

**MULTI-SECTORAL INVESTMENT PLAN FOR  
ADAPTATION TO COASTAL RISKS INDUCED BY  
CLIMATE CHANGE IN BENIN**  
*Final report*



## **COLOPHON**

### **Project**

Multi-sectoral investment plan for adaptation to coastal risks induced by climate change in Benin

### **Client**

The World Bank  
1818 H Street, N. W.  
Washington, DC 20433

### **Service provider**

Antea Belgium nv  
Roderveldlaan 1  
2600 Antwerp  
Belgium

Tel : +32 (0)9 261 63 00  
Fax : +32 (0)9 261 63 01  
www.anteagroup.be  
TVA: BE 414.321.939  
RPR Anvers 0414.321.939  
IBAN: BE81 4062 0904 6124  
BIC: KREDBEBB

### **Project number**

421118

### **Date:**

April 20th, 2017

### **Status / revision:**

Final version

### **Approval**

Renaat De Sutter, Contract Manager

### **Check**

Tom D'Haeyer, Consultant

### **Project collaborators**

Jihane Elyahyoui, Consultant  
Ilina Rebordão, Consultant  
Dick van den Berg, Consultant  
Raoul Läibi, Consultant

© Antea Belgium nv 2017

Prior written permission of Antea Group is required for the reproduction of parts or extracts of this text, for the storage in an electronic database and for any form of photocopying and multiplying.

## TABLE OF CONTENT

<b>ACRONYMS</b> .....	<b>6</b>
<b>EXECUTIVE SUMMARY</b> .....	<b>8</b>
<b>PART 1      REPORT</b> .....	<b>10</b>
<b>1    INTRODUCTION</b> .....	<b>11</b>
1.1 CONTEXT OF THE WACA PROGRAM.....	11
1.2 OBJECTIVES OF THE INVESTMENT PLAN.....	12
1.3 ELABORATION OF THE PLAN .....	12
1.4 STRUCTURE OF THE REPORT .....	13
<b>2    METHODOLOGY</b> .....	<b>15</b>
2.1 INTRODUCTION.....	15
2.2 SCHEMATIC WORKFLOW .....	15
2.3 MULTI-CRITERIA ANALYSIS.....	16
2.4 ELABORATING THE MSIP .....	17
<b>3    CONTEXT</b> .....	<b>19</b>
3.1 DELINEATION OF THE STUDY AREA .....	19
3.2 GENERAL DESCRIPTION .....	20
<b>4    COASTAL RISKS IN BENIN</b> .....	<b>29</b>
4.1 CHARACTERIZATION OF EROSION RISKS .....	29
4.2 CHARACTERIZATION OF COASTAL FLOODS.....	38
4.3 SUMMARY TABLE OF COASTAL RISKS PER ZONE.....	40
<b>5    INSTITUTIONAL FRAMEWORK</b> .....	<b>41</b>
5.1 INTRODUCTION.....	41
5.2 INVENTORY OF STAKEHOLDERS .....	42
5.3 GOVERNANCE OF COASTAL MANAGEMENT .....	49
5.4 INTERACTIONS OF STAKEHOLDERS FOR LAND USE.....	50
<b>6    LEGAL AND REGULATORY FRAMEWORK</b> .....	<b>54</b>
6.1 DESCRIPTION OF EXISTING LEGAL INSTRUMENTS .....	54
6.2 LEGAL FRAMEWORK OF MEASURE IMPLEMENTATION .....	56
6.3 CHALLENGES REGARDING THE LEGAL FRAMEWORK .....	57
<b>7    EXISTING ADAPTATION PROJECTS</b> .....	<b>62</b>
7.1 COMPLETED, SET-UP, ON-GOING AND PLANNED PROJECTS.....	62
7.2 PROPOSED PROJECTS.....	67
7.3 SELECTION OF PROJECTS FOR THE PLAN .....	72
<b>8    MULTI-SECTORAL INVESTMENT PLAN</b> .....	<b>74</b>
8.1 INTRODUCTION.....	74
8.2 HYPOTHESIS OF THE INVESTMENT PLAN .....	75
8.3 MAIN STRATEGIC AXES OF INTERVENTION.....	76
8.4 SUMMARY TABLE .....	89
<b>9    CONCLUSION</b> .....	<b>93</b>
9.1 ACTION PRIORITIZATION – BUNDLING IN PACKAGES .....	93
9.2 PLANNING DRAFT.....	99
9.3 MAIN KEY ACTORS INVOLVED .....	103

9.4	COMPLEMENTARITY WITH THE OTHER CHALLENGES AND PROJECTS OF THE COASTAL ZONE .....	103
9.5	RESTRAINING AND FAVORABLE CONDITIONS .....	104
9.6	OVERALL CONCLUSION.....	105
	<b>REFERENCES.....</b>	<b>107</b>

## FIGURES

FIGURE 1.1	CONTEXT OF THE WACA PROGRAM AND OF THE INVESTMENT PLAN .....	12
FIGURE 1.2	GLOBAL VISION OF THE STUDY LEADING TO THE MSIP.....	13
FIGURE 2.1	USE OF THE MCA IN THE CONCEPTION OF THE MSIP. ....	16
FIGURE 3.1	THE COASTAL ZONE SENSUS LATO AND THE DELINEATION OF THE COASTAL ZONE SENSUS STRICTO INTO FOUR GEOGRAPHIC ZONES.....	19
FIGURE 3.2	GEOLOGICAL MAP OF THE BENIN COASTAL ZONE. ....	21
FIGURE 3.3	ANNUAL VARIATION OF MONTH-AVERAGED WIND SPEED ALONG THE BENINESE LITTORAL, IN COTONOU (AVERAGE OVER 50 YEARS FROM 1955 TO 2005).....	24
FIGURE 3.4	INTER-ANNUAL VARIABILITY OF THE AVERAGE SEAL LEVEL COMPUTED FROM THE HEIGHT DATA OFFSHORE BENIN (DG-EAU, 2015). ....	25
FIGURE 4.1	CORRESPONDENCE BETWEEN THE 8 WACOM SEGMENTS AND THE 4 DEVELOPMENT ZONES OF THE SDAL. 30	
FIGURE 4.2	PHOTO OF THE IMPORTANCE OF EROSION IN HILLACONDJI (PICTURE FROM THE MUNICIPALITY OF GRAND-POPO, 2014). ....	31
FIGURE 4.3	A FISHERMEN VILLAGE IN HILLACONDJI (PICTURE 10/04/2014).....	31
FIGURE 4.4	THE FISHERMEN VILLAGE HAS DISAPPEARED DUE TO COASTAL EROSION (PICTURE 08/09/2016).....	31
FIGURE 4.5	PHOTO OF THE STATE OF THE BEACH BETWEEN DJONDJI AND MÈKO (PHOTO LAÏBI, 2015). ....	33
FIGURE 4.6	PHOTO SHOWING THE PROXIMITY OF THE SHORE FROM THE FURROWED FISHERY ROAD IN BAH (PHOTO LAÏBI, 2015). ....	33
FIGURE 4.7	PHOTO OF THE MAGNITUDE OF EROSION IN FRONT OF THE BIERGARTEN HOTEL (PHOTO LAÏBI, 2015). ....	34
FIGURE 4.8	FIELD OF SEVEN GROYNES BUILT IN 2014 IN THE CREEK DOWNSTREAM THE SIAFATO GROUYNE (P-LEC/DABC, 2014). ....	35
FIGURE 4.9	CREEK CREATED BY EROSION PHENOMENA DOWNSTREAM THE GROUYNE FIELD (PHOTO LAÏBI, 2015). ....	35
FIGURE 4.10	PHOTO SHOWING THE EROSION SCARP IN OKOUN-SÈMÈ (PHOTO LAÏBI, 2015). ....	36
FIGURE 4.11	SPATIAL CHARACTERIZATION OF COASTAL EROSION RISK ALONG THE LITTORAL OF BENIN (DG-EAU, 2015; ADAPTED FROM MOLOA, 2016). ....	37
FIGURE 4.12	OVER WASH EVENTS IN DJONDJI (PHOTOS LAÏBI, 2008).....	38
FIGURE 5.1	OVERVIEW OF THE MINISTRIES OF THE REPUBLIC OF BENIN (SOURCE: OFFICIAL WEBSITE OF THE GOVERNMENT, HTTP://GOUV.BJ/). ....	41
FIGURE 5.2	GRAPHICAL VIEW OF THE KEY (GREEN) AND NON-KEY (ORANGE) STAKEHOLDERS PER THEMATIC SECTOR. ADAPTED FROM ANIVER (2016).....	46
FIGURE 5.3	SMALL-SCALE FISH FARMING (PHOTO : INFONET-BIOVISION.ORG) .....	52
FIGURE 5.4	CONSTRUCTION OF A NEW SEAWALL (1 KM) IN DEN HAAG, NETHERLANDS (PHOTO : DUTCHWATERSECTOR.COM). ....	52
FIGURE 6.1	MAIN ELEMENTS OF THE IMPLEMENTATION OF MEASURES AGAINST COASTAL RISKS. ....	57
FIGURE 7.1	COMPARED PROPOSITIONS FOR THE SEGMENT HILLACONDJI – GRAND-POPO. ....	68
FIGURE 7.2	COMPARED PROPOSITIONS FOR THE SEGMENT GRAND-POPO - BOUCHE DU ROI. ....	68
FIGURE 7.3	PROPOSITIONS FOR THE CENTER WEST ZONE. ....	69
FIGURE 7.4	PROPOSITIONS FOR THE SEGMENT FIDJROSSÈ – SIAFATO GROUYNE.....	70
FIGURE 7.5	PROPOSITIONS FOR THE SEGMENT SIAFATO GROUYNE – SIBEAU SITE.....	71
FIGURE 7.6	PROPOSITION FOR THE EAST ZONE. ....	72
FIGURE 8.1	INTERVENTIONS IN THE WEST ZONE - SEGMENT HILLACONDJI - GRAND-POPO. ....	77
FIGURE 8.2	INTERVENTIONS IN THE WEST ZONE - SEGMENT GRAND-POPO – BOUCHE DU ROI.....	78
FIGURE 8.3	INTERVENTIONS IN THE CENTER WEST ZONE. ....	79
FIGURE 8.4	INTERVENTIONS IN THE CENTER EAST ZONE – COTONOU. ....	80
FIGURE 8.5	INTERVENTIONS IN CENTER EAST ZONE – SIAFATO TO SIBEAU SITE.....	81
FIGURE 8.6	INTERVENTIONS IN THE EAST ZONE. ....	82
FIGURE 9.1	ADAPTIVE MANAGEMENT FRAMEWORK (ADAPTED FROM BENNETT AND LAWRENCE, 2002). ....	93

## TABLES

TABLE 2.1 LIST OF INDICATORS PER CRITERION FOR THE MCA. ....	17
TABLE 3.1 ZONING OF THE BENINESE LITTORAL ACCORDING TO THE CHOICE OF LAND USE (FROM ABE, 2004).....	19
TABLE 3.2 EXTREME WIND SPEED AND SIGNIFICANT WAVE HEIGHTS WITH THEIR CORRESPONDING RETURN PERIODS (DG- EAU, 2015).....	25
TABLE 3.3 POPULATION DATA OF THE COASTAL CITIES AND TRENDS (MUHA, 2015).....	26
TABLE 4.1 CHARACTERIZATION OF COASTAL RISKS AND STAKES PER ZONE. ....	40
TABLE 5.1 RANKING OF KEY AND NON-KEY STAKEHOLDERS PER THEMATIC SECTOR. ....	46
TABLE 5.2 CLASSIFICATION OF KEY AND NON-KEY STAKEHOLDERS PER THEMATIC SECTOR IN THE EAST ZONE. ....	47
TABLE 5.3 CLASSIFICATION OF KEY AND NON-KEY STAKEHOLDERS PER THEMATIC SECTOR IN CENTER EAST ZONE.....	47
TABLEAU 5.4 CLASSIFICATION OF KEY AND NON-KEY STAKEHOLDERS PER THEMATIC SECTOR IN CENTER WEST ZONE.....	48
TABLEAU 5.5 CLASSIFICATION OF KEY AND NON-KEY STAKEHOLDERS PER THEMATIC SECTOR IN WEST ZONE. ....	48
TABLE 5.6 SUMMARY OF THE MAIN LAND AND SPACE USE, AND THEIR ACUITY (SOURCE : ABE, 2004). ....	51
TABLE 5.7 POSSIBLE WIN-WIN ARRANGEMENTS. ....	51
TABLE 6.1 MAIN LAWS AND DECREES REGARDING COASTAL MANAGEMENT IN BENIN. ....	54
TABLE 8.1 SUMMARY OF THE MULTI-SECTORAL INVESTMENT PLAN. ....	89
TABLE 9.1 COSTS PER ACTION PACKAGE ....	94
TABLE 9.2 HIGH PRIORITY PACKAGES. ....	95
TABLE 9.3 PRIORITY ACTIONS PACKAGES.....	96
TABLE 9.4 LONG TERM ACTIONS PACKAGES.....	97
TABLE 9.5 POTENTIAL FUNDING BODIES. ....	98
TABLE 9.6 PLANNING DRAFT FOR PIMS IMPLEMENTATION. ....	100
TABLE 9.7 PROJECT EXAMPLES DEALING WITH OTHER CHALLENGES RELATED TO BENIN’S COASTAL ZONE. ....	104

## Acronyms

---

ABE	Benin Environmental Agency
ABeGIEF	Beninese Agency for the Integrated Management of Border Areas
DG-Eau	General Direction for Water
MCVDD	Ministry of Agriculture, Livestock and Fishery
MCVDD	Ministry of Quality of Life and Sustainable Development
MEHU	Ministère de L'Environnement de L'Habitat et de L'Urbanisme
MUHA	Ministère de l'Urbanisme, de l'Habitat et de l'Assainissement
WB	World Bank
WACA	West Africa Coastal Areas Management Program
AFR CBP	African Climate Business Plan
IDA	International Association for Development
PIMS	Multisectorial Investmant Plan
ANPC	Agence Nationale de Protection Civile
BPLP	Brigade for Coastal Protection and Anti-Pollution Fight
MCA	Multi-criteria analysis
SDLAO	Schéma Directeur Littoral de l'Afrique de l'Ouest
MOLOA	Mission d'Observation du Littoral Ouest-Africain
SDAL	Schéma Directeur de l'Aménagement du Littoral
EWS	Early-warning system
CC	Climate change
WAEMU	West African Economic and Monetary Union
IUCN	International Union for Conservation of Nature
NGO	Non-governmental organization
PTRP	Projet Touristique de la Route des Pêches
CZ	Coastal zone
LZ	Littoral zone
SPEA	Stakeholder and Political Economy Analysis
FULAM	Front United Against Coastal Erosion
GDP	Gross Domestic Product
PAC	Cotonou Port Authority
UNAPECAB	National Union of Continental and associated fishermen of Benin
UNAPEMAB	National Union of Marine and associated fishermen of Benin
BEES NGO	Benin Environment and Education Society
UN	United Nations
MCA	Millenium Account Challenge
USA	United States of America
EU	European Union
ISDB	Islamic Development Bank
BADEA	Arab Bank for Economic Development in Africa
UAC	Abomey-Calavi University
IRHOB	Institute of Fisheries and Oceanology Researcge
PUGEMU	Emergency Project of Environmental Management in Urban Zone
COP21	21th Conference of Parties

AGETIP	Nationale Agency of Works of Public Interest
AGETUR	National Agency of Urban Works
GIZ	German Corporation for International Cooperation
AFD	French Development Agency Programme Pluriannuel d'appui au secteur de l'Eau et de l'Assainissement
PPEA	
UNDP	United Nations Development Programme
FAO	Food and Agriculture Organization of the United Nations
WHO	World Health Organization
ESI	Environmental Study Impact
CNPGL	National Unit of Protection and Management of the Littoral
OBLM	Beninese Observatory of Littoral and Sea?
NB	national budget
DABC/MCVDD	Direction de l'Aménagement des Berges et des Côtes (MCVDD)
IRD	French Research Institute for Development
OFID	OPEC Fund for International Development
OPEC	Organization of the Petroleum Exporting Countries
FSD	Foundation for Sustainable Development
GEM	Global Environment Facility
NDF	Nordic Development Fund
ADBG	African Development Bank Group
ZTI	Zone of touristic interest
ANDF	Agence Nationale du Domaine et du Foncier
SDAU	Schéma Directeur d'Aménagement et d'Urbanisme
PDU	Plan Directeur d'Urbanisme
MISP	Ministere de l'Intérieur et de la Sécurité Publique
CNPC	Comité National pour la Protection Civil
PDC	Plan de développement communal
APS	Avant-projet sommaire
APD	Avant-projet détaillé

## ***Executive summary***

---

The World Bank's *West Africa Coastal Areas* program has a global aim of reducing coastal risks in Mauritania, Guinea, Ivory Coast, Togo and Benin, taking into account the potential effects of climate change. This program aims to implement strategies sustainably and coherently between the different intervention scales (local and regional scales), in order to ensure long-term improvement of living conditions of all actors in the West African coast.

In order to promote appropriate action for a good coastal zone management in Benin, a multi-sectorial investment plan for coastal risk adaptation towards climate change in Benin was done. The plan presented includes the description of current and future risks, the inventory of capacities and responsibilities of coastal stakeholders, as well as the analysis of the legal framework of Benin's coastal management.

The options presented were indexed, presented and debated in a participative way with the coastal stakeholders. The selected projects for the plan are detailed on different aspects like: cost, stakeholders involved, actions details, temporality, multi-sectorial implications, etc.

At the end of the work, the study concluded that:

(i) Coastal erosion issues are particularly serious on the majority of Benin's coast, compared to other West African countries, and are partially from natural origin, and partially cause by anthropogenic factors,

(ii) There are hot spots which need an urgent attention, even considering implementing temporary measures, waiting for a sustainable solution,

(iii) A clear definition of acceptable risk limits and necessary protection levels is missing in the current legislation (this lack should be filled with the future coastal law and its applications documents),

(iv) The unavailability and the messy space use are in the heart of the long term problem, and the long term solution will require inland development,

(v) Inter-sectorial, inter-institutional and international communication is not enough and causes the coordination lack (hence the effectiveness) between the different actions,

(vi) The knowledge status on coastal dynamics is advances, despite data dispersion,

(vii) There are many ways of combining coastal risk reduction with existing large projects currently being implemented for Benin's development,

(viii) There are win-win opportunities to defend and value the coastal zone.

The investment plan coming from analyses, meetings with stakeholders, participative workshops, documentary analyses, is articulated in 5 strategic axes:

***Axis 1 Local strategies***

Technical and regulatory actions to implement, which target directly coastal risk reduction.

***Axis 2 Legal and institutional framework reinforcement***

Legal and institutional framework adaptation, to coordinate and protect coastal zone value.

***Axis 3 Adaptation and protection strategies maintenance***

Tools implementation in order to ensure continuity of actions taken along the coast.

***Axis 4 Knowledge and communication reinforcement***

Development of the supervision and the knowledge of mechanisms, which determine coastal dynamic.

Information sharing development and reinforcement between different stakeholders (public, private, etc.), at different scales.

**Axis 5 Regional collaboration reinforcement**

Regional scale collaboration promotion allowing coordinated and more ambitious actions.

Local strategies (Axis 1) take into account important sediment refilling measures to treat the most sensitive Benin areas, and which aim to compensate sediment lack (generated by different obstacles along the coast), as well as occupation measures, good land use and planning, which aim to both strengthen soils and to reduce occupation in risk zones.

The other axes (Axes 2 to 5) aim to develop coastal integrated management, regarding improvement ideas described earlier. The legal aspect, focused on the coastal law implementation, in project since 2001, is one of the most important actions of this plan, as well as the monitoring and maintenance improvement of the coastal zone. They open the door to a valuation of the coastal zones through social, economic and natural components.

The different measures are then divided in three packages, following a logical prioritization. The first package addresses emergency actions, mainly focused on hot spots treatment, and on legal and institutional improvements. The second package has measures to implement in the short term, in order to do the necessary works all along the coast, and to allow coastal zone management structures to be effective and operational. Finally, the third package also has important measures, but they don't need to be started on the very short term, and which may be adapted depending on the evolution of the coastal zone. The packages different costs are showed in the following table. It is an order of magnitude calculated from the sum of cost estimates of all proposed and selected measures.

	<b>Package 1</b>	<b>Package 2</b>	<b>Package 3</b>
<i>Initial cost</i>	<b>20.1 billion FCFA</b> (33.5 million €)	<b>17.6 billion FCFA</b> (26.8 million €)	<b>52.5 billion FCFA</b> (79.8 million €)
<i>Maintenance cost per year</i>			<b>3.8 billion FCFA/an</b> (5.8 million €/year)

The WACA program action plan has the possibility to set up a coastal risk adaptation mechanism, combining technical protections, rational use of space and good management. Because knowledge is not sufficient enough for now to determine for sure climate change impacts and coastal planning, it is essential to manage in an adaptive way the coastal zone. The proposed plan participates in this coastal zone adaptive management as it requires the combination of coastal system strategic vision, planning, implementation, monitoring and data collection in an iterative way. It is about continuously improving policies and management practices, based on operational program results.

In the short term, it is advised to ask external donors in large program frameworks (like the *African Climate Business* of which WACA is part). The large funds available allow to consider innovative strategies on the long term, in respect to strict requirements, in order to have a good long term follow-up. In the long term, it is preferable that coastal zone management as a whole frees from those funding, which would be sign of a strong and stable economy.

