

A Quantitative Assessment of Human Interventions and Climate Change on the West African "Sand River"

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Layout of the presentation



- WACA: West African Coastal Areas Management Program (Miguel)
 - The Coastal Erosion Issue
 - The World Bank response
- Objectives of the study carried out at Deltares (Alessio)
- Study Approach
 - Literature review and desk assessment
 - Data collection and pre-processing
 - Numerical modelling (waves, sediment yield from rivers, potential alongshore sediment transport and shoreline evolution)
- Results
 - Hindcast model (1985-2015)
 - Future scenario runs (actual situation, anthropogenic interventions, climate change)
- Towards a regional sediment management plan



West Africa Coastal Areas Management Program

West Africa Coastal Areas Management Program

Genova, Italy - 15 June 2017

Part A The Coastal Erosion Issue

West Africa is Loosing its Coastal Economic Assets

Un constat ...



Route côtière au Togo grignotée par l'érosion. © mondequitable.onlc.eu





Pan d'une habitation détruite par les vagues lors de la tempête maritime des 24, 25 et 26 août 2011, Gonzagueville (Côte d'Ivoire) © Selay Marius Kouassi - http://www.rnw.nl/afrique



Credit: Deltares

Loss of Land, Assets and Livelihoods

Mauritania

Guinea-Bissau

Senegal

Ghana

WEST AFRICA COASTAL AREAS PROGRAM SAVING WEST AFRICA'S COASTAL ASSETS

500,000 PEOPLE ARE IMPACTED are impacted by Coastal Floods in West Africa every year.

Coastal areas are home to 31% of west africa's population and generate 56% of the region's GDP

340 MILLION

The estimated population of West Africa

LIVELIHOOD

COSTS

US \$296 MILLION

is the cost of degradation as a result of coastal losses due to erosion and associated economic opportunity losses, equivalent to 2.29 % OF GDP IN 2013

S11bn EXPECTED ANNUAL DAMAGE COSTS from coastal flooding by the 2050s

\$1.5 BILLION is the estimated cost of coastal protection.

TIME



90% OF URBAN AREAS

HABITAT

in Africa have no access to sewerage services

Approximately 54% OF AFRICA'S SOLID WASTE is not collected, leading to inadequate disposal causing flooding

80% OF POLLUTION

is now coming from

land-based sources

3 MILLION PEOPLE are employed by the fishing industry

Every year, legally captured fish stocks generate \$2.5 BILLION

0

The surface area of mangroves in the region has DECREASED **BY A QUARTER** between 1980-2006

COASTAL EROSION & CLIMATE CHANGE

H

H



Temperature projections indicate a warming scenario of

C — 6°C by 2100

23-30 M IN A GIVEN YEAR Rate of erosion recorded in some areas of West Africa

18,000 km2 Projected loss of West African coastline resulting

from a 1 meter rise in sea level

Environmental Stresses is an Economic and Poverty Issue

Environmental stresses interacting with increasing societal pressures on natural resources

Environmental Stresses

- Natural Hazard (e.g. flooding, erosion)
- Environmental Degradation (e.g. pollution, reduction in water quality)
- Variability in Environmental resources (e.g. biodiversity loss, depleted of natural resources)
- Climate Change (e.g. climate variability, extreme weather events, sea level rise)

Societal changes

Increased pressure on the environment due to:

- Population growth
- Land tenure and resource conflicts
- Urbanization
- Market price volatility

Increasing vulnerability of the poor

Less secure livelihoods Due to depleted social, financial, physical, natural resources, and human assets and increased displacement of people

Increased health risks (e.g. Malnutrition, Cholera, Typhoid, Dysentery, Dengue)

Constrained economic opportunities Short- and long-term impacts of erosion, flooding, market shocks, sickness and

other extreme events

Source: Dow, K., 2005. Vulnerability Profile of West Africa, Stockholm: Stockholm Environment Institute.

In just a Few Years, the Coastal Landscape Changes



Erosion Could Cause International Disputes



Part B Bank Response, WACA

WACA, a Strategic TA Program

- WACA Programmatic, approved in March 2015, is the strategic foundation for AFR and ENR GP's long-term engagement in West Africa's coastal areas.
- Founded on the West Africa Monetary Union (WAEMU) the International Union for Conservation of Nature (IUCN) Étude sur le suivi du trait de côte et schéma directeur du littoral de l'Afrique de l'oust, and the Déclaration de Dakar du 18 mai 2011, and the Mission d'Observatoire du Littoral Ouest Africain (MOLOA), as well as UNEP's Abidjan Convention's framework for coastal zone management
- The Program works on country demand to create multi-country coastal management initiatives implemented in stages (analysis, plan, investment) in collaboration with development partners and civil society.
- WACA is designed to improve the livelihoods of coastal communities in West Africa by reducing the vulnerability of its coastal areas and promoting climate-resilient integrated coastal management.

