1 : Coastal indices

Coastal indices are the result of the multiplication of qualitative hazards indicators and social/environmental/natural exposure indicators.

Erosion & Flood Hazard Indicator	x	Exposure Indicator (SVI, ESI & NSI)	=	Coastal Index

Coastal indices maps (e.g. Eastern Ghanaian coastline sectors) help visualizing the situation.



The results of this first step have been used to support the selection of the pilot sites by the respective national authorities

Phase 2: Detailed study of the COCED and CBA of adaptation measures at selected sites ("which measures to be preferred?")

Once the sites to be further investigated have been selected, a more detailed study can be performed to select the most appropriate DRR and CCA option.

This step is further subdivided in successive steps aimed at characterizing the hazards, assessing the exposure, calculating the cost of degradation, and evaluating the cost-efficiency of remediation measures.

Step 2.1 Characterization of coastal erosion and flooding (i.e. "what is causing the problem?")

First, the threat to the coastal environment must be characterized. This can be done using very simple tools such a GIS-based flood maps or through more complex methods using hydrodynamic and hydromorphological modelling software.

In the latter case, probabilistic approaches, taking into account the impacts of extreme events along with their probability of occurrence are used. Climate change impacts, including sea level rise, are also taken into account.

BOX 2 : Coastal erosion and coastal flooding

Coastal erosion corresponds to the wearing away of land and removal of beaches or sand dunes due to waves, currents and tides and a lack of sediments. The repetitive action of waves combined with strong storms leads to land retreats of several meters and sometimes more than 10 meters per year in the study area.

Coastal flooding corresponds to inundation of dry land by seawater due to direct inundation, overtopping of crests or dune or dyke breaches. It is due to storms and especially in the case of storms occurring during periods of high sea water levels.

The end products of this step are flood maps comprising at least inundation depths and erosion maps quantifying the progressive retreat of the coastline.

Step 2.2: Characterization of the people, assets and ecosystems exposed (i.e. "who and what can potentially be affected?")

In the following step, the people and assets potentially exposed are characterized. As in the previous steps, this characterization can be done with various levels of details. Useful data can be gathered through analysis of previous studies, available data and maps, site visits, etc.

The end product of this subtasks are land use maps based on land use classes that are adapted to the local context. The land uses are defined based on population density, the presence of social assets (schools, hospitals, places of worship, monuments, etc.), of transport infrastructure (roads, railways, etc.), of specific economic activities (industry, services, ports, quarries, etc.) or of high natural value.

For each of the land-uses, a value (in US$ per hectare) is defined. This value represents the total cost of the land use form should it be completely lost to erosion or flooding. For natural areas, an overall value for ecosystems services has been estimated. For impacts on human health (fatalities), value of statistical life (VSL) has been used.

An additional feature is developed in order to take into account the fact that losses are in most cases only partial (depending for instance, on the duration and depth of a given inundation): the damage functions.

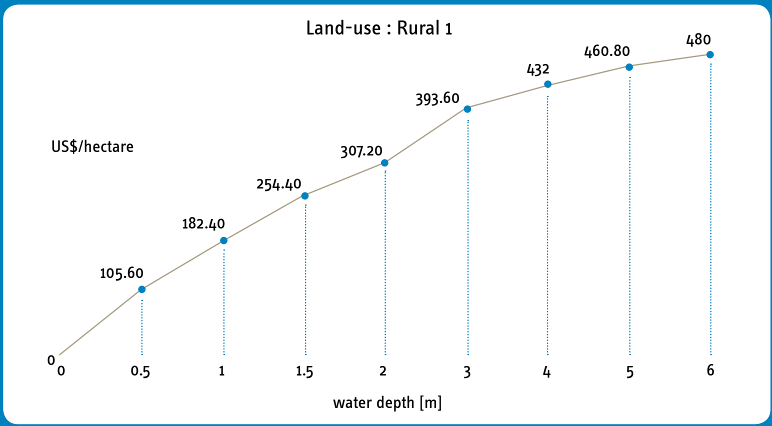
BOX 3 : Damage functions

Definition: a damage function is a function relating the damage done to an asset (generally as a percent of its total value) to certain characteristics of an event affecting it.