This is one of the reasons why the coastal zone development plans (local and national plans) as well as the large economic development projects play an essential role.

To conclude, the proposed projects in this plan will contribute to develop Benin's coastal zone integrated management, in a coherent way internally and with regional scale actions. They are focused on a rational use of land, on non-regret options and on valuation of the coast depending on local potential. This management will be successful and progress if collaboration and communication between the numerous coastal stakeholders is assured, as well as proactivity of responsible institutions and the provision of enough funds and time.

# PART 1 REPORT

---

# 1 Introduction

---

## 1.1 Context of the WACA program

The dynamic coast of the Republic of Benin is 125 kilometers long and highly sensitive to perturbations, both natural and anthropogenic. The Beninese coast is subject to some of the highest erosion rates in the world. The coastline can retreat 12 to 30 meters per year at the most critical locations (DG-Eau, 2015; Norda Stelo & BCI, 2016). Additionally, the coastal zone, like the rest of the country, is sensitive to floods that sometimes cause extensive damage (e.g. August 2010). In extreme cases, the current river-to-ocean is reversed, further exacerbating the situation.

As in most of western African countries, the economic, rural and urban activities of Benin are concentrated in the coastal zone. About 1.8 million inhabitants live within the *stricto sensu* coastal area, or about 18% of the total population (RGPH4, 2013). The cities of Cotonou, Abomey-Calavi and Sèmè-Kpodji contribute 57% and 33% of the urban and national GDP, respectively (INTA, 2010). The concentration of these activities close to the coast increases the exposure.

The dense population and economic activities in the Benin coastal zone generate an important pressure, which will only increase in the coming decades. In addition to the existing risks of coastal erosion and flooding, the coast is subject to additional pressure of climate change. In particular, sea level rise (about 3 millimeters per year according to the most optimistic scenario) and the increase in frequency of extreme events will increase the erosive capacity of the ocean (accelerating the loss of land), and the extent and the frequency of flooding, etc.

In 2010, the IUCN conducted a regional study of the shoreline from Mauritania to Benin and defined a management plan for the West African coastal area, funded by the UEMOA (SDLAO, 2010). The study identified the main axes to follow to adapt to coastal risks (protection and attenuation of impacts, monitoring, preparation, and capacity building) for the whole study area. It also highlighted the extreme severity of erosion in Benin. The study formulated recommendations that the participating States are encouraged to implement among the various sectors concerned by the management of the coastal zone. Furthermore, the MOLOA was created at the end of the validation of the SDLAO study to incorporate the recent evolution of the coastline and corresponding risks. This "Report 2015-2016 of the West African littoral/update of the SDLAO" will be completed in March 2017.

In addition to the threats in the coastal zone, opportunities can also be identified. Some important infrastructural, port and touristic projects (at various stages of completion) are currently being implemented along the coast. The aspects of coastal risks and protection/adaptation measures must be taken into account in the implementation of these projects. The choice of an adequate strategy can significantly promote the valuation of a segment of the coastal zone. Solutions exist to make valorization and adaptation projects to work together in a beneficial way.

In 2014, within the framework of the *African Climate Business Plan* (AFR CBP), the World Bank launched the West Africa Coastal Areas Program (WACA) at the COP21 of Paris. The goal of this program is to help West African countries increase resilience to coastal risks and consequences of climate change. More precisely, the African Climate Business Plan aims to do the following by 2023 (AFR CBP, 2015):

- Decrease the erosion rate by 30% at the most critical spots,
- Decrease the flood risks by 30% of the population living in flood prone areas,
- Set up monitoring systems on coastal information to inform decision-making.

The WACA program consists of several phases. The first phase provides technical assistance to the participating countries in developing multi-sectoral investment plans to address the current and future issues. Later phases will involve advisory services and analytics, the conceptual design for a series of projects, and the project tendering process (Figure 1.1).

This document is part of the technical assistance program for the Republic of Benin. It aims to serve as a guideline for the future funding of adaptation and mitigation projects. It is funded by the

*Gesellschaft für Internationale Zusammenarbeit* (GIZ), in parallel with other studies funded by the *Nordic Development Fund* (NDF):

- Regional long-shore sediment transport study (Deltares, on-going),
- Stakeholder, policy, and economic analysis (Aninver Infra PPP), and
- Communication and awareness

The results of these studies are integrated in this investment plan.



**Figure 1.1 Context of the WACA program and of the investment plan.**

## 1.2 Objectives of the Investment Plan

The Multi-Sectoral Investment Plan (MSIP) for adaptation to coastal risks induced by climate change in Benin is one of the tools set up in the framework of the program of technical assistance of WACA, and is financed by GIZ. The World Bank has contracted Antea Belgium to develop this plan. The plan was developed from August to December 2016 and has been supported by three missions in Benin. During these missions, the project team met with stakeholders to collect necessary and relevant information and to validate the methodology and results. The study has been guided and commented by the members of the Steering Committee and the Ministry of Quality of Life and Sustainable Development (*Ministère du Cadre de Vie et du Développement Durable – MCVDD*).

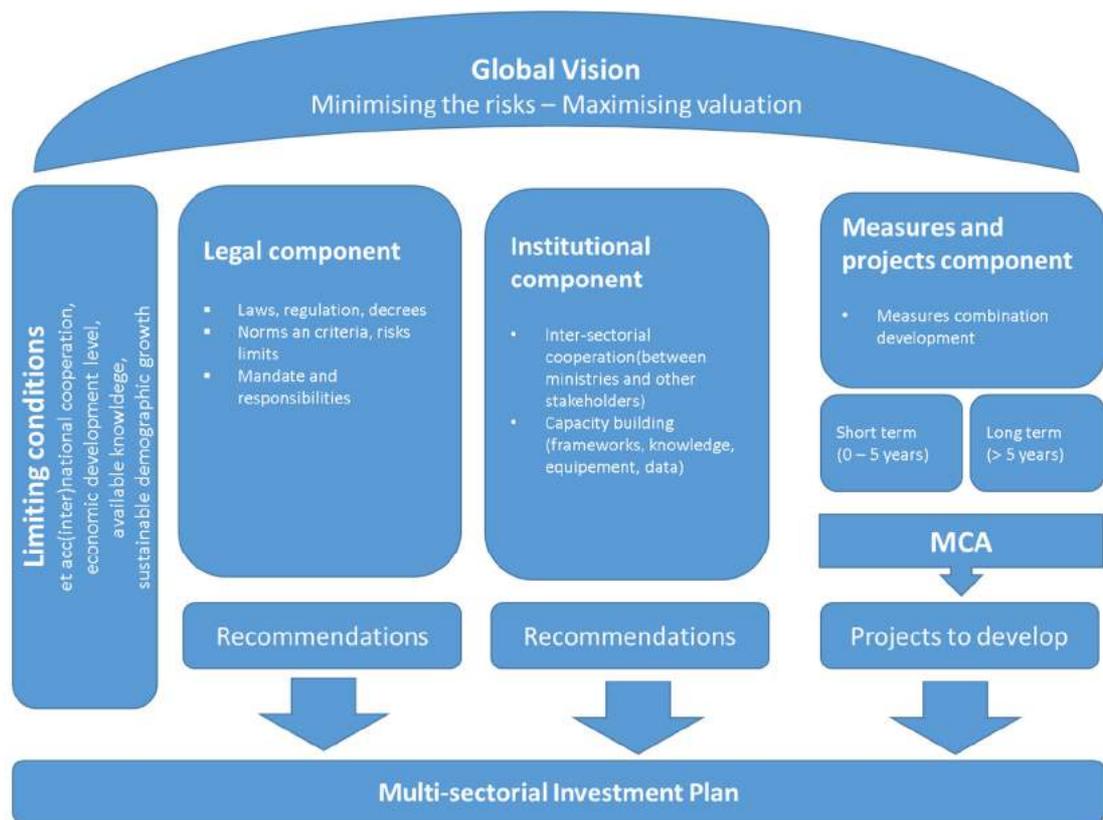
The objective of the plan is to present recommendations and guidelines for coherent management of the Beninese coast, both spatially (local, national and regional scales) and temporally (short-term, no regret actions of protection, and long-term actions to mitigate the negative impacts of climate change). To achieve this, this objectives of the plan are to:

- Synthesize the current and future coastal risks (hazard, vulnerability, exposition) and, with the support of the other WACA studies, identify and assess the existing adaptation projects as well as other potential solutions,
- Propose a strategic plan to implement a series of projects (technical and non-technical in nature) within a common vision,
- Present technical, juridical and institutional recommendations needed for coherent management of the coastal zone.

The multi-sectoral aspect is fundamental in this study because, beyond the protection of land, the resilience of the whole coastal communities must be improved. The coastal risks and the on-going or planned measures have impacts on various sectors. Ideally, any proposed measure will have a positive impact on one or several sectors and, at worst, a neutral impact on all others.

## 1.3 Elaboration of the plan

The plan has been elaborated with, as two main objectives, to reduce the coastal risks and to promote the valorization of the coastal zone. Figure 1.2 presents an overview of this study, which accounts for limiting factors (boundary conditions) that are essential to the development and implementation of a long-term strategy. The study is built around three components: legal, institutional, and measures/projects.



**Figure 1.2 Global vision of the study leading to the MSIP.**

The measures/projects component concerns the assessment of the on-going and potential projects, over two timescales: short-term (0 – 5 years) and long-term (> 5 years). This assessment is performed via a multi-criteria analysis (MCA) whose goal is to select the most appropriate projects to meet the two main objectives. Then, the selected projects are analyzed more deeply to identify the impacts on various sectors, cost estimates, schedules, technical needs, legal/institutional needs, maintenance and monitoring needs, etc.

The analysis of juridical and institutional frameworks leads to recommendations. The aim is to improve the performance of the existing tools of institutional authorities at various scales to combine their efforts in coastal zone management.

The selected projects and the recommendations form the so-called Multi-Sectorial Investment Plan. The plan is summarized in a table on page **Fout! Bladwijzer niet gedefinieerd..**

## 1.4 Structure of the report

The structure of the report is as follows: The present chapter (Chapter 1) presents the context of the study and its main objectives.

Chapter 2 describes the methodology applied to develop the plan, including literature review, bilateral interviews, definition of the objectives and criteria, multi-criteria analysis, and the writing of the plan.

Chapter 3 describes the geographic limits and the existing conditions of the Beninese coast. The description is organized into four coastal areas, each of which is later individually addressed in the next chapters.

A detailed description of the coastal risks in Benin is given in Chapter 4.

Chapter 5 concerns the analysis of the institutional framework and the stakeholders involved.

The juridical and regulatory aspects are addressed in Chapter 6. It describes the existing regulatory and policy environment and identifies missing or contradictory laws and policies.

Chapter 7 presents, by zone and theme, the completed and on-going projects addressing (sometimes partially) coastal risks. At the end of Chapter 7, a series of potential projects are proposed for each zone and for the whole coast. The proposed projects were subject to review during a participatory workshop (October 2016). The most appropriate projects are assessed and detailed to integrate them into the plan.

The detailed plan is developed in Chapter 8 and summarized in a table on page 89.

The conclusions about various aspects (funding, responsibilities, temporal aspects, other related risks and limiting conditions) are discussed in Chapter 9.

## 2 Methodology

---

### 2.1 Introduction

This chapter describes the methodology used to develop the Multi-Sectoral Investment Plan.

First, an inventory of ongoing, planned, and proposed projects was developed (complete list in Chapter 7). The projects were subject to review during a stakeholder workshop (25<sup>th</sup> and 26<sup>th</sup> October 2016). The aim of that workshop was to invite stakeholder input to the potential projects. These options were then assessed using a multi-criteria analysis based on criteria and indicators set up during another technical and participative workshop (15<sup>th</sup> September 2016).

After the MCA, the most appropriate projects were selected. The selected projects were then further analyzed and detailed. The other studies conducted in parallel by the WACA Benin program were considered during this last step. The plan consists of the results of this analysis. It was then subject to review by the members of the Steering Committee. Their feedback was integrated into the final version of the study, presented to the stakeholders during a final National Workshop (30<sup>th</sup> and 31<sup>st</sup> January 2017).

### 2.2 Schematic workflow

The study was conducted from August 2016 to January 2017 in three main phases:

- First phase:
  - Collecting information about existing coastal risks,
  - Collecting information about completed, ongoing, planned, and potential projects,
  - Assessing the global need to reduce the risks (site visits),
  - Elaborating the MCA methodology;
- Second phase:
  - Validating/improving the proposed projects during a workshop,
  - Assessing the comparable projects using an MCA,
  - Defining a global strategy for the whole coastline;
- Third phase:
  - Developing the global strategy based on the selected options:
    - Detailed description of the measures,
    - Multi-sectoral implications,
    - Legal and institutional needs,
    - Budget and timing needs;
  - Validation of the global strategy during a national workshop.

During the first mission (6<sup>th</sup> to 16<sup>th</sup> September 2016), the project team met several important coastal zone stakeholders. These interviews focused on the involvement, roles and responsibilities of the stakeholders, the current stress on the coastline and the issues at stake, and to collect official and otherwise undocumented information on the ongoing and planned coastal projects. The methodology was presented to the stakeholders during a first, technical workshop (15<sup>th</sup> September 2016).

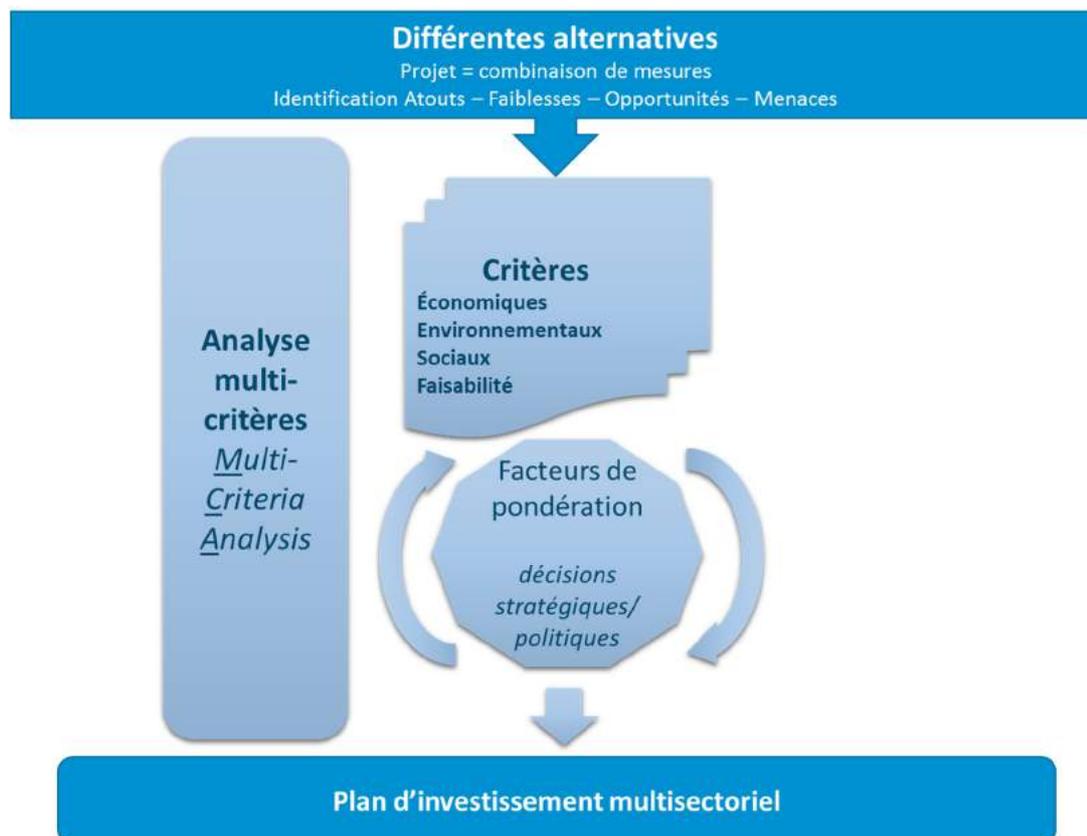
The first mission and the literature review resulted in a provisionary report delivered in French on October 10<sup>th</sup> 2016. The report and the proposed projects within were reviewed and validated during a second workshop (25<sup>th</sup> and 26<sup>th</sup> October 2016).

A final draft version of the report was delivered on November 28<sup>th</sup> 2016. The comments from the Steering Committee and World Bank were compiled and addressed in provisionary second version dated December 23<sup>d</sup> 2016. The results of recent studies conducted for the WACA Benin programme were compiled into a final version of the report, validated by a national workshop on 30<sup>th</sup> and 31<sup>st</sup> January 2017.

## 2.3 Multi-criteria analysis

### 2.3.1 Basics of a multi-criteria analysis

A multi-criteria analysis is a tool used to compare several alternatives based on qualitative and/or quantitative indicators. Indicators are thus set up to assess the performance of a certain project on various aspects of a criterion. The analysis ranks options and highlights the preferable option(s) for addressing a given issue. Figure 2.1 illustrates how the MCA is used in this study.



**Figure 2.1 Use of the MCA in the conception of the MSIP.**

A weighting factor is assigned to each indicator. These factors fix the importance of the indicators relative to each other. The determination of the weighting factors of the various indicators and criteria is subjective and reflects the opinions of the decision-makers.

As a first step, a list of criteria and indicators is set up. A (qualitative or quantitative) scale is defined for each indicator (qualitative example:  $-1$  corresponds to a very negative impact,  $0$  to a neutral impact and  $+1$  to a very positive impact). Then, each project is assessed: a score is given per project for each indicator.

The projects can then be compared criterion by criterion, which allows for better interpretation of the results (for instance: a project can score best in the general ranking while scoring very poorly for an essential criterion).

The weighting factors for the various criteria and indicators can be refined to reflect the strategic choices or to impose particular restrictions (for instance, imposing that the projects may not have a negative impact on the social criterion). An 'ideal' project is generally robust to modifications applied to weighting factor.

### 2.3.2 Determination of the criteria

The seven main criteria on which the MCA is based are chosen for their pertinence in the framework of the management of coastal risks. These are:

- Social: concerns the number of inhabitants and social structures (schools, hospitals, cultural sites, religious sites, etc.),
- Economic: positive or negative impact on the various economic sectors (agriculture, livestock, fishery, industry, tourism),
- Infrastructural: positive or negative impact on the various transportation sectors (port, airport, road and rail networks) and on public facilities (water distribution, electricity distribution, etc.),
- Environmental: positive or negative impact on natural marine and terrestrial areas,
- Impact on the other areas within the coastal zone,
- Costs: initial investment costs and maintenance costs over the long term,
- Feasibility: regarding technical and juridical complexity, international consequences, adaptability ('no-regret'), implementation time, efficiency against erosion and social acceptance.

An initial list of indicators per criterion was submitted for stakeholder review. It was then adapted to reflect their feedback. The final list of indicators is given in Table 2.1.

**Table 2.1 List of indicators per criterion for the MCA.**

<b>Social impact</b>	<b>Impact on the other areas within the coastal zone</b>
Number of people affected	Impact on the other areas within the coastal zone
Number of social structures affected	
	<b>Costs</b>
	Initial investment
	Maintenance/monitoring
	<b>Feasibility</b>
	Technical complexity (incl. source of sediments, likelihood of success)
	Legal complexity
	International political consequences
	Adaptability (no regret)
	Implementation time
	Efficacy against erosion
	Social acceptance
<b>Economic impact</b>	
Value agricultural sector	
Value livestock sector	
Value fishery sector	
Value industrial sector	
Value touristic sector	
<b>Infrastructure impact</b>	
Road and railway networks	
Port and airport	
Public services	
<b>Environmental impact</b>	
Impact on marine natural areas	
Impact on terrestrial natural areas	

The choice of weighting factors between the various criteria is a strategic choice that must be made by the decision-makers. For this study, the seven criteria are given equal weighting factors.

## **2.4 Elaborating the MSIP**

After validating the most appropriate projects along the coastline, the detailed context, objectives and components of these projects are described, including the maintenance needs.

### **2.4.1 Details of the selected projects**

The cost estimates of the projects are estimated based on previous project proposals in Benin or similar projects in other countries, if the information is available. These budgets include the estimated cost of relocation/retreat of installations and by maintenance activities over 30 years.

It is important to note that the investment plan presented here contains a series of recommended actions, some of which still require environmental and social impact studies, detailed technical and economic feasibility studies. It is understood that the implementation of certain actions can only be envisaged once all the necessary studies have confirmed the relevance of these.

The project implementation steps are drafted and the most urgent projects are distinguished based on the current state of the physical conditions and the legal and regulatory framework.

#### **2.4.2 *Institutional and organizational recommendations***

Improvements regarding the institutional and organizational framework are proposed. These are necessary and/or recommended measures to increase the chances of success of the proposed plan.

The institutional and organizational recommendations can be significant and require adaptations, transfer of mandates, laws and regulations. These recommendations are extracted from the analysis of the institutional and legal framework of Chapters 0 and 6. They are incorporated into the plan as separate measures.

#### **2.4.3 *Validation of the proposed plan***

The draft MSIP was reviewed by members of the Steering Committee. This report also includes additional information about potential funding sources. After including the feedback from the Steering Committee and the World Bank, the final MSIP was then presented and validated during a national workshop on 30<sup>th</sup> 31<sup>st</sup> January 2017.

#### **2.4.4 *Bundling actions in packages***

Finally, the investment plan's final version integrates recommendations taken from the validation workshop. Between others, the plan is adapted depending on the most recent developments of some projects and measures, and the actions and projects are distributed in different packages, which distinguish priority actions from all the plan's projects.