Strategic Partnerships are Forming to Respond at the Scale Needed

Partenariats et financement

- Fonds de partenariat de l'Afrique pour la préparation aux investissements climatiques (Fonds multi-donateurs, GIZ)
- Fonds Nordique de Développement
- Water Partnership Program
- Protocole d'entente avec l'UEMOA
- Protocole d'entente général avec l'UICN
- Arrangement administratif avec la France
- Discussions with USAID/WABiCC
- WB Africa Climate Business Plan, including IDA 17 Pipeline

Responses underway

- <u>Regional technical assistance and knowledge exchange to promote solutions, coastal monitoring, and coordinate action</u>
- National Dialogue, leading to investments priorities in countries
- Mobilization of partners and finance, in order to bring action to the scale that is needed

WACA is a Convening Platform that helps Countries access Expertise and Finance to Sustainably Manage their Coastal Areas

Countries and their EEZ's



The "Sand River"



Actions taking place along the "sand river" are interrelated

Objectives of the study

- Estimation, with a <u>consistent approach</u> and based on <u>numerical</u> <u>modelling</u>, of the <u>sediment budget</u> along the West African coast, <u>from Ivory Coast to Benin</u>
- Quantitative assessment of <u>major anthropogenic interventions</u> and possible <u>trans-boundary implications</u>
- Quantitative assessment of the effects of <u>climate change</u>
- <u>Awareness</u> and <u>communication</u> with local stakeholders (regional workshops, and coastal viewer)



Desk study and literature review

- Extensive literature review
- Analysis of shoreline changes supported by the use of Multiple Landsat Images (Aqua Monitor Tool: <u>https://aqua-monitor.appspot.com/</u>).
- Validation cases near major harbors to provide estimate of alongshore transport rates



Data collection and pre-processing

Wave modelling

- Bathymetry data: GEBCO data (offshore) + digitalization admiralty charts (nearshore)
- Wind and Waves: Global ERA-Interim data (35 years) + Altimeter data

Hydrological modelling and sediment yield

- DEM derived from HydroSHEDS data
- Land Use and Soil Maps
- Precipitation (Era-Interim)

Shoreline modelling

Satellite data



Creation of one consistent data-set for the four countries

Numerical modelling – General Framework





Wave modelling





- One overall model
- 15 nested models
- Wave climate analysis based on ERA-Interim data
- 139 combined wind-wave classes used to construct transformation-matrix to transform offshore data to nearshore

Wave modelling –results







Wave roses



Mean significant wave height alongshore

Hydrology and Sediment input from rivers

- Hydrology of the main rivers in West Africa
- Sediment yield estimated based on Dendy & Bolton (1976)
- Sand fraction estimated as 10% of the total sediment yield
- Trapping efficiency of dams computed based on Brune (1953)



Alongshore transport and shoreline modelling



- Based on the UNIBEST-CL+ code
- Potential sediment transport computed at different locations along the coast, based on information on incoming wave energy and direction, coastal angle and sediment diameter
- Shoreline changes computed from gradients in alongshore transport
- Schematization of the coastline, in order to reproduce large-scale patterns
- One representative $D_{50} = 250 \ \mu m$

Potential alonsghore sediment transport - results



Hindcast period: 1985 - 2015

Potential alonsghore sediment transport – results



Forecast period: 2015 – 2045 (actual situation)

Alongshore sediment transport – scenario run (no harbours)

200

400



Provide figures on the effects of:

- Anthropogenic interventions (i.e. major harbours)
- Possible mitigation schemes (e.g. sand bypassing)

Alongshore transport

600

Longshore distance [km]

1000

1200

Alongshore sediment transport – scenario run (no dams)



Provide figures on the effects of:

- Anthropogenic interventions (i.e. major dams)
- Possible mitigation schemes (e.g. reduction of sediment trapping)

Alongshore transport



Alongshore sediment transport – scenario run (climate change)



Towards a regional sediment management plan



Predicted land loss/gain by 2100

Simulation	Total area loss (ha /year)	Total area gain (ha/year)
Effect of major ports	33	33
Removal of major river dams	0	18
Change in wave condition due to:	18	19
a) 0.3 m RSLR + b) change in		
offshore wave climate		
Change in wave condition due to:	18	18
1.0 m RSLR; b) change in offshore wave climate		
Change in hydrology due to:	1	0
+20% precipitation; b) +6°		
temperature		
Change in hydrology due to:	0	1
a) -20% precipitation; b) +6°		
temperature		
Coastline retreat 0.3 m RSLR	30	0
(Bruun rule)		ÿ
Coastline retreat 1.0 m RSLR (Bruun rule)	100	0

Scientific outreach



- Technical report
- Freely available dataset of nearshore wave conditions
- Giardino, A., Schrijvershof, R., Nederhoff, C.M., de Vroeg, H., Brière, C., Tonnon, P.-K., Caires, S., Walstra, D.J., Sosa, J., van Verseveld, W., Schellekens, J., Sloff, C.,J. (submitted). A Quantitative Assessment of Human Interventions and Climate Change on the West African Sediment Budget. Journal of Ocean & Coastal Management.
- Coastal viewer



Recommendations for further work

- The modelling framework can be used as support tool to derive a regional sediment management plan, complemented with information from local organizations
- Derive boundary conditions for detailed models at specific hot-spot locations (i.e. at which solutions or new coastal developments are being planned)
- As basic platform to work together with local organizations (e.g. in combination with trainings, etc.)
- Basic infrastructure for data harmonization (e.g. populate the digital coastal viewer with new available data)

Deltares

• Extend the study to neighboring countries

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