Damage functions have been developed in the frame of e.g. river flooding projects in Europe and have been applied throughout the world. The damage curves used in this study build on a world-wide review of existing curve. They have been adapted to the West African context.

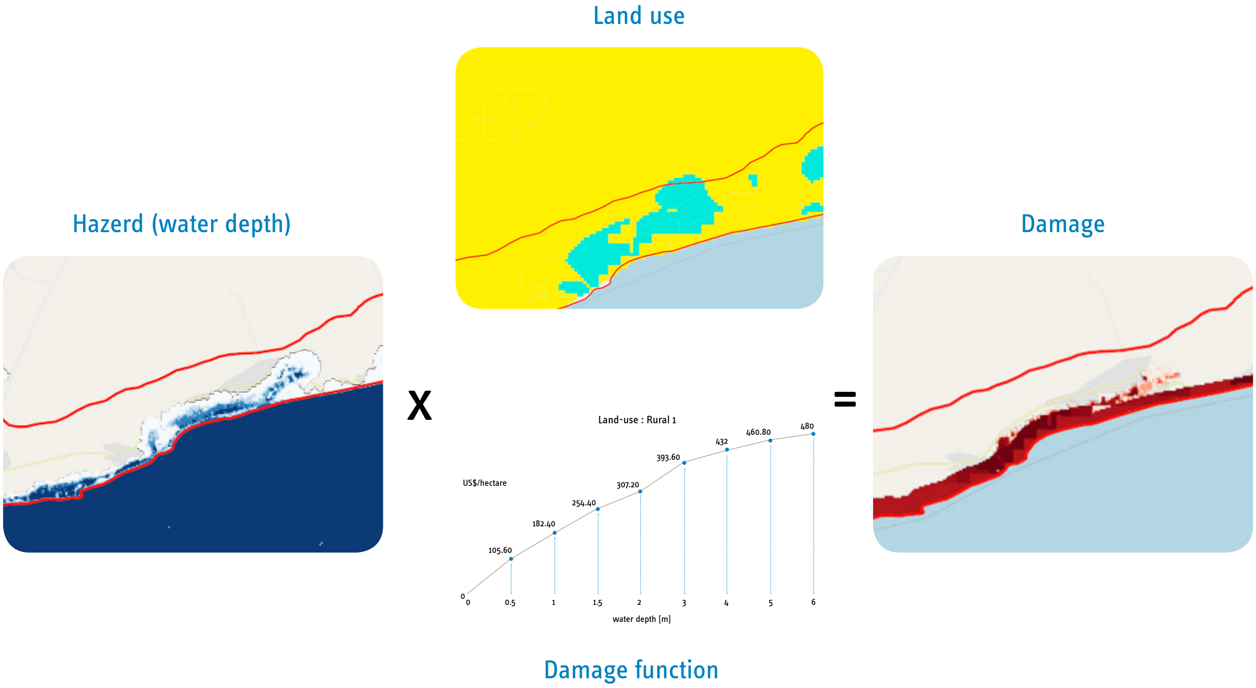
In some specific cases (e.g. flooding impacts on natural areas or on human health), new simplified curves have been developed as no existing curves could be found.

Example: land-use “Rural 1” defined for this project and corresponding to “areas with 0-1 inhabitants per hectare, agriculture as only economic activity and no other specific asset or infrastructure” has a total value per hectare estimated at 480 US$. Its total value is considered lost for flooding depths of more than 6 meters. For flood depths of 1.5 meters, roughly half of its value is lost (254.40 US$).



Step 2.3: Calculation of the expected damage

In this step, hazards and land use maps are combined with damage functions to obtain damage maps. Technically, this is carried out through (raster) multiplication of maps of similar pixel sizes.



Step 2.4: Cost benefit analysis of solutions (i.e. "what is the most cost-efficient solution to the problem?)

The next step aims at selecting the most cost-efficient remediation measures. This is done using cost-benefit analysis methods.

Possible CCA and DRR measures include:

- Protection,
- Retreat,
- Accommodation (flood proofing of assets),
- Combination of the above, in space and time.