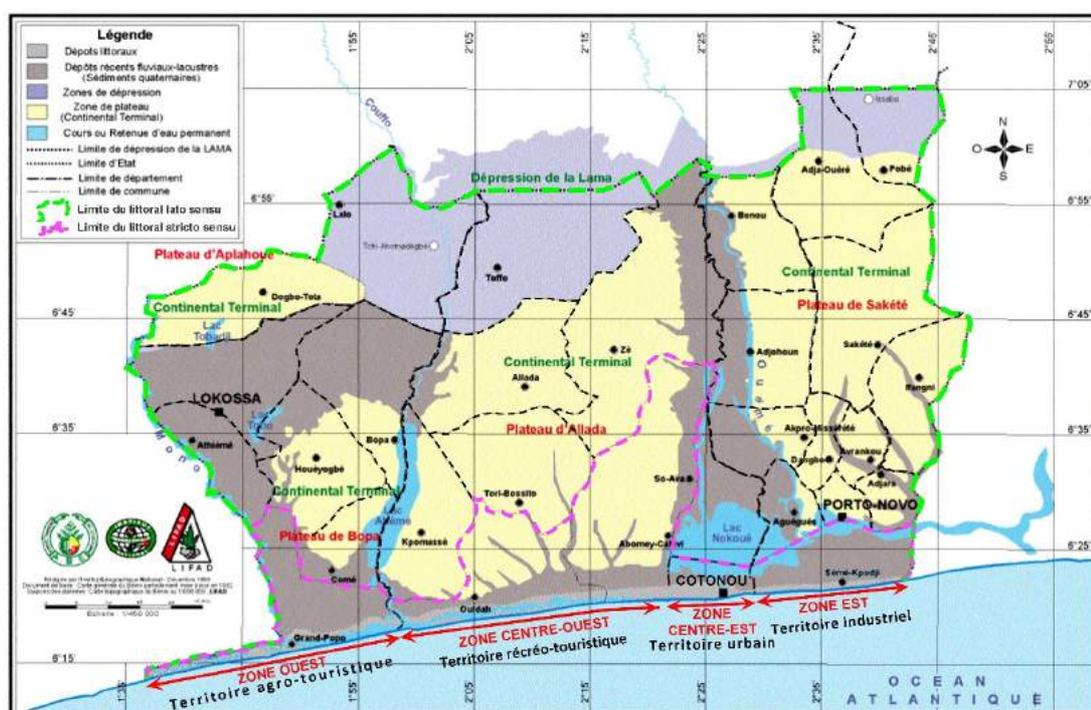
### 3 Context

This chapter presents the study area and describes its biophysical and socio-economic characteristics.

#### 3.1 Delineation of the study area

The administrative coastal zone *sensus lato*, also called South-Benin region, is found between 6°10' and 6°40' North and 1°40' and 2°45' East (ABE, 2001). It covers 30 administrative districts and spreads over 8,692 km<sup>2</sup> (7.7% of the national territory). It includes the southern part of the plateaus of the coastal sedimentary basin and the margino-littoral area.

The coastal zone *sensus stricto* includes five coastal cities: Sèmè-Kpodji, Cotonou, Abomey-Calavi, Ouidah and Grand-Popo (Figure 3.1). It has been divided into four zones, as described in the original master plan of coastal zone management ("*Schéma d'aménagement directeur du Littoral – SDAL*", see ABE, 2004 and Figure 3.1): East, Center East, Center West and West. The descriptions of their geographic limits are given in Table 3.1.



**Figure 3.1** The coastal zone *sensus lato* and the delineation of the coastal zone *sensus stricto* into four geographic zones.

This study focuses on these five cities and four coastal zones *sensus stricto*. Nevertheless, for long-term horizons (more than 5 years), the study will propose adaptation, preventive measures in the study area that consider the entire coastal zone *sensus lato*.

**Table 3.1** Zoning of the Beninese littoral according to the choice of land use (from ABE, 2004).

Zone	Eastern limit	Western limit	Area	Municipalities	Land use
West	E 01°58'	E 01°45'	133 km <sup>2</sup>	Grand-Popo	agro-touristic
	Chenal de l'Aho	Border with Togo			

Zone	Eastern limit	Western limit	Area	Municipalities	Land use
<b>Center West</b>	E 02°18'	E 01°58'	144 km <sup>2</sup>	Abomey-Calavi	recreational and touristic
	Fidjrossè	Chenal de l'Aho		Ouidah	
<b>Center East</b>	E 02°33'	E 02°18'	137 km <sup>2</sup>	Cotonou	urban
	Djeffa Plage	Fidjrossè			
<b>East</b>	E 02°43'	E 02°33'	116 km <sup>2</sup>	Sèmè	industrial
	Border with Nigeria	Chenal de Totchè			

## 3.2 General description

The following section contains a general description of the natural and socio-economic characteristics of the coastal zone. A description is given per city in Appendix 3.

### 3.2.1 Geology, geomorphology and pedology

#### 3.2.1.1 Geologic and geomorphological context

The coastal zone contains the coastal plain and southern plateaus.

The coastal plain is composed of three generations of sandy units, recent or originating from the marine oscillations of the Late Quaternary (Lang et al. 1988; Laïbi, 2011): yellow sandy intern units, grey sandy median units and current and subactual brown-grey sandy units.

The area of southern plateaus consists of three « terre de barre » soil plateaus isolated by erosion and tectonic uplift, including the plateaus of Sakété, Allada and Comè (Figure 3.2). This area is bounded to the north by a median depression WSW-ENE called “depression of the Lama”. Off the coast, the Beninese continental shelf covers about 2800 km<sup>2</sup> between isobaths 10 m and 100 m (Crosnier et Berrit, 1963). It has a trapezoidal shape and is about 125 km long. Its width varies between 22 and 24 km in the west, up to Ouidah, and reaches about 32 km at the eastern border with Nigeria.

#### 3.2.1.2 Pedology

The soils of the coastal zone are poorly developed soils. In between the leached substrate without concretions and the littoral units, lies a soil complex consisting of (1) ochre-yellow, temporarily saturated sediments, and (2) grey or ochre waterlogged material of the freshwater and salt marshes.

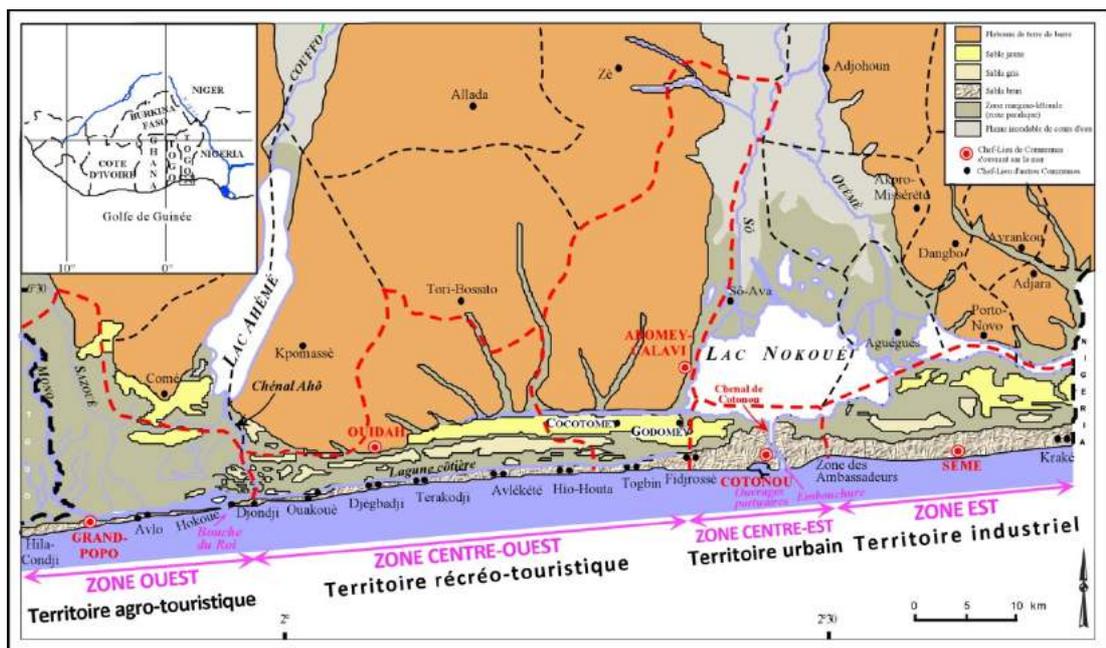


Figure 3.2 Geological map of the Benin coastal zone.

### 3.2.2 Hydrology

The hydrographic network of the Beninese coastal zone is quite dense and forms a wetland (Figure 3.2). It is characterized by a series of lagoons and marshy depressions connected with the Atlantic Ocean by two main passages, which are the natural mouths of major rivers (Ouémé-So, Mono-Couffo). This hydrologic network forms two estuarine systems: the estuary of the Mono (or western estuary) and the estuary of the Ouémé (or eastern estuary).

Mono estuary: it comprises a narrow lagoon, elongated parallel to the coast, called *coastal lagoon*, and another, further inland, *lake Ahémé*. Additionally, dead-lagoons are also present. The western estuarine system is interconnected with the sea via a narrow mouth (100 to 300m wide), which is mobile. This mouth is called the *Bouche du Roi*.

Ouémé estuary: Like the Mono estuary, the eastern estuary also comprises a narrow lagoon, elongated parallel to the coast, called lagoon of Porto-Novo, and another lagoon further inland, forming *lake Nokoué*. Additionally, dead-lagoons are also present. The overall system is interconnected with the sea through a tidal passage called *Channel of Cotonou (Chenal de Cotonou)*, which was mechanically opened in 1885 and is now more than 200 m wide.

### 3.2.3 Biodiversity

#### 3.2.3.1 Flora and green landscapes

The flora of the Beninese coastal zone is typical of the green landscape of the Dahomey-Gap: determined by savannah formations alternating with forest blocks of guineo-camerouno-congolaise to the east and of guinean type to the west. Several authors, such as Mondjannagni (1969), Paradis (1980), Akoègninou (1984, 2004, 2006), Adjakidjè (1984), Tossou (2002), and Agassounon (2002) have studied the vegetation of southern Benin. According to them, the vegetation of the Beninese coastal zone essentially consists of hydromorphic formations, whose evolution depends on hydroclimatic and pedologic conditions present in the two estuarine systems described above. Therefore, there is significant contrast between West and East; each of the two estuarine systems is characterized by its own forest formation, to which some degraded forms of substitution are associated. The climax of the western estuarine is a forest formation of mangroves, which reflects the high salinity of the soil. It is primarily composed of *Rhizophora racemosa* and *Avicennia germinans*. The climactic formation

associated with the eastern system is a marshy forest composed of *Symphonia globulifera*, *Mitragyna ciliata*, *Alstonia congensis* and *Ficus congensis*. This plant community is evidence of the persistent influence of fresh water.

### 3.2.3.2 Fauna

Three types of species contribute to the functioning of the coastal ecosystems: aquatic fauna, terrestrial fauna, and avian fauna.

#### Aquatic fauna

##### *Lagoon species*

The lagoon species include fish and shellfish living in the waters and wetlands. The cichlids *Sarotherodon melanotheron* and *Tilapia guineensis* are the most important ones. The most abundant shellfish species in the lagoon is the shrimp (*Penaeus duorarum*). The blue crab (*Callinectes latimanus*) is abundant during periods of high salinity in the lagoon. The patriot crab (*Cardiosoma armatum*) can be found all year long at the interface between water and ground. Finally, oysters *Cassostrea gasar* are present in brackish water and in mangrove roots. These have a high commercial value.

##### *Marine and coastal species*

The threatened marine and coastal species are:

##### Whales

Whales, primarily Jubarte (*Megaptera novaeangliae*), have been observed very recently on the continental shelf at depths varying between 27 and 600m, with an exceptional sighting between depths of 13 and 35m (MEPN, 2007). Dolphins (*Tursiops truncatus*) have been observed 31 m deep.

##### African manatees

The African manatee is common along the coast of Benin, especially in the eastern and western wetlands (Ramsar sites 1017 and 1018). It is severely threatened for therapeutic, food supply, and commercial reasons. In the Lower Ouémé Valley, the population is only about 50 individuals between Dasso and Porto-Novo, where they find shelter in burrows and in calm branches of the Ouémé River. A few still inhabit the Lower Ouémé Valley between Agbannakin and Hêvê.

##### Sea turtles

Four species of turtles are present along the Beninese coast, according to the NGO Nature Tropicale: the olive ridley sea turtle (*Lepidochelis olivacea*), the leatherback sea turtle (*Dermochelys coriacea*), the green sea turtle (*Chelonia mydas*) and the hawksbill sea turtle (*Reitmochelys imbricata*). This NGO contributes to the preservation of these species by setting up local committees of eco-guards and fenced off breeding areas. Two families of turtles are often caught in fishing nets along the Beninese coast: *Chelonidae* and *Dermochelidae*. Turtle capture is forbidden in Benin, as in most countries along the Gulf of Guinea.

#### Terrestrial fauna

The terrestrial fauna is composed of both mammals and reptiles. The most common reptile is the ball python (*Python regius*), called "Dangbé" by the locals. It is protected because of its cultural value as a "totem snake". It is harmless. Other species that can be found include the African rock python (*Python de sebae*), which can reach 7 meters long, the viper (Djakpata) *Causus sp.*, also called "naja" or "xlibo" and very dangerous because of its neurotoxic venom, the Nile monitor (*Varanus niloticus*), the Nile crocodile (*Crocodylus niloticus*), and some colubrid snakes (*Psammophis sp.*).

Various mammals can be found in the wetland ecosystems of the Benin coast, including cane rats (*Tryonomys swinderianus*), also called "agouti", hedgesogs, striped ground squirrels, also called "rat palmiste" (in French), monkeys, vervet monkeys (*Cercopithecus aethiops*, seen in Togbin and Adjaha), and river pigs (*Potamocheirus porcus*) that existed in the area of Adjaha. The wildcat (*Felis silvestris*) can be observed in the villages of Togbin and Adounko. The hippopotamus (*Hippopotamus amphius*) can be observed along the Mono River.

#### Avian fauna

According to the work of Adjakpa *et al.* (1996), 168 bird species have been identified in the wetlands of South Benin. The coastal lagoons are home to about 160 species, due to the mangrove habitat and the expansive mudflats that serve as nesting and foraging sites.

In conclusion, the coastal zone is home to various fragile and threatened species. Protected species and avian fauna are subject to anthropogenic pressures such as poaching, habitat destruction, bird eggs collection, etc.

### **3.2.4 Climate**

#### **3.2.4.1 Existing climate**

##### **Rainfall**

The climate of the Beninese coastal zone is sub-equatorial humid, mostly influenced by the Atlantic Ocean. It is characterized by four naturally alternating seasons of unequal duration:

- One long rainy season from April to July, starting with storms and humid winds blowing from South-West. Humidity is very high;
- One short dry season starting in August. Humidity is still;
- One short rainy season starts due to the wind reduction, south to the eighth parallel and to the weakening of Beninese currents, between September and November. Humidity is high;
- One long dry season from December to March, characterized by breeze and by the Harmattan wind from the Libyan anticyclone. Wind is weak and humidity is relatively low.

The study of inter-annual variability of precipitation for the period 1951-2010 has revealed that in South Benin, the most important rainfall shortage events were recorded in 1977 and 1983 (drought years), while the most important rainfall surplus events, corresponding to flood years, occurred in 1988, 1997 and 2010 (DCN, 2011). Some anomalies can occur at a seasonal scale, like a high concentration of rainfall over a short period followed an abrupt interruption while still in the middle of a rainy season.

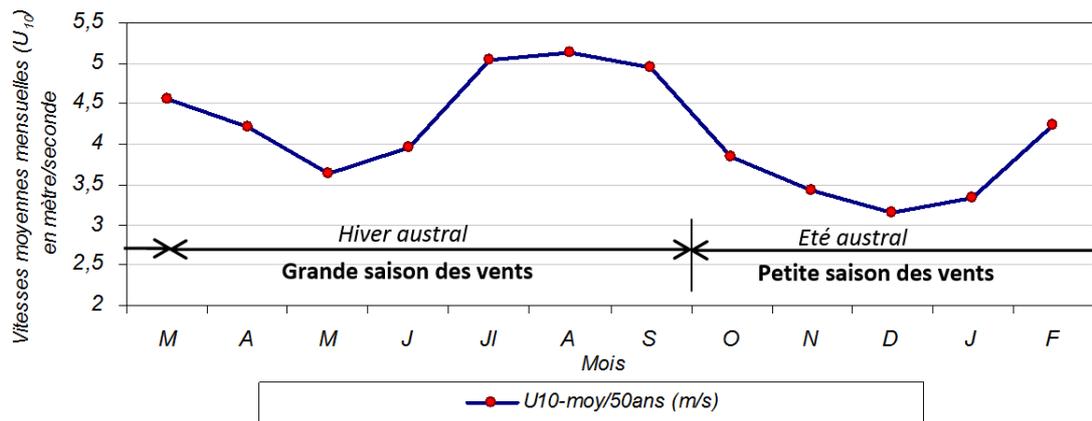
Rainfall follows a regular decreasing gradient from West to East (1500 mm/year in Sèmè, 1300 mm/year in Cotonou, 1100 mm/year in Ouidah and 900 mm/year in Grand-Popo). Furthermore, the coasts of Benin and Togo are abnormally dry (800-1500 mm/year; Toffi, 2008), which explains the absence of dense forests at these latitudes, in contrast with Ivory Coast and Nigeria, located at the same latitudes (Dahomey-gap).

##### **Temperature**

The annual average temperature is around 27°C. Although temperature variations depend on the duration of sunshine and on maritime influence, they are rather weak in the coastal zone. The evolution of the observed average annual temperature from 1961 to 2010 does not show a clear increasing or decreasing trend, though deviations range from -0.6°C to +0.8°C (DCN, 2011). Evapotranspiration varies from 3.33 mm/day in July to 5.33 mm/day in February, with an annual average of 4.24 mm/day. The annual sunshine duration is approximately 1700 hours.

##### **Wind regime**

Winds blowing on the Beninese coast generally come from South-West. These winds determine two seasons, depending on their directions and speeds (Laïbi, 2011): one long windy season, during which wind speed is rather high (average minima around 3.6 m/s in May, average maxima around 5.12 m/s in August), then one short wind season during which wind speed is lower (average minima around 3.15 m/s in December, average maxima around 4.55 m/s in March, see Figure 3.3).



**Figure 3.3 Annual variation of month-averaged wind speed along the Beninese littoral, in Cotonou (average over 50 years from 1955 to 2005).**

### Wave climate

Waves and wind are the two forces acting on the coastline, driving sediment transport and seasonal erosion (natural factors). The analysis of the intra-annual variation of significant wave heights  $H_s$ , averaged over 1958 to 2011, indicates two major wave seasons (DG-Eau, 2015): the first one is characterized by an intense wave regime ( $H_s > 1.3\text{m}$ ) from April to October, and the second one by a moderated wave regime ( $H_s < 1.3\text{ m}$ ) from October to April.

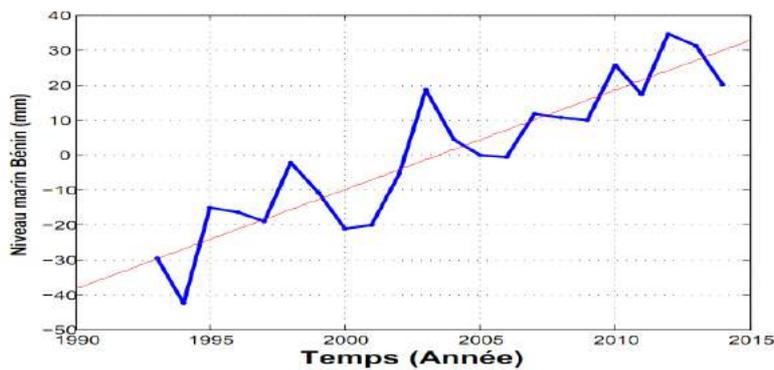
Longshore currents dominate the processes shaping the coast. The incident wave angle varies between  $4^\circ$  and  $9^\circ$ , with an average around  $6^\circ$ - $7^\circ$  (Rossi, 1989). The dominant current direction is from West to East, with speeds, measured in Cotonou, between 0.3 to 1 m/s (Sitarz, 1960 ; DG-Eau, 2015). This current is responsible for an annual littoral drift of 1.2 to 1.5 million  $\text{m}^3$  of sand along the coast of the Gulf of Guinea (Sitarz, 1960; Nedeco, 1975; Lackner, 1983 et LCHF, 1984).

#### 3.2.4.2 Current climatic and meteo-marine trends

On an annual scale, the analysis of the current climate does not show any significant trends in rainfall, temperature or wind, though the seasonal analysis does show fluctuations since 1971 (DCN, 2011). Between 1971 to now, 2010 was the most extreme year in terms of recorded human losses (about fifty) due to severe floods that have affected 55 of the 77 municipalities of Benin.

The sea level has a clear increasing trend, according to a study made over 22 years of daily water level data (DG-Eau, 2015). This increase is 25, 45 and 31 mm respectively in 2010, 2012, and 2013 (Figure 3.4). However, the short measurement period makes it difficult to isolate the effect of sea level rise from other long-term sea level fluctuations. Assuming the observed trend can be attributed to sea level rise, a sea level rise of  $2.8 \pm 0.01\text{ mm/year}$  has been observed along Benin, which is in line with the value reported by the IPCC ( $3\text{ mm/year}$  for the global ocean).

Analysis of the world atmosphere and of the surface conditions also show a slight increasing trend in the extreme values of wave height and wind speed (DG-Eau, 2015). The return periods from 2 to 100 years are presented in Table 3.2 for the extreme values of significant heights and wind speeds (DG-Water, 2015).



**Figure 3.4 Inter-annual variability of the average sea level computed from the height data offshore Benin (DG-Eau, 2015).**

**Table 3.2 Extreme wind speed and significant wave heights with their corresponding return periods (DG-Eau, 2015).**

Return period	Wind speed (m.s <sup>-1</sup> )	Estimated Hs (m)
2 years	15.90	2.25
5 years	17.02	2.45
10 years	17.94	2.57
20 years	18.25	2.65
30 years	18.96	2.75
50 years	19.50	2.81
100 years	20.05	3.00

Since 2013, the long windy season (March to September, Figure 3.3) is subject to more and more extreme events of storm surges. A few significant surge events have been recorded since 2013; one between May 31<sup>st</sup> and June 1<sup>st</sup> 2013, and one between June 12<sup>th</sup> and 14<sup>th</sup> 2013. These were regional surges (from Ivory Coast to Benin). Wave events have caused damages on the beaches of Hillacondji (zone West) and Akpakpa (zone Center East). In Hillacondji the beach was submerged, and more than 500 fishing shelters were destroyed, leaving more than 800 people homeless and washing away infrastructures and porcs; in Akpakpa, ships were beached.

On September 7<sup>th</sup> 2016, a surge was also recorded in the area of Akpakpa and caused damages up to 300m inland.

### 3.2.4.3 Climatic and oceanographic projections

Rainfall projections indicate that, in South Benin (latitude inferior to 7.5°N), one can expect unchanged pluviometric conditions up to horizon 2100, compared to the reference period 1971-2000 (DCN, 2011). On a seasonal scale, rainfall variations over the period March-April-May, during which farmers prepare the land, would be negligible in South Benin up to horizon 2050. On a monthly scale, a decrease in rainfall could reach 21% up to horizon 2100 during April.

Temperature projections indicate an increase in all regions of Benin up to 2100 (DCN, 2011); the highest increase would be 3.27°C, compared to the reference period 1971-2000, while the smallest increase would be 2.6 °C in the South-Western region. Since the increase in temperature logically induces an increase in potential evapotranspiration, this process could provoke a water shortage under certain conditions.

Based on the climatic scenario established for the future evolution of the coastal zone, sea level could rise and reach as much as 0.81m over the period by 2100 relative to 2000, confirming the IPCC predictions. This rise would directly impact the coastal zone through increased coastal flooding and salt intrusion into watercourses and aquifers. These effects would in turn affect the human facilities, public infrastructures, fishing and other economic activities along the coast, physiochemical characteristics of inland water (Ouémé and Mono rivers, lake Nokoué, etc.) and the biodiversity of coastal ecosystems.

### 3.2.5 Population

The coastal zone of Benin is home to 60% of the population of Benin, concentrated in 8% of the country's area. The major cities of Cotonou, Porto-Novo, Abomey-Calavi and Ouidah, and key infrastructure like the port, airport, highway, the major hotels, etc. draw more and more people to the coast. These two major trends conflict with the problems of land ownership and coastal erosion.

Table 3.3 shows that the population of the five littoral cities has increased from 497,765 inhabitants in 1979 to 1,720,590 inhabitants in 2013. This corresponds to an average annual increasing rate of 4.5%. Table 3.3 also shows that the municipality of Cotonou has already been saturated since the 1970s. Its growth rate has progressively decreased from 3.76% between 1979 and 1992 to 0.18% between 2002 and 2013. Consequently, the demographic explosion of Cotonou has spread to the cities of Sèmè and Abomey-Calavi, the latter having also reached a saturated level, with a decrease of its growth rate between 2002 and 2013. Ouidah and Grand-Popo, less populated, are now also subject to this demographic frenzy. According to the statistical projections of INSAE, the population is expected to continue growing due to a high fertility rate (4.9 children per woman; RGPH4, 2013). However, the fertility rate is also expected to drop to 2 children per woman by 2050.

The demographic and urban dynamics of the five coastal cities creates a worrying situation. Indeed, within these cities, space for urbanization is mostly composed of low, sandy soil threatened by coastal erosion and flood risks.

**Table 3.3 Population data of the coastal cities and trends (MUHA, 2015).**

	Coastal cites	Sèmè-Kpodji	Cotonou	Abomey-calavi	Ouidah	Grand-Popo	Total
<b>1979</b>	<b>Total</b>	<b>37 220</b>	<b>320 348</b>	<b>60 786</b>	<b>52 584</b>	<b>26 827</b>	<b>497 765</b>
<b>1992</b>	<b>Total</b>	<b>65 016</b>	<b>536 827</b>	<b>126 507</b>	<b>64 433</b>	<b>33 079</b>	<b>825 862</b>
	Rate 1979-1992	4,06%	3,76%	5,37%	1,46%	1,51%	
<b>2002</b>	<b>Total</b>	<b>115 238</b>	<b>665 100</b>	<b>307 745</b>	<b>76 555</b>	<b>40 335</b>	<b>1 204 973</b>
	Men	55 928	323 168	149 663	36 669	19 254	584682
	Women	59 310	341 932	158 082	39 886	21 081	620291
	Rate 1992-2002	5,89%	2,17%	9,30%	1,74%	2,00%	
<b>2013</b>	<b>Total</b>	<b>224 207</b>	<b>678 874</b>	<b>655 965</b>	<b>161544</b>	<b>57 490</b>	<b>1 720 590</b>
	Men	110 144	325284	321 962	78196	28 207	863793
	Women	114 063	353590	334 003	83348	29 283	914287
	Rate 2002-2013	6,09%	0,18%	6,96%	6,86%	3,20%	

### 3.2.6 Economy

The coastal zone is the core of the national economy, because it is home to the main cities, the port and airport infrastructure, and many industries. The main economic activities are agriculture, fishing, salt production, trade, and mining.

### 3.2.6.1 Tourism

Tourism is a major driver of Benin economy in the coastal zone, but is currently developing in an unsustainable way (MEPN, 2007). There are four distinct zones of touristic interest (ZTI): estuaries (Low Mono valley), lakes (lake Ahémé, lake Nokoué), deltas (Low Ouémé valley) and the coastal zone (sandy beaches, coastal lagoons). They correspond to humid ecosystems that contribute to the ecological wealth of the South Benin. They have been protected since 2000 by the Ramsar convention, and divided in two sites: the Ramsar site 1017, comprising the Low Ouémé valley, lake Nokoué and the lagoon of Porto-Novo, and the Ramsar site 1018, corresponding to the wetlands of the Low Couffo valley, the coastal lagoon, the Aho Channel and lake Ahémé.

According to INSAE (2002), 21,935 people are employed in the tourism sector, among which 27% have permanent positions and 74% have seasonal jobs. These numbers do not account for itinerant activities of restoration, that employs up to 13,000 people. Including this informal sector, the total number of jobs rises to 35,000, providing the livelihood of about 206,500 people.

### 3.2.6.2 Agriculture

Agriculture is an important component of the economy in the coastal zone. It consists in slash-and-burn agriculture, with rudimentary tools (hoe, ax, *coupe-coupe*, etc.). Modernization is noticeable due to the recent involvement of traders, retired officials, young unemployed graduates, etc. More than 80% of planted areas are dedicated to corn and cassava plantation. Palm oil, coconut and pineapple are also important crops. Vegetables such as eggplant, melon, onion (*Alium cepa*), tomato (*Lycopersicom esculentum*), pepper (*Capsicum frutescens*), carrot (*Daucus carotta*), and watermelon are also common.

### 3.2.6.3 Salt production

The area of salt marshes in the coastal zone was estimated at more than 83 hectares in 2001 (MEPN, 2007). The municipality of Ouidah is the main exploiter of wetlands for salt production (66% of area). Grand-Popo and Abomey-Calavi also exploit respectively 27% and 6% of the wetland area. Salt extraction is performed by local women using mostly mangrove wood because of its slow combustion, even when not dry (Bamisso, 2006).

### 3.2.6.4 Maritime transportation and port

Maritime traffic data indicate that several ships navigate and/or dock at the port of Cotonou (PAC), including small fishing boats, from rowboats to motorized boats with outboard engine, as well as large vessels. The port traffic reached 5.152 million tons in 2005 before the modernization works in 2008-2010 of the multi-criteria analysis project. The port plays a major role in the economic development of Benin, but data quantifying this role is scarce. The port of Cotonou plays a large role in traffic to/from landlocked West African countries (Mali, Burkina-Faso and Niger).

The construction of a second deep-water port in Sèmè-Kpodji is planned in the coming years.

### 3.2.6.5 Aquaculture

Traditional ponds or fish-catch holes typically seen in the South Benin were once the most common method of fishing. They consist of trenches (*Ahlo's*) or holes (*Whédo's*) dug near water bodies or in river floodplains. The *whédo's* are filled during flood periods and naturally colonized by fish that are trapped there when the flooding recedes. The *Ahlo's* are permanently connected to the watercourse or the waterbody and are filled up by tidal action. The fish production of these techniques is hard to quantify but is estimated at 650 tons per year in some regions (PAZH, 1997).

### 3.2.6.6 Fishery

The fishing sector plays an essential role in both reducing unemployment and providing a source of dietary protein. About 100,000 people live on Lake Nokoué, and fisheries on this lake contribute more than 40% of the animal protein consumed in Benin (Direction des Pêches, 2002). This lake is the largest

waterbody of southern Benin, at 15,000 ha. According to statistics from the *Direction des Pêches*, it provides the most important annual fish production and generates substantial incomes to Tofinu's installed on the lake.

The fisheries of the coastal zone are negatively impacted by the deterioration and pollution of ecological habitats caused by existing fishing techniques, the gillnet, the dragnet, the fish and shrimp trap, the *médokpokonou* net, the *gbodoègo*, etc.

### **3.2.6.7 Industry and sand mining**

The agro-industrial sector comprises oil refineries, soap factories, breweries, textile industries (SOBETEX), glazing industries, food industries and bakeries. The construction industry is also present in the form of cement plants and corrugated sheets manufacturers.

Mining operations consist mainly of sand mining. In 2008, in order to reduce coastal erosion, the Beninese government adopted the N°2008-615 decree forbidding extraction of beach sand and recommending the mining of lagoon sand instead. Since March 2009, incentives from the government (tax exemptions) have assisted development of sand mines in the Abomey-Calavi, Cotonou, Sèmè and Porto-Novo wetlands.

## 4 Coastal risks in Benin

---

Several definitions of risk exist in the literature. In this document, the definition used is taken directly from SDLAO (2010): the idea of *risk* can be expressed as the combination of *hazard*, *vulnerability* and *exposure*. *Hazard* is the physical, natural, cause at the origin of the risk (meteorological event, seismic event, etc.). Hazard does not fully define the risk. However, when it occurs in an area where *exposure* is high (for instance, a densely populated area) and where *vulnerability* of the system (susceptibility to be affected by a hazard) is important, the risk factor increases considerably.

The main risks in the coastal zone are due to erosion and floods. To a lesser degree, the Beninese coast is also affected by storm surges. These various risks are often amplified by the unplanned development and unsustainable land management practices. Consequences generally include soil, air, water, and estuarine pollution, destruction of wetlands, massive fish mortality (causing fishery performance to collapse), destruction of costly infrastructure, and massive population migration. The combined effects of demographic growth and climate change are expected to amplify these impacts, as described in the previous chapter.

There are several ways to adapt to coastal risks in order to meet the objectives established in a given location (hardening the shoreline, adapting to coastline retreat, beach nourishment). A non-exhaustive list of generic measures is presented in Annex 2. It briefly describes the various options, which are classified into three categories: hard engineering, soft engineering, and land use planning.

### 4.1 Characterization of erosion risks

Coastal erosion is the retreat of the shoreline under the effect of winds, waves and tidal action, in a context of shortage of sediments and/or sea level rise. Coastal erosion is a natural process that has always existed and shaped the Beninese coast. However, the current magnitude of this hazard is no longer natural. The anthropogenic dimension is now the dominant cause of the modern erosion rates on the Beninese littoral. This section describes the current status of erosion in all four zones defined in section 3.1.

**The West African Coast Observation Mission (WACOM<sup>1</sup>), created consequently to the IUCN-UEMOA regional study for shoreline monitoring, is a project focused on characterization of the coastal erosion risk and hazard at regional scale, from Mauritania to Benin. The study established a division of the Beninese shoreline into 8 segments according to the associated risk. The borders of these segments align more or less with the four zones used in the present study. A map depicting the two sets of boundaries is presented on** Hereby, the risk is characterized locally, on the basis of the methodology drawn from the DG-Eau report (DG-Eau, 2015, methodological note " Détermination des seuils et niveaux d'alerte relatifs aux risques d'élévation du niveau de la mer et d'érosion côtière au Bénin"). In this methodology, erosion risk is classified according to the rate of erosion deduced from measurements and analyses of the position of the coastline:

- low: less than 0.5 m / year,
- average: between 0.5 and 2 m / year,
- high: greater than 2m / year.

---

<sup>1</sup> *Mission d'Observation du Littoral Ouest-Africain (MOLOA)* in French.

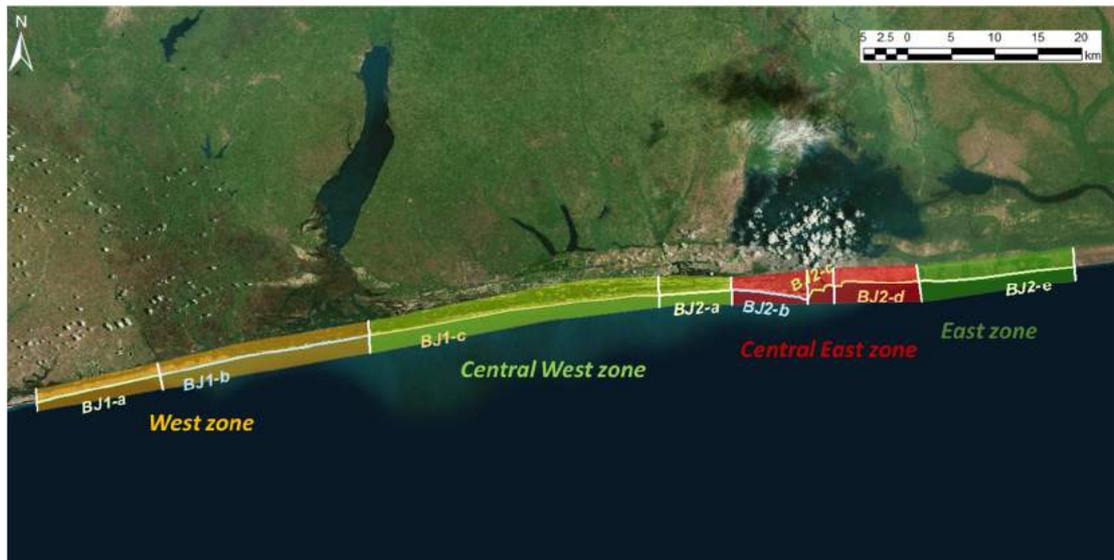


Figure 4.1.

Hereby, the risk is characterized locally, on the basis of the methodology drawn from the DG-Eau report (DG-Eau, 2015, methodological note " Détermination des seuils et niveaux d'alerte relatifs aux risques d'élévation du niveau de la mer et d'érosion côtière au Bénin"). In this methodology, erosion risk is classified according to the rate of erosion deduced from measurements and analyses of the position of the coastline:

- low: less than 0.5 m / year,
- average: between 0.5 and 2 m / year,
- high: greater than 2m / year.

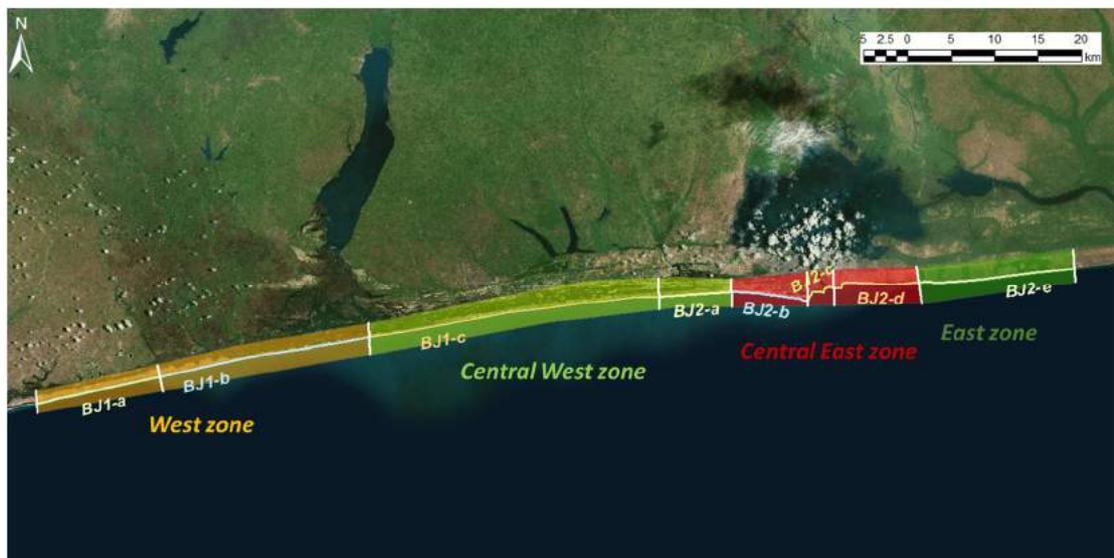


Figure 4.1 Correspondence between the 8 WACOM segments and the 4 development zones of the SDAL.

#### 4.1.1 West Zone

The West Zone corresponds to segments BJ1-a and BJ1-b of the WACOM segments. It is characterized by net sediment transport from Hillacondji to Djondji (west to east), where a part of the sediments accumulate, forming a sandy spit. The zone is composed of beaches subject to high erosion rates, characterized by flood events and consequent destruction of habitats and infrastructure.

The West Zone includes natural areas that are in the process of being added to the UNESCO network of biosphere reserves (biosphere reserve of the Mono river). Along the coastline, several “community areas of biodiversity conservation” (“*aires communautaires de conservation de la biodiversité – ACCB*”) were created, like the one of the *Bouche du Roi*. The WACOM has recommended an intensive and regular monitoring of this cell (MOLOA, 2016).

In 2012, groynes on the eastern Togolese coastline were rebuilt. This has blocked a large fraction of the sediment that would otherwise be transported towards the Beninese coast. Consequently, erosion has increased significantly along the beaches of Hillacondji and Agoué. The (proposed) construction of additional coastal defense structures in Togo, up to 50 meters from the border, is expected to result in the loss of the 23km-strip of land Hillacondji-Grand-Popo and consequently, the loss of more than 325 miles (12,027 km<sup>2</sup>) territorial waters. The Beninese government has undertaken diplomatic actions to delay the works. The proposed project is currently undergoing technical and environmental review.

There are three coastal segments with distinct morphological evolution in the West Zone (DG-Eau, 2015; Figure 4.11): Hillacondji-Ayiguénou, Ayiguénou-Avlo and Avlo-Djondji. Each of these segments are described below.

- *Segment Hillacondji – Ayiguénou*

The intensity of erosion is high between Hillacondji and Agoué, then moderate between Agoué and Ayiguénou (Figure 4.11). However, the whole segment is categorized as *high risk*. This is due to the configuration of the segment: it is composed of a strip of land between the sea and the Togolese border. The city of Hillacondji (see pictures on Figure 4.2, Figure 4.3 and Figure 4.4) and the interstate road (RNIE), located only 500 meters from the shore in some place, are both at risk. Additionally, the Togo-Benin border, which follows the Gbaga river connecting the Mono River to the Aného lagoon, is located less than 300 meters from the RNIE at some places.



**Figure 4.2 Photo of the importance of erosion in Hillacondji (picture from the Municipality of Grand-Popo, 2014).**



**Figure 4.3 A fishermen village in Hillacondji (picture 10/04/2014)**



**Figure 4.4 The fishermen village has disappeared due to coastal erosion (picture 08/09/2016)**

- *Segment Ayiguénou - Avlo*

This segment includes the beach of Grand-Popo. It is sensitive to erosion and accretion cycles, but the cause of these fluctuations is not well understood. Since the exceptional erosion events mentioned by Henri Hubert (1908) and the successive periodic erosion episodes (1900 to 1905, 1922 and 1944) that damaged Grand-Popo, the sea has progressed inland up to 1982. However, this segment has now been accreting since 1982, with some erosion episodes<sup>2</sup> interrupting this trend. The risk is here characterized as moderate, because part of the beach (Ayiguénou-Grand-Popo) consists of a strip of land between the sea and the border with Togo.

- *Segment Avlo – Djondji*

This segment marks the transition between the western and central littoral cells, the border defined by the dynamic Mono river mouth, or “Bouche du Roi”. Since the construction of the Nangbéto dam (Togo) on the Mono River in 1987, this segment has alternated between erosion and accretion, due to the instability of the Bouche du Roi. Prior to construction, the Bouche du Roi was a seasonally closed lagoon, alternating between open and closed conditions of the beach berm at the mouth. The opening of the lagoon was not, however, always natural (Guilcher, 1959 ; Pliya, 1976 ; Oyédé, 1991). These open-close cycles provoked intense adaptation phenomena of beaches, however limited in space up to the island of Kouéta. One can talk about a relatively stable position.