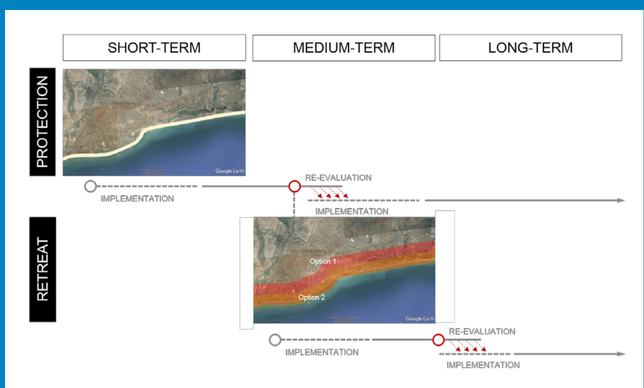
BOX 4 : DRR and CCA measures

Protection: examples are "hard solutions": construction of dykes, seawalls, groins, revetments, armour units, breakwaters, storm surge barriers, land reclamation, etc. and "soft solutions": beach nourishment, dune construction and rehabilitation, mangrove restoration, "building with nature concept", etc.

Retreat: examples are managed retreat, dike realignment, dike (re)opening, de-embankment and de-polderisation, coastal setbacks, etc

Accommodation: examples are coastal ecosystems reinforcement, wetland restoration, flood-proofing, floating agricultural systems, flood hazard mapping, flood warnings, etc.agricultural systems, flood hazard mapping, flood warnings, etc.

Combination of different measures in space and time. Flexible plans combining a series of short term actions with periodic decision points over time, to address longer term objectives.



The cost-benefit analysis of these solutions involves the calculation of economic indicators such as the net present value (NPV). The calculation of the NPV of measures requires the following actualized inputs:

- Costs: investment and maintenance cost of measures (construction of dykes, beach nourishment works, relocation of assets, flood proofing of buildings, etc.).
- Benefits: value of risks avoided if the measure were to be implemented.

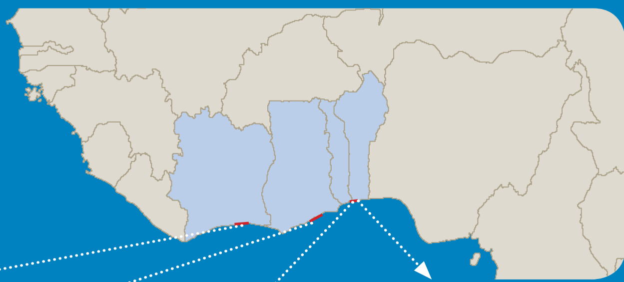
Avoided damages are calculated as described in previous step. Protection measures have an impact on the hazards while retreat and accommodation measures have an impact on exposure. Both ultimately lead to reduced damage.

Application of the methodology to the 4 pilot sites in Benin, Côte d'Ivoire, Ghana and Togo

The methodology has been applied to 4 pilot sites which have been selected by national authorities of participating countries. The selection process was supported by the presentation of the results of "Phase 1: Identification and ranking of the hotspots"

BOX 5 : The pilot sites

4 pilot sites have been selected in collaboration with national authorities



Côte d'Ivoire:
Sector from Abidjan to Port-Bouët

Ghana:
Sector from New Ningo to Lekpoguna

Togo:
Sector including cities of Togoville, Agbodrafo and Aneho

Benin:
Sector from Togo border to Grand-Popo

Main outcomes

At all four pilot sites and based on available data, scenarios combining planned retreat and accommodation of buildings/houses show the best benefit/cost ratio compared to other measures. They can indeed offer a large share of the benefits (50% to 90%) of full protection at a much lower cost. Their costs will be earned back within a few decades by reduction of the risks.

Early implementation of planned retreat and accommodation (e.g. limiting future economic development in areas at risk after 2050) can limit future costs and improve the efficiency of the scenarios.

It must be noted that the reliability of the selection of measures depends on the accuracy of the cost and benefit estimates and that for policy-supporting application of the method, it is advisable, given the important issues at stake and the scale of the interventions, that more detailed data and parameters are used.

It is also important to note that some costs and impacts cannot be monetized and therefore cannot be captured by the cost-benefit analysis. This is particularly the case of social impacts (e.g. destruction of cemeteries, of places of worship, etc.). The selection of measures therefore requires taking additional criteria into account. Such criteria are, for instance: the financial, technical and political feasibility, the social acceptability and the environmental sustainability of measures.