After the construction of the dam in 1987, the Bouche du Roi has been permanently open and migrating eastward, in the direction of littoral drift at a velocity sometimes reaching 700 meters per year (Laïbi *et al.*, 2012). While moving eastward, the Bouche du Roi defines the sink zone upstream, then the source zone downstream. The sink zone is a sandy spit growing in the direction of the littoral drift, while the source zone is a creek migrating along the downstream beach.

In order to maintain this transition segment between Avlo and Djondji, artificial breaches are dug in Avlo, about every five years. This technique attempts to preserve as much as possible the heritage of landscape and natural resources around the Bouche du Roi by preventing river migration, while not inhibiting the electric generation by the dam, essential to economic development. Indeed, the zone is an attractive touristic site and a wetland classified by the Ramsar convention (site n°1018). This soft method then guarantees a *low risk level* in this segment.

#### **4.1.2 Center West Zone**

This recreational and touristic zone covers most of the wetlands of Ramsar site 1018, containing the wetlands of the Lower Couffo valley, the coastal lagoon, the Aho Channel, Lake Ahémé and, at sea, the protected marine area of Avlétéké (the zone corresponds to sectors BJ1-c and BJ2-a as defined by the WACOM). This zone is assigned a moderate risk level, with a regular monitoring of the coastline (MOLOA, 2016). The zone can be further subdivided into four sub-segments based on coastal erosion trends (DG-Eau, 2015; Figure 4.11): Djondji-Mèko, Mèko-Agouin, Avlétéké-Adjahédji and Adounjo-Bah.

- *Segment Djondji – Mèko*

This segment is characterized by erosion rates around 1 m/year (Figure 4.11 and Figure 4.5). This evolution is a result of the west-east migration of the Bouche du Roi that has occurred since the construction of the Nangbéto dam on the Mono river. The more the Bouche du Roi approaches Djondji, the stronger the erosion between Djondji and Mèko. In summary, the severity and extent of local erosion depends on the position of the Bouche du Roi within its area of mobility. *The erosion risk here is moderate.*

---

<sup>2</sup> like the episode of 1986 during which the shore has retreated over 15 meters in 18 months in front of the former City hall of Grand-Popo



**Figure 4.5 Photo of the state of the beach between Djondji and Mèko (photo Laïbi, 2015).**

- *Segment Mèko – Agouin*

This segment is accreting at a rate close to 1.4 m/year, so erosion risk here is negligible.

- *Segment Avlétéké – Adjahédji*

The coast west to Avlétéké village is eroding at an average rate of 0.25 m/year (low hazard), while it is accreting between the eastern side of Avlétéké and Adjahédji, at an average rate of 0.58 m/year (negligible hazard). The risk levels between Avlétéké and Adjahédji are thus *low to negligible*.

- *Segment Adounko – Bah*

This segment is eroding at an average rate of 0.52 m/year. The hazard level is *moderate*, as is the risk level. On the other hand, at this stage, the shoreline has almost reached the Fishery Road (“*Route des Pêches*”) (less than 10 meters away at some locations). This road is sometimes furrowed by runoff water (Figure 4.6). This road is the core of an ambitious development project, the Touristic Development Project of Fishery Road (“*Projet de Développement Touristique de la Route des Pêches – PDTRP*”), currently in the planning stage. Additionally, the old coastal beaches behind the current beach are actively exploited by many companies, outside of any formal development plan. Deep depressions filled with water are abandoned backwards of this segment, like around Togbin.



**Figure 4.6 Photo showing the proximity of the shore from the furrowed Fishery Road in Bah (photo Laïbi, 2015).**

#### **4.1.3 Zone Center East**

The Center East Zone comprises the protected marine area of lake Nokoué – Ganvié. It corresponds to WACOM segments BJ2-b, BJ2-c and BJ2-d. The zone is classified as high priority intervention, requiring

a regular monitoring of the coastline (MOLOA, 2016). On Figure 4.11, it includes a short part of the coast east of the Port of Cotonou (BJ2-b) and segments A, B and C west to it.

- *Segment Fidjrossè – port of Cotonou (BJ2-b)*

The segment Fidjrossè – Port of Cotonou experiences accretion at an average rate of 6.20 m/year. This accretion is a result of the impoundment of sand against port infrastructure (breakwater/jetty) that acts as a fixed lateral border. *Hazard and erosion risk are negligible* here.

- *Segment A*

Segment A represents the coast between the western groyne and the eastern groyne of the port. At the time when the port was built, the construction of two extra groynes was planned directly downstream the port infrastructures (with regard to the littoral drift, i.e. to the east), to prevent complete beach erosion and marine invasion in the channel. These are the western groyne, built on the right bank of the channel's mouthing, and the Sifato groyne, on the beach, about 2 kilometers further to the east. These were built to protect the exit of the channel of Cotonou and some private development like the Biergarten, PLM Alédjo, and Eldorado hotels. Between 1962 and 2008 the segment between these two groynes has been stable (erosion phenomena were actually shifted further east of the Sifato groyne).

In 2008, with the support of the Millenium Challenge Account Programme, the PAC extended the sand-blocking groyne 300 meters further south to prevent siltation of the port basin, deepen the navigation channel, and thereby improve the economic capacities of the port.

Since 2009, the beach between the western groyne and the Sifato groyne has been experiencing severe erosion, threatening various socio-economic infrastructures along the coast. The erosion scarps visible on Figure 4.7 show the severity of erosion in front of hotel Biergarten. The hazard is characterized as very high in this segment, with erosion rates around 7 meters per year.

Due to this hazard and to the presence of valuable socio-economic infrastructure (several hotels, the CAME center, high rise residential quarter, important economic activities), the *risk in this segment is high*.

- *Segment B*

Since 1962, after the construction of the port infrastructures and of the two extra groynes, erosion increased considerably east of the Sifato groyne, creating a vast creek in the « Ambassador zone », called Akpakpa creek. Some attempts have been performed to fix this situation, like geotextile tubes installed perpendicularly to the coast ("stabiplates") and short groynes. The stabiplates of J. Cornic, implemented in December 1997 (370 million FCFA) and the short rock groynes built in March-May 1998 (pilot groynes of the Organization of African Unity, 50 million FCFA) were not sufficient to stop erosion and were destroyed less than one year after implementation.



**Figure 4.7 Photo of the magnitude of erosion in front of the Biergarten hotel (photo Laïbi, 2015).**

In the meantime, new private and public infrastructure has been constructed along the Akpakpa creek. Consequently, the Beninese Government has decided to look for financial funding to provide protection to the creek. Financing was obtained in 2007 to launch the project of Fight against Coastal Erosion at the East of the Port of Cotonou ("*projet de Lutte contre l'Erosion Côtière à l'Est du port de Cotonou – P-LEC*") in 2009. The project was completed within five years, in 2014. It has led to the rehabilitation of the Siafato groyne, the construction of a consolidating revetment in the most sensitive part of the creek and the construction of seven new groynes over 7.5 kilometers. These structures are perpendicular to the shoreline and form a groyne field (Figure 4.8).

Mapping and field observations within the framework of this study show that the sediment dynamics within the cells defined by these groynes is characterized by pronounced erosion / accretion patterns. This is why the hazard is qualified as high within these cells (Figure 4.11). This is a classical evolution around groynes, characterized by a sedimentary balance and a stable zigzag-shaped coastline. For this reason, the *erosion risk is maintained to a low level* along this segment protected by the groyne field.



**Figure 4.8** Field of seven groynes built in 2014 in the creek downstream the Siafato groyne (P-LEC/DABC, 2014).

- *Segment C*

Segment C corresponds to the portion of the coast directly east of the section of Akpakpa Creek protected by the groyne field (Figure 4.9). In the Gulf of Guinea, all beaches located downstream of a groyne become source zones from which sediments are transported away by the littoral drift to feed the coast eastwards. Severe erosion phenomena observed since 2014 in segment C are simply a result of the long-term, existing sediment dynamics of the Gulf of Benin combined with the sand impoundment at the harbor and in the groyne field. The erosion rate is excessive (30 m/year), resulting in a high hazard level, causing the rapid loss of land and damage of social and community infrastructure. The *erosion risk is thus high*.



**Figure 4.9** Creek created by erosion phenomena downstream the groyne field (photo Laïbi, 2015).

#### 4.1.4 East Zone

The East Zone is the industrial region of the Benin coast. It also covers the Ramsar site 1017, comprising the Low Ouémé valley, lake Nokoué and the Porto Novo lagoon (WACOM segment BJ2-e ; MOLOA, 2016). On Figure 4.11, it includes segments D and E east of the groyne field.

- *Segment D*

Segment D is accreting, as it is on the receiving end of sediments eroded from from segment C. The *erosion risk is here negligible*.

- *Segment E*

Segment E consists of two small accreting sections alternating between three highly erosive segments (Figure 4.10). This segment is located east of the accreting segment D. Its morphology is thus in contradiction with its geographical position, when considering the understanding of coastal dynamics in the Gulf of Guinea (model of sediment cell). In reality, the morphodynamic evolution of this stretch is linked to the changing geometry of the coast. The sediment budget in this zone is considered to be in equilibrium, with a *moderate erosion risk*.



Figure 4.10 Photo showing the erosion scarp in Okoun-Sèmè (photo Laïbi, 2015).

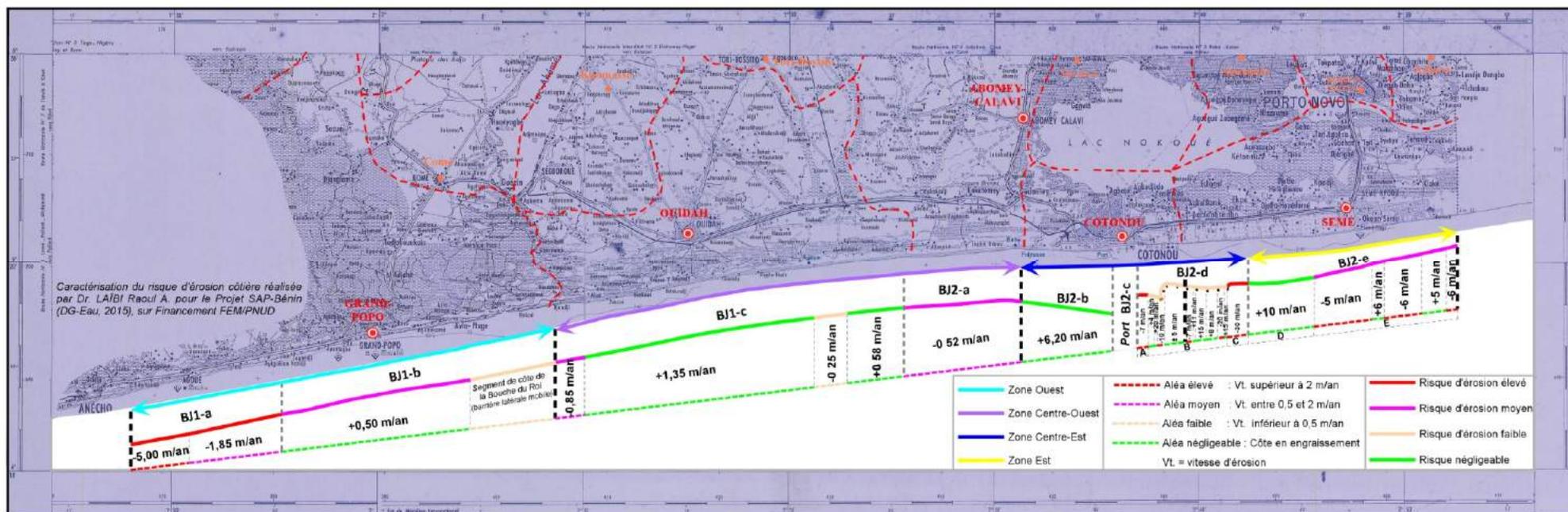


Figure 4.11 Spatial characterization of coastal erosion risk along the littoral of Benin (DG-Eau, 2015; adapted from MOLOA, 2016).

## 4.2 Characterization of coastal floods

The littoral zone of Benin is exposed to two types of floods: river floods and coastal (or marine) floods.

The risk associated with river floods is very high over the entire coastal zone due to the shallow groundwater table, high fraction of impermeable surfaces, inadequate sewer network, uncontrolled urbanization, poor waste management, etc. The PUGEMU program is currently financing studies and development of management tools to deal with these seasonal river floods.

The risk of coastal floods (over wash) has always been present on the Beninese littoral, with minor damages. Flooding usually occurs during two seasons, April-May and July-September, following the seasonality of wind and wave regimes (see section 3.2.4.1 and Figure 4.12). The frequency of coastal flooding has, however, increased during the last decade, and has spread over the whole coastal zone, now occurring during one to two extreme events per year. They lead to the overflow of marine waters on the beaches and cause serious damage

In the following section, this risk is assessed on the basis of beach morphology, current issues and historical events and their impacts.



Figure 4.12 Over wash events in Djondji (photos Laïbi, 2008).

### 4.2.1 West Zone

Flood risks affect the coast between Hillacondji and Grand-Popo (segment BJ1-a), causing submersion of the beach, destruction of fishermen's huts and modest infrastructures, and washing away porks. Due to the population density (fishermen and smugglers) along this coast, *the risk of coastal flooding is high*.

Between Grand-Popo and Djondji (segment BJ1-b), from July to September, overwash events are strengthened by spillover effects due to the seasonal increase in water level of the Mono in the coastal lagoon (Laïbi, 2011). Consequently, the beach becomes narrower and can be breached due to the action of waves and river currents. The exposed units are the thin beach stretch, shaped as sandy spits, and human habitation former built on the preexisting beach. *The risk is moderate*.

### 4.2.2 Center West Zone

The coast along Avlétéké (Figure 4.11) is frequently exposed to isolated overwash events that submerge the beaches locally and threaten the fishing boats and Fishery Road, eventhough this segment is accreting (BJ1-c). This is the reason why atypical erosion observed is linked to these coastal floods, though no statistical data of extreme events are available. *The risk is moderate*.

The segment BJ2-a does not appear to be affected by frequent coastal floods. *The risk is negligible* (even though this segment is eroding).

### 4.2.3 Zone Centre East

Segment BJ2-b has a wide beach as a result of high accretion. Coastal flood events are rarely recorded. *The risk is negligible*.

Segment BJ2-d is subject to intense storm surges, mostly between April-May and July-September. Coastal floods cause damages each year: beach submersion, destruction of fishermen's houses, ship grounding, etc. *The risk is high* due to the importance of infrastructures at stake along the coast. The port infrastructure (segment BJ2-c) is somewhat better protected from the consequences of this risk.

#### **4.2.4 East Zone**

Storm surge events that affect segment BJ2-e are similar to those of segment BJ2-d. Nevertheless, human development is less dense in this segment. Therefore, *the risk is moderate*.

### 4.3 Summary table of coastal risks per zone

Table 4.1 Characterization of coastal risks and stakes per zone.

Zone	Segment	WACOM code	Risks			Assets at risk per sector									
			Coastal erosion	Coastal floods	Other risks	Residential	Natural	Cultural	Agriculture	Fishery	Industry	Tourism / recreation	Port	Other transportation	
West	Hillacondji - Grand-Popo	BJ1-a	High	High	River floods  Soil, water and air pollution  Saltwater intrusion	✓✓				✓✓		✓✓		✓	
	Grand-Popo - Djondji	BJ1-b	Moderate	Moderate			✓✓			✓		✓		✓	
Center West	Djondji - Togbin	BJ1-c	Negligible	Moderate			✓✓	✓		✓✓		✓✓			
	Togbin - Fidjrossè	BJ2-a	Moderate	Negligible			✓✓	✓		✓✓		✓✓			
Center East	Fidjrossè - Djeffa Plage	BJ2-b	Negligible	Negligible			✓	✓	✓		✓✓		✓✓		✓
		BJ2-c	Negligible	Negligible				✓		✓	✓		✓✓	✓	
		BJ2-d	High	High		✓✓		✓		✓	✓	✓			
East	Djeffa Plage – Nigerian border	BJ2-e	Moderate	Moderate		✓	✓✓		✓	✓✓	✓		✓		

## 5 Institutional framework

### 5.1 Introduction

The aim of this chapter is to identify the key stakeholders of each sector described in Chapter Context3. The institutional landscape of the Beninese coastal zone is as complex, diverse, and dynamic as its natural environment. Therefore, the following description and interactions between stakeholders is only a snapshot of the present situation. The stakeholders, their mandates, and roles, are continuously changing.

In addition to the inventory of the main actors, this chapter describes their mutual interactions and the governance of the coastal zone. At the end of this chapter, an analysis of conflicting land use and of potential win-win arrangements is presented.

Most of the measures to control erosion and flood risk are implemented and coordinated by the Ministry of Quality of Life and Sustainable Development (“*Ministère du Cadre de Vie et du Développement Durable – MCVDD*”). The Directorate of Banks and Coast Development (“*Direction de l’Aménagement des Berges et des Côtes – DABC*”) is the department in charge of construction and maintenance aspects of coastal development. However, the MCVDD is a new ministry and changes in its organization are anticipated (cf. the stakeholder and political economy analysis of WACA, Aninver, 2016). Figure 5.1 shows the new list of ministries of Benin since the recent elections (2016).

LES MINISTÈRES		
▶ Ministère d’Etat chargé du plan et du développement	▶ Ministère de l’intérieur et de la Sécurité publique	▶ Ministère de l’Economie Numérique et de la Communication
▶ Ministère de la justice et de la Législation	▶ Ministère de l’Agriculture, de l’Elevage et de la Pêche	▶ Ministère des infrastructures et des Transports
▶ Ministère délégué auprès du président de la République chargé de la Défense	▶ Ministère de la Décentralisation et de la Gouvernance locale	▶ Ministères de l’Industrie du Commerce et de l’Artisanat
▶ Ministère des Affaires étrangères et de la coopération	▶ Ministère du travail, de la Fonction publique et des Affaires sociales	▶ Ministère de l’Energie l’eau et des Mines
▶ Ministère de l’Economie et des Finances	▶ Ministère de la Santé	▶ Ministère du cadre de vie et du Développement durable
▶ Ministère des Enseignements secondaire, technique et de formation professionnelle	▶ Ministère de l’Enseignement supérieur et de la Recherche scientifique	▶ Ministère du Tourisme et de la Culture
	▶ Ministère de l’Enseignement maternelle et primaire	▶ Ministère des Sports

**Figure 5.1 Overview of the ministries of the Republic of Benin (source: official website of the government, <http://gouv.bj/>).**

The stakeholder analysis is based on information from existing studies and documents. In addition, the project team has supplemented available information with site visits across the entire coastal zone, interviews with various stakeholders, and in-depth discussions with the members of the Steering Committee and the WACA program.

The information gathered was used to develop an inventory of the main stakeholders and an assessment of their relative importance in coastal zone management. The current report uses the same structure as used in the study of stakeholders and political economy analysis in Benin by Aninver InfraPPP Partners (WACA study, draft version August 2016). The following criteria were applied (partly based on the aforementioned report):

- Legitimacy or mandate: does the stakeholder hold a position of influence or a strong legitimacy? Is it concerned or interested by the issues of coastal erosion and flooding?
- Internal capacity and resources: does the stakeholder possess the capacity and resources that allow them to take action?
- Network and informal influence/power: is the stakeholder sufficiently connected with the other stakeholders of influence?

Based on these main criteria, the stakeholders are classified into four groups:

- Key stakeholders with **high influence and high interests** → necessary to the process,
- Non-key stakeholders with **low influence but high interests** → useful to form coalitions,
- Non-key stakeholders with **low influence and low interests** → not strictly necessary,
- Key stakeholders with **high influence and low interests** → sleeping stakeholders.

The sleeping stakeholders are powerful stakeholders that have the capacity to interrupt the coastal adaptation process because of their high influence, but have little interest in the topic (e.g. example?).

Next, a review of mandate (interest in coastal flooding and erosion) is presented per stakeholder. Then, their capacities (staff, budget, organizational level) and their influences (network or informal power) are assessed. This analysis leads to a qualitative classification into the four key/non-key classifications described above. They are then assessed with regard to each thematic sector (e.g. example).

Finally, a cross-analysis of sectors and stakeholders is done for each of the four zones to discuss their interdependencies in terms of interests and land use conflicts. The same approach is used to highlight the potential win-win arrangements. This way, the investments can be directed towards these win-win arrangements.

## 5.2 *Inventory of stakeholders*

The stakeholder analysis is conducted on the basis of thematic sectors covering all societal issues and various land uses. The list of sectors is inspired by a study published after the 2010 flood disaster (World Bank and United Nations, YEAR), and includes four thematic functions:

- Social functions: housing, health, education, others (sport, religion, etc.),
- Production functions: agriculture, livestock, fishery, industry, mining, trade and tourism,
- Infrastructural functions: transportation (port and others), public services (water, electricity, gas),
- Transversal functions: environment (ecosystems, pollution), knowledge and research.

Subcategories, listed next to each thematic function, tend to represent various land uses.

The notion of risk can be expressed as the combination of hazard, vulnerability and exposure. To reduce risks, one can thus use strategies that reduce one of these factors, or a combination of them. But not all stakeholders have sufficient means and/or skills to act on all three factors. Most of them only have the capacity to act on one of them: reducing hazard (e.g. with beach nourishment), vulnerability (e.g. by strengthening exposed buildings), or exposure (e.g. by restricting the construction of buildings). Normally, a combination of measures is applied, requiring coordination and cooperation between stakeholders in order to come to an effective solution.

In the following tables, a qualitative scale is used to evaluate each stakeholder's legal mandate (and interests), (institutional) capacity, and (in)formal power. Power does not only depend on legal mandate but also on the financial situation and the number of citizens represented. The qualitative scale ranges from 1 to 3 (1 = weak, 2 = medium, and 3 = strong).

### 5.2.1 *Social functions: housing, health, education, others (sport, religions, etc.)*

Name	Sector	Mandate/role	Capacity	Power	Type
Cotonou Municipality	Public	3; urban development	2	3	Key, strong interest
Municipalities of other coastal cities	Public	2; urban development	1	2	Key, strong interest
Construction promoters	Civil society	1; development and construction	2	2	Non-key, strong interest

Name	Sector	Mandate/role	Capacity	Power	Type
Civil society (associations of residents FULAM et JAK Rehab)	Civil society	1; private interests	2	1	Non-key, strong interest
National Agency of Civil Protection (« Agence Nationale de Protection Civile », ANPC/MISP), dpt. of prevention and management of natural and hydroclimatic crises and disasters)	Public	2 ; protection of population	1	2	Key, high interests

### 5.2.2 Production functions: agriculture, livestock, fishery, industry, mining, trade and tourism

Name	Sector	Mandate/role	Capacity	Power	Type
Beninese Office of geologic and Mining Research (“Office Béninois de Recherche Géologique et Minière », OBRGM/MEEM)	Public	2; natural resources management	1	1	Non-key, strong interest
General Directorate for Forestries and Natural Resources (« Direction Générale des Forêts et des Ressources Naturelles », DGFRN/MCVDD)	Public	2; management and protection, law application	2	2	Key, strong interest
Municipalities of littoral cities (other than Cotonou)	Public	2; licence, management and protection	1	1	Non-key, strong interest
Chamber of commerce and industry in Benin	NGO	1; interests of companies	2	1	Non-key, weak interest
Representatives of major industries	Private	1; private interests	2	3	Key, strong interests
Ministry of Tourism and Culture (MTC)	Public	2; development of tourism	1	1	Non-key, strong interest
Associations of hotels and restaurants	Private	1; hotels/restaurants interests	2	1	Non-key, strong interest
Tourism promoters	Private	1; development and construction	2	2	Non-key, strong interest
(International) travel agencies	Private	0	2	1	Non-key, low interests
Associations of professional craftsmen	Privé	1	1	1	Non-key, low interest

Name	Sector	Mandate/role	Capacity	Power	Type
Ministry of Agriculture, Livestock and Fishery (« Ministère de l'agriculture, de l'élevage et de la pêche », MAEP)	Public	2; resources management	1	2	Non-key, strong interest
Associations of fishermen (sea and lagoon)	Civil society	1; fishermen's interests	1	2	Key, strong interest
Association of vegetable producers	Civil society	1; producers' interests	1	2	Non-key, low interest
South Atlantic Petroleum (SAPETRO)	Private	2; offshore concessions in Sèmè	3	2	Key, low interest
SIBEAU	Private	2 ; concession wastewater of Cotonou	3	2	Key, strong interest

### 5.2.3 *Infrastructural functions: transportation (port and others), public services (water, electricity, gas)*

Name	Sector	Mandate/role	Capacity	Power	Type
Ministry of Infrastructures and Transportation (« Ministère des infrastructures et du transport », MIT)	Public	2; transport routes	1	1	Non-key, strong interest
Cotonou Port Authorities (« Port Autonome de Cotonou », PAC/MIT)	Public	2; port development	2	3	Key, strong interest
National Water Society of Benin (« Société Nationale des Eaux du Bénin », SONEB)	Public	3; water and sanitation	2	2	Key, low interest
Electric Community of Benin (« Communauté Electrique du Bénin », CEB)	Public	3; electricity	2	2	Key, low interest
West African Gas Pipeline Company (WAPco)	Semi-public	2 ; international gas pipeline	2	2	Key, low interest

### 5.2.4 *Transversal functions: environment (ecosystems, pollution), knowledge and research*

Name	Sector	Mandate/role	Capacity	Power	Type
General Directorate for Forestry and Natural Resources (DGFRN/MCVDD)	Public	2; management and protection, law application	2	2	Key, strong interest
General Directorate of Water (« Direction Générale de l'Eau », DG Eau/MEEM)	Public	2; integrated management of water resources, law	1	2	Key, strong interest

Name	Sector	Mandate/role	Capacity	Power	Type
		application			
Benin Agency for Environment (« Agence Béninoise pour l'Environnement », ABE/MCVDD)	Public	3; environmental and social impact studies, law application	2	3	Key, strong interest
National Agency of Land Ownership (« Agence Nationale du Domaine et du Foncier », ANDF/MISP)	Public	3; management of land ownership	2	2	Non-key, strong interest
General Directorate of Environment and Climate (« Direction Générale de l'Environnement et du Climat », DGEC/MCDD)	Public	3; application of law and regulations, environmental management	2	2	Key, strong interest
Nature Tropicale ONG	National NGO	1; monitoring, conventions and consultancy	2	1	Key, strong interest
International Union for the Conservation of Nature (IUCN)	International NGO	1; monitoring, conventions and consultancy	2	2	Key, strong interest
Eco-Bénin	National NGO	1; monitoring, conventions and consultancy	2	1	(*)
BEES	National NGO	1; monitoring, conventions and consultancy	2	1	(*)
University of Abomey-Calavi (UAC)	Research	2; research and consultancy on risks and measures	2	1	Non-key, strong interests
Institute of Fisheries and Oceanology Research (« Institut de Recherches Halieutiques et Océanologiques du Bénin », IRHOB)	Research	2 ; research and consultancy on risks and measures	2	1	Key, high interests

(\*) Many NGOs are active in Benin. The ones cited are mentioned as examples. One NGO should play the role of representative for the others.

The National Agency of Civil Protection (ANPC), and more specifically the Brigade for Coastal Protection and Anti-Pollution Fight (“Brigade de la Protection du littoral et de la Lutte anti-Pollution”, BPLP) could play an active role in enforcement of environmental laws and regulations. This role could include the definition of risk levels and of safety standards in erosive and floodable zones.

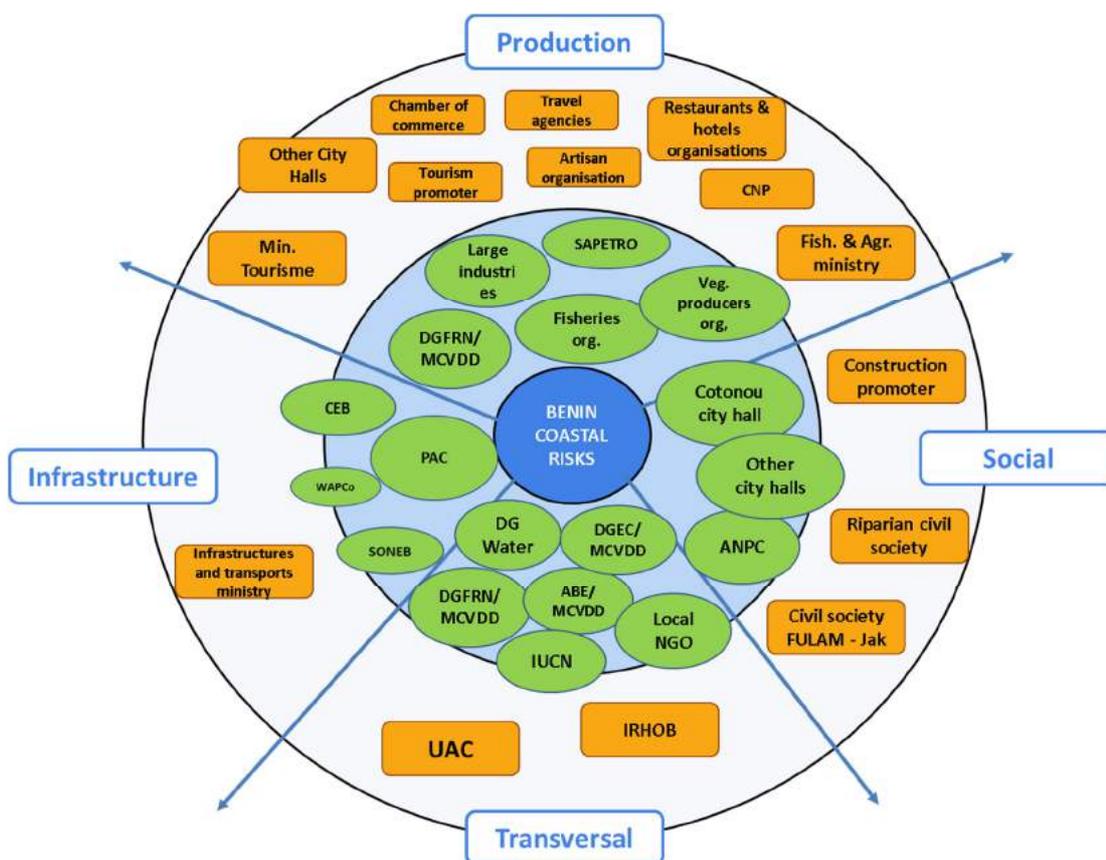
### 5.2.5 Analysis of key and non-key stakeholders

After applying classification criteria to differentiate key and non-key actors, the following ranking is made, per thematic sector:

**Table 5.1 Ranking of key and non-key stakeholders per thematic sector.**

Thematic sector	Total number of stakeholders	Non-key, weak interest	Non-key, strong interest	Key, weak interest (sleeping)	Key, strong interest
Social	5	-	3	-	3
Production	15	5	5	1	4
Infrastructure	5	-	1	3	1
Transversal	9	-	2	-	7

A graphical view of the stakeholders of each thematic sector is presented on Figure 5.2. The key stakeholders with a strong interest are those who must be convinced and involved in development of sustainable solutions. The non-key stakeholders with strong interest are privileged partners who will ideally be involved in the process, to improve awareness and (political) attention. One must keep in mind that the interests of stakeholders are not always the same. In general, interests are either complementary or contradictory.



**Figure 5.2 Graphical view of the key (green) and non-key (orange) stakeholders per thematic sector. Adapted from Aniver (2016).**

One major feature that appears from the grouping and ranking of stakeholders in thematic sectors is the large number of key stakeholders with strong interest (and/or high influence). This illustrates the complexity of the institutional configuration of the coastal zone. Additionally, several stakeholders play an active role in multiple sectors, like the ABE, the DG Eau and several strong (inter)national NGOs.

The large number of stakeholders makes it possible to identify many opportunities for collaboration between those who share common or complementary interests. Together, these stakeholders have a

greater capacity to support long-term sustainable solutions. Therefore, it is highly recommended to group stakeholders for each of the four coastal zones. The implementation of a National Agency of Coastal Zone Protection and Management, will be essential for facilitating collaboration between these four groups of stakeholders.

### 5.2.6 Inventory of key stakeholders per zone

After identifying the major stakeholders, one needs to analyze their connections with each other. The sub-categories of thematic sectors are linked to different uses of the land sensitive to erosion and floods. Therefore, the connection analysis is done for each zone separately:

- East Zone (industrial and natural development),
- Center East Zone (urban development and port of Cotonou),
- Center West Zone (touristic development),
- West Zone (agricultural, natural and touristic development).

For each zone, a review of the main stakeholders is presented below in Table 5.2 through Tableau 5.5.

**Table 5.2 Classification of key and non-key stakeholders per thematic sector in the East Zone.**

<i>East Zone (industrial and natural development)</i>					
<b>Thematic sector</b>	<b>Total number of stakeholders</b>	<b>Non-key, weak interest</b>	<b>Non-key, strong interest</b>	<b>Key, weak interest (sleeping)</b>	<b>Key, strong interest</b>
Social	4	-	2	-	2
Production	8	1	2	1	4
Infrastructure	3	-	1	2	-
Transversal	9	0	2	-	7

The key stakeholders with a strong interest in East Zone are:

- The National Agency of Civil Protection (Prevention and management of crises and natural and hydroclimatic disasters) (ANPC/MISP)
- The General Directorate for Forestry and Natural Resources (DGFRN/MCVDD),
- Fisherman associations (sea and lagoon),
- Representatives of major industries,
- SIBEAU,
- The Municipality of Sèmè-Kpodji.

**Table 5.3 Classification of key and non-key stakeholders per thematic sector in Center East Zone.**

<i>Center East Zone (urban development and port of Cotonou)</i>					
<b>Thematic sector</b>	<b>Total number of stakeholders</b>	<b>Non-key, weak interest</b>	<b>Non-key, strong interest</b>	<b>Key, weak interest (sleeping)</b>	<b>Key, strong interest</b>
Social	6	-	4	-	2
Production	10	5	3		2
Infrastructure	5	-	1	3	1
Transversal	9	0	2	-	7

The key stakeholders with a strong interest in the Center East Zone are:

- The Municipality of Cotonou,
- The port authorities (PAC),
- The National Agency of Civil Protection,
- The General Directorate for Forestry and Natural Resources,
- Representatives of major industries.

**Tableau 5.4 Classification of key and non-key stakeholders per thematic sector in Center West Zone.**

<b>Center West Zone (touristic development)</b>					
<b>Thematic sector</b>	<b>Total number of stakeholders</b>	<b>Non-key, weak interest</b>	<b>Non-key, strong interest</b>	<b>Key, weak interest (sleeping)</b>	<b>Key, strong interest</b>
Social	5	-	3	-	2
Production	8	2	3	-	3
Infrastructure	4	-	1	3	-
Transversal	9	-	2	-	7

The key stakeholders with a strong interest in the Center West Zone are:

- The National Agency of Civil Protection,
- The General Directorate for Forestry and Natural Resources,
- Fisherman associations (sea and lagoon),
- Agricultural (vegetable) associations,
- The Municipalities of Abomey-Calavi and Ouidah.

**Tableau 5.5 Classification of key and non-key stakeholders per thematic sector in West Zone.**

<b>West Zone (agricultural, natural and touristic development)</b>					
<b>Thematic sector</b>	<b>Total number of stakeholders</b>	<b>Non-key, weak interest</b>	<b>Non-key, strong interest</b>	<b>Key, weak interest (sleeping)</b>	<b>Key, strong interest</b>
Social	5	-	3	-	2
Production	9	-	6	-	3
Infrastructure	4	-	1	3	-
Transversal	9	-	2	-	7

The key stakeholders with a strong interest in the West Zone are:

- The National Agency of Civil Protection,
- The General Directorate for Forestry and Natural Resources,
- Fishermen associations (sea and lagoon),
- Agricultural (vegetable) associations,
- The Municipality of Grand-Popo.

The main stakeholders for West and Center West Zones are almost the same. The two zones are separated because of their different choices of development: the West Zone is more focused on agricultural production while the Center West Zone is more focused on tourism (along Fishery Road).

In all zones, the key stakeholders of transversal functions (environment) will play a major role. The main stakeholders of this sector are:

- The General Directorate for Forestry and Natural Resources (DGFRN/MCVDD),
- The General Directorate of Water (DG-Eau),
- The National Agency of Land Ownership (ANDF),
- The Benin Environmental Agency (ABE/MCVDD),
- Nature Tropicale ONG (as representative of NGOs),
- The International Union for Conservation of Nature (IUCN).

The MCVDD is the authority in charge of land use management and environmental regulations. It is responsible for the definition and the reinforcement of the main laws and regulations regarding land use and environment. In parallel, the DG-Eau has the mandate to maintain the coastline and waterbodies. Finally, the ANPC is responsible for the management of risks and disasters and for the definition of safety standards and actions.

### **5.3 Governance of coastal management**

Effective governance of the coastal zone requires two types of management and adaptation measures:

- Short-term measures: actions aimed to control and decrease vulnerability in immediate dangerous situations (land use functions in vulnerable zones), and
- Long-term measures: preventive actions aimed to prevent threats linked to future land use and coastal erosion.

In both cases, the government of Benin is responsible for protection and safety of its citizens. When the situation along the coast becomes too dangerous and protection/management techniques cannot adequately address it, it will be necessary to implement managed retreat.

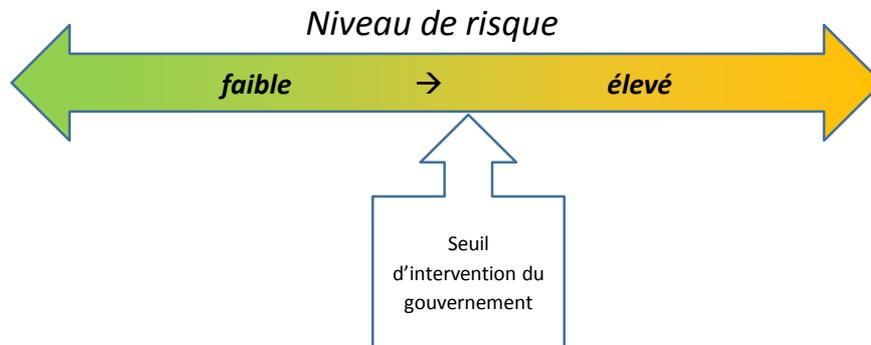
The spatial assessment of risk and vulnerability is a prerequisite to apply this approach, as well as the definition of threshold of acceptable risk. These safety standards must appear in laws and regulations, so that governmental agencies have legal instruments to undertake appropriate actions. In many countries, the level of intervention of the government is based on political debates (see box below).

Because most of the coastal zone is already densely occupied, relocation of the population and its activities will be a big challenge. It will not only require acceptable compensation for relocation of houses and industries, but also the need to create new opportunities for displaced citizens. Many professional development programs will be necessary, as have already been developed in Grand-Popo, where a part of the fishing community has converted to agriculture.

To prevent creating additional high-risk zones, a strict land use planning policy must be developed in the short term. A risk atlas must be developed based on safety standards and hazard levels in order to inform this land use planning. Restrictions on land use can then be determined as a function of risk level and expected erosion rate, especially for permanent development. Along the Beninese coast, a law already exists to control land use over the first 100 meters from the high-tide line (“Cent pas du roi”). However, in many places 100 meters is not a sufficient buffer considering extremely high erosion rates (that can locally reach 10 – 30 m/year!). In the new version of the Coastal Law, a 200 meters buffer is proposed (see next chapter).

### **Roles and responsibilities of stakeholders in risk management**

*In risk management, the effects of high risks (victims and heavy damages) are the responsibility of the public sector. Effects of lower risks can be managed by private stakeholders. However, the threshold between high and low risk must be determined according to certain risk criteria. These thresholds must then appear in laws and regulations.*



Government agencies dealing with spatial planning (« Délégation de l'Aménagement du Territoire – DAT ») and land ownership (« Agence Nationale du Domaine et du Foncier – ANDF ») will thus play a central role in the coming decades.

In addition to spatial planning and regulation, integrated coastal zone management must also include the following aspects:

- Risk and natural disaster management,
- Environment (including protection of nature),
- Water resources management (including wastewater treatment),
- Urban and infrastructure development,
- Mining resources management (sand and salt).

Legal aspects of each aspect are discussed in Chapter 6.

## **5.4 Interactions of stakeholders for land use**

The coastal zone already comprises most of activities of Benin modern society. Because of natural and anthropogenic phenomena, pressure on this zone is rapidly increasing. The urban population is expected to have doubled between 2000 and 2020. In Benin, some urban zones will reach a population density of 1800 inhabitants per km<sup>2</sup>. This high density, coupled with pressure caused by natural hazards, exacerbates competition between interests of the stakeholders.

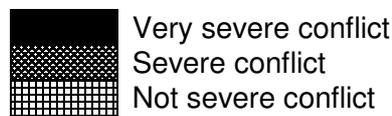
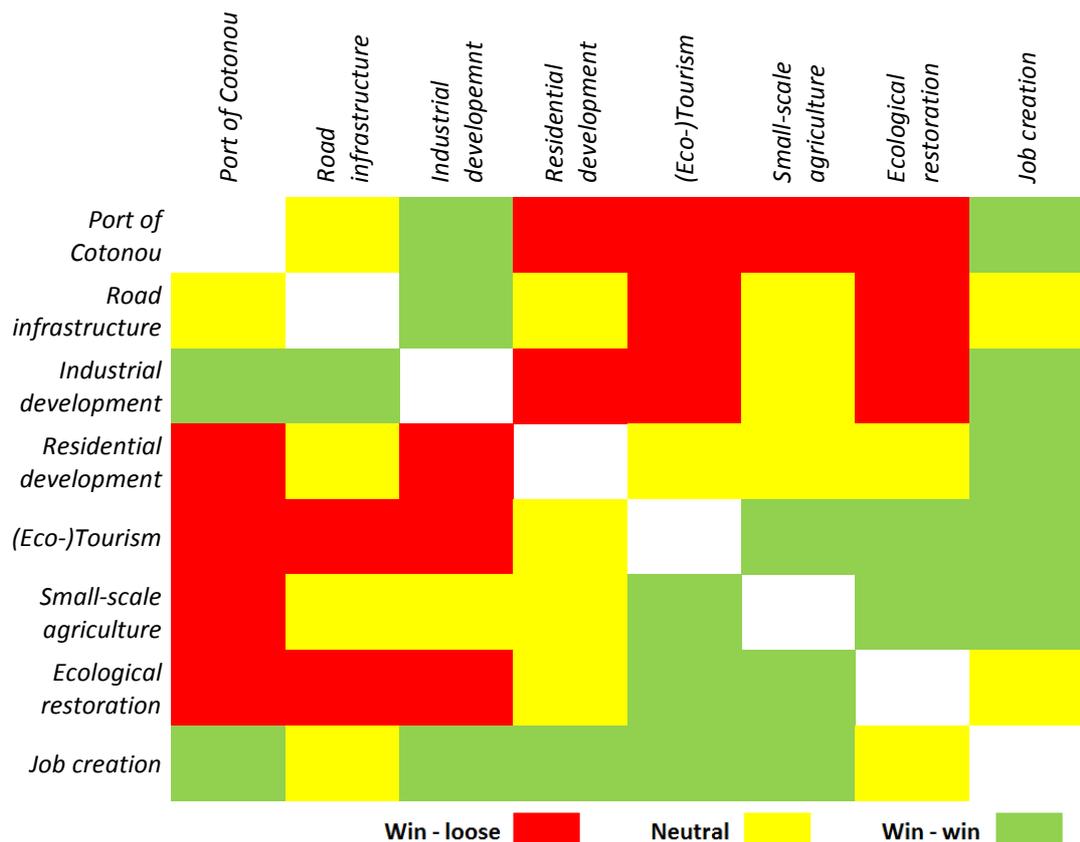
Section 5.2 illustrated that many different groups of stakeholders exist in the coastal zone. Conflicting land use often originates from the multi-functionality of land, or its capacity to fulfill various services for multiple users. Besides, the coastal zone also presents a number of possible sustainable developments of land and activities.