Ways forward

1. Reuse the methodology, for various purposes, with better data, in other places, at other times, etc.

This framework was developed in order to not only study and quantify the coastal erosion and flood risk based on the available data, but also to quantify the cost of coastal environmental degradation, and identify and compare possible DRR and CCA measures in economic terms.

The results obtained by this type of analysis help to further develop strategic investment plans, by indicating the sites where investments should come first, and by highlighting the DRR and CCA measures that should be preferred.

This flexible and robust methodology offers an operational framework that has several advantages:

- it can be applied on different spatial scales: regional level or pilot site level;
- it can make use of very detailed data or generally available datasets;
- it can be applied with different sorts of tools: from basic applications (GIS based approaches) to very detailed models (e.g. hazard assessments with detailed numerical models);
- it can serve at different stages of a study or project cycle: pre-feasibility, feasibility, predesign, detailed design, since it can cope with different data types and different levels of detail.

The methodology should also be reused at different times to make sure that measures remain adapted to the risks as the latter may evolve with time for various reasons (e.g. climate change, economic or demographic growths, change in land use, etc.).

As described in the introduction, the problems linked to coastal erosion and flooding in the study area are huge. The economic, environmental and social costs of the remediation options will likely be of the same nature, thus requiring very well informed decision making. The present methodology represents a very efficient tool to serve this purpose.

2. Improve the quality of data in the West African coastal zone

The method is robust and can work with very limited metocean, morphological, physical or economic data. The application of the methodology to the four pilots sites of Benin, Côte d'Ivoire, Ghana and Togo, has yielded results but has also highlighted the lack of data that will be useful for further, more detailed, applications of the methodology

Examples of critically missing data are:

- Beach profile and crest elevation, which is of crucial importance for the evaluation of coastal erosion and the overtopping of seawater during storms;
- Local demographic and economic data, as the usage of national data is often misrepresenting the reality of the (much) more urbanized and developed coastal zone.

Future land use maps that predict how national economic or demographic growth will affect land use in coastal areas, as well as local climate change impact scenarios will also help improve the evaluation of the future situation.

Further improvements should also focus on availability of data in digital format and availability of spatial data with reasonable resolution.

3. Integrate other hazards (e.g. river flooding)

Within the present project, direct and indirect impacts of two different hazards, coastal erosion and coastal flooding, have been analyzed independently and jointly. Understanding where and how these multiple hazards will likely affect social and economic systems and infrastructure in coastal areas enables a more intelligent and cost-effective selection of DRR and CCA measures. An impact-based approach is therefore crucial to risk reduction decision-making. Adding different hazards, such as river flooding, into this analysis is possible, and would give an even broader and more complete insight into the land and people at risk.

4. Involve stakeholders

Stakeholders, not only experts but also ordinary citizens play an important role as providers and recipients of information on coastal risk and approaches to define and select DRR and CCA measures. Local residents are understood as gatekeepers of important historical and cultural knowledge, who often hold the key to understanding behaviours and attitudes in relation to coastal risk and DRR approaches and measures. Effective disaster risk reduction requires an 'all-of-society' engagement and partnership.

An active involvement of different stakeholders was encouraged and facilitated by performing a multi-criteria analysis (MCA) of the different proposed DRR and CCA measures during the final workshop for the presentation and discussion of the results of the study. First the MCA allowed to take into account environmental, social and political aspects in selecting the preferred DRR and CCA measures, next to the technical and economic information obtained from the present study. Second, the MCA promoted interaction and discussion between the different stakeholders during the workshop, which might result in new and better contacts that will also last afterwards.

5. Promote regional cooperation

Through in-depth analysis of the four different countries and the selected pilot sites, the project has revealed some interesting challenges for DRR management in West-Africa. Despite the differences in between the countries, some common challenges have become evident.

These relate primarily to the need for clarity in governance structures and procedures as well as the importance of citizen engagement, both in terms of providing local knowledge and in terms of awareness-raising for effective coastal DRR and CCA responses.

Also, the coastal erosion hazard in West-Africa is a regional phenomenon, which can only be tackled by regional, cross-boundary operation and management. DRR measures with a positive impact in one country could heavily deteriorate the situation in the neighbouring country.

FOR MORE INFORMATION

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