A conflict is a form of social relationship most often seen as the confrontation of several actors with opposing interests, in competition for the same good. In this case, the “good” is space and/or a common natural resource. Among the many (potential or existing) conflicts, some deserve particular attention due to their impact on coastal development. These conflicts are summarized in Table 5.6, from the Strategic Environmental Assessment of the Beninese Coastal Strico Sendu (ABE, 2004).

Instead of focusing on negative effects, it is also possible to highlight the positive effects. In general, conflicts between stakeholders can be resolved on a constructive way if a win-win arrangement is found between all parties. In the present study, the goal is to maximize the value of the coastal zone (social, environmental and economic aspects) while minimizing the risk of coastal erosion and flooding. Table 5.7 shows some potential win-win arrangements.

**Table 5.6 Summary of the main land and space use, and their acuity (source : ABE, 2004).**

Land use categories	Agriculture	Fishery	Industry	Extraction	Landfill / dump	Recreational / Tourism	Residential	Urban
Agriculture				Not severe conflict	Not severe conflict	Not severe conflict	Very severe conflict	Very severe conflict
Landfill / dump	Not severe conflict					Very severe conflict		
Extraction	Not severe conflict					Very severe conflict		
Industry				Not severe conflict	Very severe conflict	Very severe conflict	Not severe conflict	Not severe conflict
Recreational / tourism	Not severe conflict		Very severe conflict	Not severe conflict	Very severe conflict	Not severe conflict		
Fishery								Not severe conflict
Urban	Very severe conflict	Not severe conflict			Not severe conflict	Not severe conflict	Very severe conflict	
Residential	Not severe conflict		Not severe conflict		Not severe conflict			


**Table 5.7 Possible win-win arrangements.**


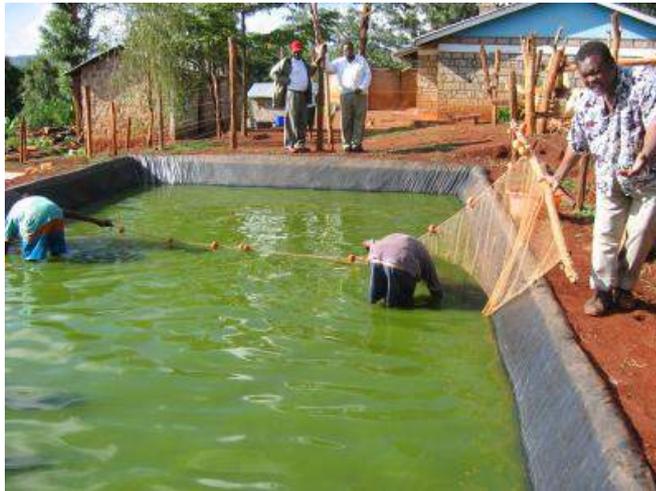
To be able to take advantage of various situations, it is necessary to set up a very clear land planning policy. Because of existing land use conflicts, the stakeholders usually defend their own interests without considering the overall benefits. This is why cooperation between key stakeholders is a crucial step. Besides, coalitions between key and non-key stakeholders will be necessary to develop

multifunctional solutions. In this approach, the complementarity of stakeholders' capacities will be a driver for (sustainable) decision making on the long term.

Some examples of possible win-win arrangements are described below for the four coastal zones.

### West and Center West Zones

West of Cotonou, it is possible to develop an intelligent combination of small-scale agriculture (horticulture), sustainable tourism and artisanal fishery in the sea and lagoons. The development of sustainable fish farming would also help to meet the dietary needs of the urban population (see example photo in Figure 5.3).



**Figure 5.3 Small-scale fish farming (photo : Infonet-biovision.org)**

### Center East Zone

Due to its extent and location, the PAC (essential stakeholder of the Beninese economy) is limited in its development. A win-win comprise could be found between the port and the city of Cotonou through collaboration in the long-term development of an attractive seafront, attracting commercial activities and tourism.



**Figure 5.4 Construction of a new seawall (1 km) in Den Haag, Netherlands (photo : DutchWaterSector.com).**

In parallel, dredged material from the port could be reused to develop polder zones along the southern banks of lake Nokoué (on-going project within the framework of the Delta Plan, in collaboration with the Dutch Embassy). This would facilitate urban development while creating a new protection against the frequent flooding in the city.

### East Zone

The SIBEAU site of wastewater treatment through decantation basins is currently severely damaged by coastal erosion and flooding, creating a strong point source of pollution. Over the last two decades, innovative techniques have emerged to reuse nutrient and energy lost in wastewater. The threat of coastal erosion can be used as a trigger to invest in new innovative installations further landward, to guarantee a proper wastewater treatment while valorizing the clean water for agriculture, the

nutrients as fertilizers, etc. A project financed by the African Water Facility further elaborates on this potential project (AWF, 2012).

## 6 Legal and regulatory framework

In this chapter, a summary of the laws that play (or will play) a role in coastal management is presented. The process of implementing a protection/adaptation measure on the littoral is schematized with the linked regulations and institutions responsible to apply them to the corresponding steps.

Some important elements of the law texts are discussed, like the new Littoral Law and the missing elements in the national legislation.

### 6.1 Description of existing legal instruments

In Benin, a variety of legal instruments exists to manage the implementation of measures. The most important ones are presented herebelow, in Table 6.1.

**Table 6.1 Main laws and decrees regarding coastal management in Benin.**

Laws and decrees	Themes
<i>Loi Cadre Environnement (1999)</i> (environmental law)	Sectoral regulations for environmental protection Regulations on sustainable land use Creation of a Beninese Environment Agency (ABE) Mandatory environmental and social impact study Public hearing processes on environment Emergency plans
<i>Code Minier (2006)</i> (mining code)	Permit for exploitation of mineral resources Interdiction of marine/beach sand exploitation Regulations for quarries of lagoon sand
<i>Loi Cadre Aménagement du Territoire (DAT, 2016)</i> (land use law)	Fundamental rules and practices of land use in Republic of Benin: - rational management of natural resources, - protection of cultural and natural heritage against anthropogenic degradation. Determination of the managing bodies of territory at national scale: - the <i>Conseil Supérieur d'Aménagement du Territoire</i> (CSAT), - the <i>Conseil National d'Aménagement du Territoire</i> (CNAT), - the <i>Agence Nationale d'Aménagement du Territoire</i> (ANAT). National Scheme of Land Planning ( <i>Schéma National d'Aménagement du Territoire - SNAT</i> ), directives for sectoral development and directives for territorial development. Certificate of Spatial Consistency ( <i>Certificat de Cohérence Spatiale</i> ) Creation of a Fund for Land Use Incentive
<i>Code de l'Aménagement et de l'Urbanisme (2015)</i> (land management and urbanism code)	Land use rules : - National regulation for Urbanisme ( <i>Règlement National d'Urbanisme - RNU</i> ), - Construction rules, - Public safety rules, - Hygiene code, - Environmental law, - Public use easements. Master plan for Development and Urbanisme ( <i>Schéma Directeur d'Aménagement et d'Urbanisme - SDAU</i> ) and Master Plan for

Laws and decrees	Themes
	<p>Urbanism (<i>Plan Directeur d'Urbanisme - PDU</i>).</p> <p>Clarification of concepts of plot and urban consolidation.</p> <p>Information on urbanism certificate, construction permit and demolition permit.</p>
<p><i>Loi Portant Gestion de l'Eau (2010)</i> (water management law)</p>	<p>Integrated water resources management deals with rational use, fair allocation and sustainable exploitation of the available water resources.</p> <p>Definition of environmental quality standards and of necessary measures to preserve and restore this quality.</p> <p>Rules for water allocation to combine the interests of the different categories of users.</p> <p>Wetlands of international importance on the list of Ramsar sites (Ramsar convention of 2<sup>nd</sup> February 1971) are given a management plan.</p> <p>Master plan of development and management of waters (programme of works and actions to achieve the objectives defined).</p>
<p><i>Nouveau Code Foncier (2013)</i> (new land code)</p>	<p>Insure a fair access to land for all stakeholders.</p> <p>Insure a sustainable land use with respect to the interests of current and future generations.</p> <p>Fight against land speculation.</p>
<p><i>Loi Littorale (2001 and 2016)</i> (littoral law)</p>	<p>Protection and rational and ecological valorization of the littoral zone.</p> <p>The littoral zone requires a specific protection policy:</p> <ul style="list-style-type: none"> <li>• Implementation of research actions and initiatives to collect and gather data on the specificities and resources of the littoral,</li> <li>• Restoration and protection of biological and ecological balance, fight against coastal erosion and pollution, preservation of sites, landscape and heritage,</li> <li>• Preservation and development of economic activities depending on the presence of water like fishery, recession agriculture, vegetable crops, artisanal salt extraction, etc.,</li> <li>• Improved organization and development of agriculture, transport, industry, trade, craft and tourism.</li> </ul> <p>A new agency is created, called "National Cell of Coastal Protection and Management" (<i>cellule nationale de protection et de gestion du littoral - CNPGL</i>). This Cell would be a specific institution dedicated to the protection and management of the littoral zone.</p> <p>The Master Plan for Littoral Development (« schéma directeur d'aménagement du littoral » - SDAL) is an orientation document which englobes all decisions, actions and operations having any impact on the littoral. The SDAL sets the prior policy of littoral development, as well as the conditions of its implementation.</p>
<p>Selection of international conventions about environment and climate</p>	<p>Ramsar convention relative to important natural zones at international scale, like bird habitats. Benin has become a contracting party since 24<sup>th</sup> January 2002.</p> <p>Convention on biological diversity ratified on 30<sup>th</sup> June 1994, and Protocole of Carthagena, that rules transboundary movements of GMOs.</p>

Laws and decrees	Themes
	<p>Convention on the conservation of migratory species of wild animals. Benin has ratified this convention through decree n°83-204 on 31st May 1983.</p> <p>United Nations Framework Convention on Climate Change. This convention was adopted on 13rd December 1993, ratified on 30<sup>th</sup> June 1994 and the Protocole of Kyoto adopted in 1997.</p> <p>COP21 – Paris, December 2015, ratified in October 2016.</p>

This overview shows that Benin possesses already most of the legal tools required for a sustainable management of the littoral zone. However, due to the complexity of territorial aspects, a more direct harmonization of the laws and regulations is necessary. Moreover, a clear policy of (natural) disaster management is not yet covered by the texts cited hereabove.

After the floods of 2010 in Benin, the UN has assessed the damages (World Bank & United Nations, 2011). This assessment has concluded that the National Agency of Civil Protection (ANPC), which is the operational organ of the Ministry of Intern Affairs for managing natural disasters, had no sufficient capacities to carry out its tasks.

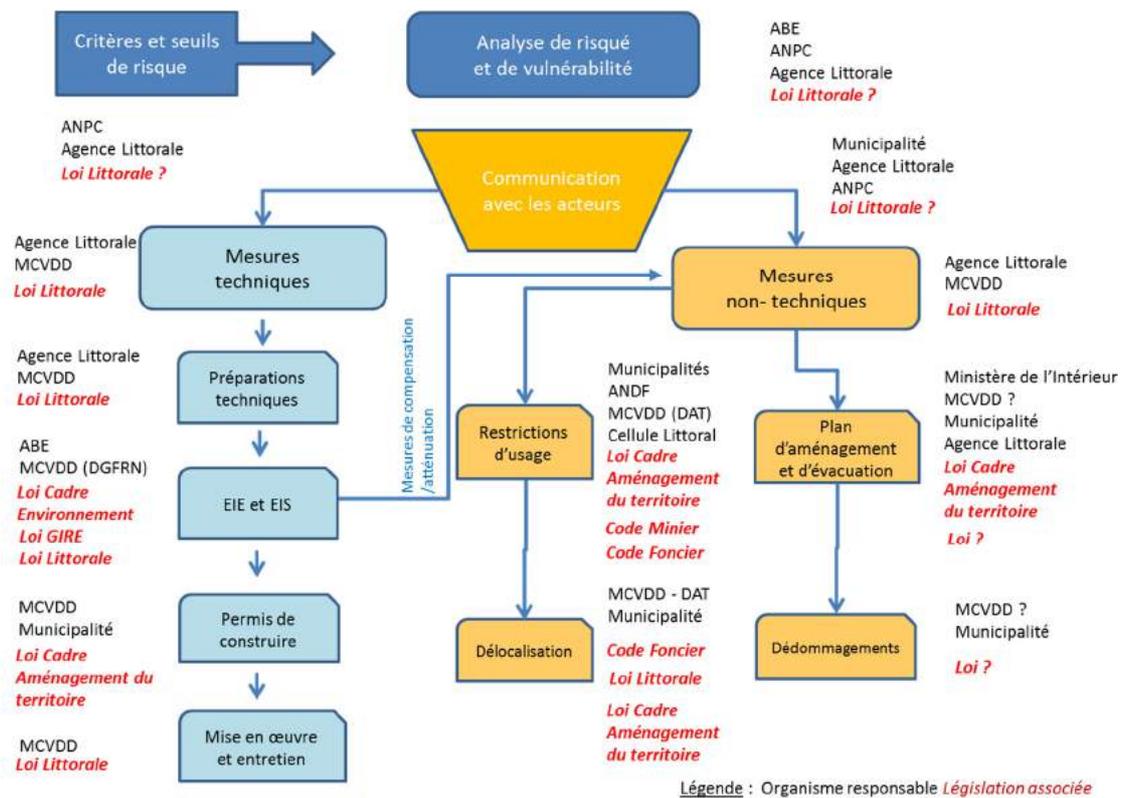
## 6.2 *Legal framework of measure implementation*

In the littoral zone, there are two causes of risks and threats for land use:

- Natural phenomena : coastal erosion, sea level rise, extreme climatic and meteorologic events (storms, waves), changes in pluviometry, decrease in sediment supply;
- Anthropogenic pressure : demographic growth, socioeconomic development, erosion downstream constructions, densification and expansion of urban zones, destruction of vegetation, agriculture, sediment blocking (dams), pollution, (uncontrolled) land occupation, overexploitation of mining resources (sand, salt).

Due to the very high level of emergency required by some beach stretches, the measures must be integrated into a strong legislation, within which mandates and responsibilities of each stakeholder are clearly identified. There is more flexibility for long-term measures. But this comes with more risks that long-term measures are subject to political (inter)national debates. Due to the extended impact of coastal floods and erosion on the whole Beninese society, the discussions and decisions about long-term actions should remain strictly apolitical. To reach this result, a strong legal context is necessary.

The possible measures can be divided into technical and non-technical measures. This distinction is important on a legal and institutional point of view. Technical measures (or engineering measures) deal with concrete impacts of the erosion on the environment. Non-technical measures, like land use restrictions or relocation of exposed infrastructures, deal with the impacts of erosion on socioeconomic aspects. The institutions and laws that rule them vary. On Figure 6.1, an overview is given of the main elements and steps to consider when implementing a measure or project.



**Figure 6.1 Main elements of the implementation of measures against coastal risks.**

The first step to select and implement any measure is to define the risk level of coastal floods and erosion. The MOLOA (WACOM) project is currently busy with the monitoring of coastline evolution. Based on this analysis, the present and future risks can be determined and fixed within the appropriate laws and regulations. The ANPC and the national agency of protection and management of the littoral will play a central role in the definition of safety standards.

Secondly, a classification is needed, based on the risk level. What is the annual erosion rate? Which types of land are and will be exposed to the risk? A risk and vulnerability analysis is required to determine the risk zones and, consequently, to define the appropriate measures (short/long-term, technical/non-technical). Risk and vulnerability maps will ideally be created by the MCVDD and by the ANPC in collaboration with the local authorities.

Generally, non-technical measures are linked to spatial planning. If the current danger level is too high, immediate evacuation is recommended and a transfer of livelihoods is necessary. If the danger level is expected to increase in a close/distant future, land use restrictions can be set up. In both cases, local authorities are in charge to apply these measures : on the short term, organizing the evacuation and compensation for the affected population, and on the long term, setting up a long-term land planning through the SDAU and PDU, in harmony with the SDAL.

In case of technical measures, a clear sequence is followed to integrate the project within the existing SDAU and SDAL, to carry out an environmental and social impact study and to obtain an environmental and social compliance certificate and a construction permit. The main texts and institutions involved are shown on the scheme of Figure 6.1.

## 6.3 Challenges regarding the legal framework

### 6.3.1 Land ownership management

Several laws and regulations rule the spatial planning in Benin. In case specific zones must be evacuated, it is a challenge to move these populations and their livelihoods to less dangerous zones. One of the biggest issues is land ownership.

Modern legal systems that rule land ownership interfere with the traditional regime of land and water use. Many conflicts happen between purchasers and presumed owners. In the coastal zone, legislation or rural cadaster do not exist everywhere. Conflicts are amplified by the increasing population density.

In the *Nouveau Code Foncier* (2013), Article 6 describes the main responsibilities of the government:

**Article 6** : *L'Etat et les collectivités territoriales en tant que garants de l'intérêt général doivent :*

- *Assurer un accès équitable aux terres pour l'ensemble des acteurs, personnes physiques et personnes morales de droit public et de droit privé ;*
- *Sécuriser les droits réels immobiliers établis ou acquis selon la coutume ;*
- *Organiser la reconnaissance juridique effective des droits fonciers locaux ou coutumiers légitimes des populations ;*
- *Lutter contre la spéculation foncière en milieu urbain, périurbain et rural et favoriser la mise en valeur effective des terres pour le bien-être des populations ;*
- *Veiller à l'exploitation durable des terres dans le respect des intérêts des générations présentes et futures ;*
- *Lutter contre le morcellement anarchique et abusif des terres rurales ;*
- *Veiller de manière générale à la protection des intérêts nationaux et à la préservation du patrimoine foncier national ;*
- *Veiller au respect de l'égalité de l'homme et de la femme dans l'accès au foncier.*

**Nouveau Code Foncier, 2013**

In reality, the situation is very complex and hard to manage. The main issues are mentioned hereafter (ABE, 2004):

*« Land is the only asset that, without any particular maintenance, creates real added value that varies with its geographical situation with regards to a city, an important way or other consequent infrastructures (market, electricity, water distribution network, etc.). This perception of the asset value englobes, among others, a futuristic dimension that consents that all environment will develop sooner or later. Therefore, all land has a monetary value that increases with time, independently from the location.*

*« The absence of a politics of social housing policies by estate agencies is an accelerating factor of the craze for individual land ownership.*

*« Beninese people have no tradition of cooperative occupation of land ownership that could lead to the construction of high buildings with several owners. Therefore, the combination of demographic pressure and the tradition of individual land ownership will accelerate land occupation through the creation of secondary neighborhoods and cities, with a low level of service.*

*« The revolutionary period with the threat of agrarian reform through expropriation of agricultural land by the State has widely contributed to the selloff of lands, emigration of peasants and arrival of new owners who consist of officials and traders from the cities. The coming years will likely be years of conflicts linked to land ownership. »*

To prevent any future conflict, a strict analysis of risk and vulnerability must be detailed in the laws and regulations regarding spatial planning.

### 6.3.2 **The Littoral Law and the Master Plan for Littoral Development**

The *Law for protection, development and enhancement of the coastal zone*, or Littoral Law, was elaborated between 2000 and 2002 but was never voted up to now. Therefore, some important measures within were never applied (like the implementation of the Master Plan for Littoral Development and the creation of a National Cell of Coastal Zone Protection and Management).

This draft law includes numerous solid basics for integrated coastal zone management. The main articles are discussed hereafter.

*Article 1er bis. La présente loi a pour objet la protection et la mise en valeur écologiquement rationnelle de la zone littorale. Elle vise à encadrer l'aménagement du littoral pour la protéger des excès de la spéculation immobilière et permettre le libre accès au public sur les sentiers littoraux.*

The Littoral Law is mostly focused on protection of environment, and not enough on safety standards associated to coastal erosion and floods.

*Article 2. La zone littorale appelle des politiques spécifiques de protection, d'aménagement et de mise en valeur, dont la mise en œuvre nécessite une coordination des actions de l'Etat et des collectivités territoriales ou de leurs groupements. Ces politiques ont pour objet :*

- la mise en œuvre d'actions de recherche et d'initiatives visant à collecter ou constituer des données sur les particularités et les ressources de la zone littorale;*
- le rétablissement et la protection des équilibres biologiques et écologiques, la lutte contre l'érosion et la pollution, la préservation des sites, paysages et du patrimoine;*
- la préservation et le développement des activités économiques liées à la proximité de l'eau telles que la pêche, l'agriculture de décrue, les cultures maraîchères, l'exploitation artisanale de sel, etc.*
- une meilleure organisation et le développement des activités agricoles en général, du transport, de l'industrie, du commerce, de l'artisanat et du Tourisme.*

This article is closely related to the WACA objectives: maximize the value and the level of protection.

*Article 5. La loi intègre les principes et directives contenus dans les conventions et accords internationaux relatifs à la conservation des ressources naturelles de la zone littorale, auxquels le Bénin est partie.*

This article calls for respect to international conventions signed by Benin (Ramsar, COP21, ...)

*Article 30. L'autorisation d'exploitation de sable et de gravier est accordée par le Ministre chargé des Mines, après avis du Ministre chargé de l'Environnement et du Conseil communal ou municipal de la Commune concernée par l'exploitation.*

The (illegal) extraction of sand and salt is one of the problems along the coastal zone. The connection is done here with the Mining Code.

**Article 72.** *Le schéma directeur d'aménagement du littoral est un document d'orientation dans lequel s'inscrivent toutes les décisions, actions et opérations qui ont un impact quelconque sur la zone littorale. Le schéma directeur d'aménagement du littoral est un instrument de planification à court, moyen et long termes, élaboré suivant une démarche participative et qui tient compte des besoins prioritaires des communes de la zone littorale.*

**Article 74.** *Le SDAL fixe les priorités de la politique d'aménagement du littoral, ainsi que les conditions de sa mise en œuvre.*

Articles 72 and 74 concern the elaboration of the Master Plan for Littoral Development (SDAL). In this master plan, a connection can be made with the SDAU, PUD and other documents regarding governance in the coastal zone. The “National Cell of Coastal Zone Protection and Management” (CNPL, see Article 90) is expected to elaborate (/update) the SDAL.

**Article 79.** *Les parties naturelles des rivages et des rives, des plans d'eau naturels sont protégées sur une distance de deux cents mètres à compter des rives et rivages. Sont interdits sur ces parties naturelles toutes constructions, toutes installations d'équipements, d'ouvrages et de routes nouvelles ainsi que toutes extractions et tous affouillements. Ce périmètre de 200 m est exclu de toute opération de lotissement.*

This article clearly establishes a safety width of 200 meters, that gives between 7 to 15 years (depending on the location) to take measures within this width. The MOLOA criteria of coastal erosion risk assessment should be inserted here.

**Article 90.** *Il est institué un organisme dénommé cellule nationale de protection et de gestion du littoral (CNPGL).*

**Article 91.** *La cellule visée à l'article 90 est chargée d'assurer la coordination de toutes les actions relatives à la protection et à la gestion du littoral et de promouvoir la coopération sous-régionale pour la protection du littoral.*

The setting up and operationalization of a centralization organization of the whole coastal zone management is crucial to apply the policies of integrated management. However, capacities and mandates of such organization need to be defined within this law. For instance, the CNPL must be powerful enough to deal with complex problems regarding the Land Code.

The Master Plan for Littoral Development will become the main policy documents of coastal zone management. Some major elements of the new SDAL (extracts of the “SDAL consolidé”) are discussed herebelow.

*Dans le souci de mieux gérer l'espace côtier aux fins d'un développement durable, un schéma directeur de développement de littoral béninois est en cours d'élaboration. Les éléments de stratégie de cette gestion intégrée concerneront :*

- *les changements de techniques et de pratiques, en particulier dans le domaine de l'énergie et de l'architecture ;*
- *la gestion agro-sylvo-pastorale ;*
- *la planification familiale ;*
- *l'amélioration des infrastructures et des services ;*
- *le renforcement de la législation et sa mise en application ;*
- *la gestion foncière ;*
- *le suivi de l'impact des aménagements hydrauliques.*

The first version of the SDAL (2000) already addressed many problems linked to coastal management. However, it seems that coastal erosion and floods did not yet appear as major elements.

*En effet, la gestion intégrée du territoire est avant tout une approche globale du territoire fondée sur la mobilisation des différents acteurs, la prise en compte de leurs intérêts divergents et des facteurs de risque, l'organisation et l'utilisation rationnelle de l'espace avec un souci constant de sauvegarder ou de réhabiliter les ressources biologiques (biocénose) et de limiter la dégradation du milieu physique (biotope). La présente étude qui porte sur le diagnostic du littoral couvre une diversité de secteurs à savoir ceux du primaire, du secondaire et du tertiaire. Cette gestion a pris en compte les différentes fonctions des écosystèmes (support, production, information, régulation).*

As described in the previous chapter, it will be challenging to find win-win arrangements in the implementation of long-term and short-term measures. This will require the protection of assets in the coastal zone against floods, erosion and other (natural) risks. An adaptive approach is necessary, i.e. promoting no-regret measures that will lead to a sustainable situation.

## 7 Existing adaptation projects

---

For about 20 years, there has been an increasing awareness of environmental issues at all levels. Specific legislation and decrees have progressively been set up, institutions become more organized, NGO's consideration and influence increase, research centers and universities have more weight, investments are raised and the private sector finds new opportunities. It takes time to activate the processes and to make them performant, but also important financial means, technical knowledge and a common will to shift to a sustainable and global management of the coast.

In this chapter, the main adaptation/mitigation projects and measures are presented. This relates to completed, on-going and planned projects over the entire coast and within each of the four zones defined in Chapter 3. The description is brief and focused on the activities carried out and on the (expected) results.

The list of measures/projects has been established based on:

- available documentation,
- gathered information during the interviews of the stakeholders, carried out in September 2016,
- expertise of the project team, the members of the Steering Committee and various external experts met.

Although this list is intended to be exhaustive with regards to the major completed and on-going projects, some measures may not be inventoried here, due to a lack of information.

*Note* : for the sake of simplicity, in this chapter, the word 'project' refers to a collection of measures or to an isolated measure.

### 7.1 Completed, set-up, on-going and planned projects

This section describes the current and planned states of the main projects relating to zones: West, Center West, East, Center East and the entire coast (*stricto sensu*).

#### 7.1.1 West Zone (BJ1-a and BJ1-b)

The West Zone comprises two problematic areas with regards to coastal erosion: the strip of land in Hillacondji and the dynamics of the Bouche du Roi (mobile mouth of the Mono river). Opportunities to develop this zone lie in activities of agriculture, fishery, tourism and nature conservation.

The rehabilitation of the Togolese groynes close to the border has aggravated erosion at the hot spot of Hillacondji. If the strip of land between the ocean and Togo were to disappear, this would imply the loss of habitations on it (which are already partially destroyed) and of a part of territorial waters of Benin.

The Bouche du Roi is a valuable spiritual and ecological site. It also englobes some villages part of the district of Grand-Popo. That mouthing was destabilized when the dam of Nangbéto was built, and its mobility has accelerated since then. Moreover, the zone is sensitive to floods caused by the floods of the Mono river (natural or due to the water release from the dam).

Some the projects and measures on-going for the management, protection and valorization of the coast there include:

- Municipal decree forbidding the sale of lots between Grand-Popo and Avlo (effective measure),
- Actions to relocate the people who lost their houses in Hillacondji (ongoing with help of the ANPC),
- Development plan (writing ongoing) that comprises:
  - Filling the dead arm of the lagoon in Hillacondji,
  - Construction of recreative infrastructure on the beach,

- Plantation of a line of trees at the Place du Dix Janvier (ongoing), dredging sediments from the North shore to the South shore of the Mono river (under consideration),
- Municipal decree concerning the ACCB Bouche du Roi : local convention of natural resources managements on the site of the Bouche du Roi (in the framework of the Transboundary Biosphere Reserve in the Mono Delta project, signed and under the responsibility of the association Doukpo): zoning measures, surveillance, development, access restrictions, etc. (Commune de Grand-Popo, 2016),
- Alert to national authorities in reaction to the rehabilitation/construction of Togolese groynes up to the Benin-Togo border: citizen mobilization that has led to the interruption of the works,
- Opening an artificial breach west to the natural location of the Bouche du Roi (regularly because the breach naturally migrates eastwards where it closes),
- Etc.

In addition, West Zone is part of the study area concerned by the « Project of Coast Protection between Djondji and Hillacondji » (conducted by DABC/MCVDD). In this project, the following options are considered:

- Combination of short groynes and breakwaters to protect the coast between Hillacondji and Grand-Popo,
- Massive and regular beach nourishment (from marine or terrestrial sources; other protection options considered are a long groyne field or other combinations of hard engineering structures (Norda Stelo, 2016),
- Regular breach opening (every 5 years) of the mouthing of the Mono river (as currently done) and relocation of the populations of Hokoué and Docloboé.

### **7.1.2 Center West Zone (BJ1-c and BJ2-a)**

The Center West Zone is less threatened by coastal risks than the others, though local erosion occurs. Opportunities in this zone mostly concern the development of tourism sector (like the Project of Touristic Development of the Fishery Road, the Gate of No Return, etc.) and the preservation of natural areas (Ramsar site 1017, community areas of biodiversity conservation, protected marine areas).

Currently no particular measure is undertaken for coastal protection in zone Center West. Within the framework of the « Project of Coast Protection between Fidjrossè and Ouidah » (conducted by DABC/MCVDD), the option of breakwaters to treat the most sensitive locations is examined.

### **7.1.3 Center East Zone (BJ2-b to BJ2-d)**

In Center East Zone, the dominant land uses are urban, port and airport. West of the port, the beach is strongly accreting. East of the port, there is a hot spot between the Channel of Cotonou and the Siafato groyne. Opportunities in this zone mostly concern port and urban development.

#### Protection of the Port of Cotonou

During the construction phase of the Port of Cotonou in 1960-1962, the West groyne, the East groyne and the Siafato groyne were built to protect the Port (from siltation) and the segment in the east of it (from erosion). The East and Siafato groynes have been efficient until 2008, when the West groyne was extended 300 m (though they have caused the acceleration of erosion after the Siafato groyne, in the Sector of Ambassadors).

In 2008, the West groyne was extended. This have reduced the siltation in the port (and consequently the dredging costs) and intensified the accretion between Fidjrossè and the port.

However, it has also made the East and Siafato groynes ineffective and resulted in a considerable aggravation of erosion in the hot spot and behind the Siafato groyne. Compensation plans were foreseen but not applied and there is an absence of communication and concertation between the stakeholders from civil society and port authorities.

### Protection East to the Port of Cotonou (hot spot)

To counter the acceleration of erosion at the hot spot between the Channel of Cotonou and the Siafato groyne, structures have been built by private sector financing, at the Biergarten hotel:

- Levee,
- Partial hardening of the facade,
- Artisanal breakwaters (with the available rocks from destroyed buildings).

These protection structures are not sufficient to stop the intensive erosion.

In the framework of the “Reinforcement and urgent protection works to the East of Cotonou”, several hard engineering options are considered for this hot spot, like a combination short revetment - additional groyne west to the Siafato groyne, or a series of 8 (?) short groynes (Roche, 2015).

### Sector of Ambassadors : groynes and revetment

East to the Siafato groyne, the area is mostly covered by industrial activities (car parks, industrial free zone, SIBEAU site of wastewater treatment). Erosion is very high in this area, causing the loss of land and a punctual source of pollution (SIBEAU site).

A field of 7 long groynes has been built east to the Siafato groyne between 2012 and 2014; in addition, the Siafato groyne was rehabilitated and a breakwater was added. The works were completed by a 300 m revetment. In addition, massive sand injections were recommended. The project has been modified several time, mostly due to the delay between the technical studies and the effective construction phase of the groynes (about 10 years), during which the shoreline has retreat more than 100 m. Erosive effects have subsequently affected residential areas east to the last groyne (#7).

The long groynes have generally been efficient, generating the classical scheme of upstream accretion / downstream erosion. Groyne #1 was not very efficient. Moreover, sand injections have clearly been insufficient.

The ongoing project of “Reinforcement and urgent protection works to the East of Cotonou” aims to improve the protection in this area through the construction of two intermediate groynes and a revetment, completed with the necessary sand injections. The project is in an advanced stage, and currently under the process of selecting a construction company.

### SIBEAU site

In the framework of the same project, a protective revetment was advised to protect the decantation basins of the SIBEAU site east to the last groyne. This option is no longer appropriate due to the current position of the shoreline, and to the fact that the sea has already destroyed 4 of the 6 basins.

The construction of a second commercial port on the territory of Sèmè-Kpodji is seriously under consideration. If it is built in the coming years, it should most probably have a similar impact to that of Cotonou on the sedimentary dynamics. A detailed study was already achieved (Pétrolin, 2015) within which mitigation measures are planned for coastal erosion: a sand transfer system and an initial stock of sand (1 million m<sup>3</sup> to the West and 6 million m<sup>3</sup> to the East of the future Port). The detailed environmental study impact was assessed by the Netherlands Commission for Environmental Assessment (CNEE, 2016), that has also suggested to examine to possibility of a sand motor to guarantee the continuity of sediment transfer.

### Floods

Next to coastal erosion, the populations are also exposed to floods. The risk is higher in urban areas like Cotonou, where the ground level is very low and the river and lake banks are densely occupied. In addition, the drainage network is not sufficient and often obstructed. Intense floodings have occurred in 2010, affecting the whole country, have highlighted the exposure of population and activities to this risk (World Bank and United Nations, 2011).

Several measures are undertaken by local authorities like regular cleaning and dredging of gutters, digging trenches, pumping and evacuation excess water, paving ways, building retention basins, extending the sewer network, through many completed and ongoing projects, like the 3CI project

(“Opération Cotonou en Campagne Contre l’Inondation”) and the PUGEMU project (“Projet d’Urgence de Gestion Environnementale en Milieu Urbain” – Emergency protection and environmental management in urban areas).

Reactive measures are directly undertaken by the population, like strengthening and rebuilding houses, structural adaptation (stilt houses), building dikes and evacuation ditches, support to victims (more efficient and faster than the authorities), and for people living directly in risky areas, temporary or definitive migration (Credel-ONG, 2010).

Several NGO’s are also active in providing assistance to victims, identifying risk areas and awareness/communication actions (project PCUG3C, Credel-ONG, etc.).

#### **7.1.4 East Zone (BJ2-e)**

The East Zone is mainly covered by agricultural areas (coconut groves), natural areas (protected forest) and houses (Sèmè, Kraké). Erosion is moderate to high and causes the loss of cultivated and inhabited land. In addition, the interstate road comes very close to the shore near the Nigerian border. Opportunities there concern mostly the development of industry (industrial free zones, project of a new commercial port), preservation of natural areas, continuation of rural and fishery activities.

Presently, the only known measure consists of the forced retreat of inhabitants whose houses and installations are swallowed by the sea. To our knowledge, local and national authorities do not provide assistance to this retreat.

#### **7.1.5 Overall projects**

Projects and measures applying to the whole coast are inventoried here.

##### Knowledge and communication

Several research and communication projects have been implemented or are ongoing. They do not always directly address to the risk reduction (through reduction of hazard, vulnerability and/or exposure) but they provide important support to motivate and implement more applied projects.

Universities and research centers in Benin have been active for decades in the characterization of the Beninese coastline and in the research of causes and solutions to coastal risks. Several projects of coastline monitoring and sedimentary hydrodynamic research have been completed or are ongoing (Coastal Erosion, 1986-1990; Regional study of the shoreline of West Africa, 2010; *SAP-Bénin*, 2013-2017, etc.).

Within the framework of the WACA programme, a sediment transport study on the entire Beninese coast is ongoing, supported by modelling tools (Deltares, 2014). Up to now, only local models had been used, in the framework of coastal protection or development projects. A study at national scale is a powerful and cheap tool to support the understanding of coastal dynamics. Moreover, it is adaptable to implementation of scenarios (constructions, adaptation, etc.).

Several projects of datasharing platforms have already been launched, like Ordinafrica (regional scale), MOLOA (regional scale), SNIEAU (national scale). These platforms often lack fundings to insure their long-term continuity. In addition, their performance is limited to the reluctance of the data-owners to share them.

An early-warning system has also been set up since the floodings of 2010 and its capacities were strengthened by acquisition and installation of monitoring devices, training, etc. (*SAP-Bénin* project, 2013-2017). The EWS is supported by a real-time monitoring network. It generates alerts transferred to the National Agency of Civil Protection.

Several NGO’s are regularly involved into communication actions to increase awareness of populations and authorities to coastal and other issues.

Finally, the ABE is helped by external expertise to assess the quality and pertinence of environmental and social impact studies before delivering the environmental compliance certificates. For instance, an second opinion was asked to the Netherlands Commission for Environment Assessment on the

environmental impact study of the potential future port of Sèmè. This initiative helps to compensate for the eventual lack of expertise of institutions.

#### Land use management

The « Hundred Steps of the King » (« Cent Pas du Roi ») is applied over the entire coast. It consists of restricting the land use and activities over a 100 m width from the coastline. These hundred meters are considered property of the State and municipalities are in charge to deliver or refuse authorizations to use this strip of land. This measure allows to spare a width of beach that can then be used to implement other measures. There is however a legal vacuum regarding the ownership of the land on eroding segments, when this width reaches terrain already sold.

#### Legislation and regulation

Since 2008, the 2008-615 decree forbids sand extraction on the beach. Extraction activities have indeed long contributed to the sediment shortage. The FULAM NGO has fought many years to increase awareness of politics and to adopt this measure. Illegal extraction still occurs but of lesser extent. The counterpart of this measure is the promotion, through tax incentives, of sand extraction in lagoons from 2009, from the quarries created in the lagoons of Porto-Novo, Cotonou and Abomey-Calavi, shifting the problem upstream.

The Littoral Law is a draft legislation from 2000-2002 that has never been voted by the Parliament. It aims to provide a strong and sustainable legal framework on any planned action to promote a sustainable coastal zone management. It is under actualization by the ABE. A Littoral Law can become a powerful tool, especially if open to modifications. Ideally, this law should be robust to any political changes (one of the limiting conditions of a sustainable management of the coastal zone), improve the attractiveness of the coastal zone for private sector and be open to innovative adaptation solutions.

#### Institutions

The Beninese Observatory of Coast and Sea is currently involved in an institutional reform project, aiming to develop help tools for decision-makers and for national policy assessment of coastal management.

A National Cell for Protection and Management of the Coastal Zone (*Cellule Nationale de Protection et de Gestion du Littoral* – CNPGL) was planned in the original text of the Littoral Law but never implemented. Such a cell would have to take in charge the overall management of the coast and would have a decision power regarding any project/activity that could affect the coastal zone. The creation of this cell would be specified in the Littoral Law and would require an important effort in training.

Next to this, the ABE has also established a Programme of Integrated Management of Environment and Climate Change (*Programme de Gestion Intégrée de l'Environnement et du Changement Climatique* – PGIECC), which address to the overall management of natural risks (drought, floodings, late and severe precipitation events, sea level rise) through a multi-sectoral approach (ABE, 2016). The PGIECC is based on the vulnerability per sector (established in the framework of the PANA programme – National Action Programme for Adaptation to Climate Change) and aims to strengthen the institutional capacities of the ABE, to promote inter-sectoral and intercommunal actions for environmental management and to develop specific analytic and research tools. This project includes a section dedicated to the integrated coastal zone management.

#### Hard engineering protection proposition

A hard protection project along the entire coastline with help of a seawall was proposed by the private sector (Alapini, 2016). Such a protection would preserve the existing land but also cause the loss of the whole beach and the access to the sea for fishermen who depend on it (unless adding necessary adjustments). The initial investment and the maintenance costs would be extremely high. Besides, careful and constant maintenance would have to be carried out.

#### Floods

Floods in urban areas is the core of the ongoing PUGEMU project, started in 2012, that focuses on urban agglomerations from Ouidah to Port-Novo.

This project includes construction, development and rehabilitation of infrastructure (dredging, sanitation, dump sites, etc.), actualization and operationalization of contingency plans, development plans, standards and regulations, institutional reinforcement, communication and awareness actions. The actions undertaken target improve five components: improvement and rehabilitation of the dredging systems, solid waste management, support to wastewater management, support to prevention and management of floods and natural disasters, and project management.

In addition, a Delta Plan is being prepared (“PPEA”) for the Lower catchment of the Ouémé river and of Lake Nokoué . This should end up to a plan for restoration and rehabilitation of the exploitation of the downstream part of the Ouémé river and its delta. A possibility to create polders in the southern part of Lake Nokoué is considered, to both reduce floods and space shortage for urban development.

## **7.2 Proposed projects**

The projects proposed here are formulated based on the ideas initially proposed and the input of the participative workshop with stakeholders on October, 24<sup>th</sup> and 25<sup>th</sup> 2016. The projects addressing the same spots as some other pre-cited projects in the above section are compared together with a multi-criteria analysis to assess their global impacts. The list of criteria and indicators used is given in Chapter **Fout! Verwijzingsbron niet gevonden.**, page 17 (Table 2.1).

On short term, it is important to prevent making things worse in the identified hot spots, with help of palliative measures (that can eventually be temporary if the hot spot cannot be saved on the long-term) and to provide acceptable compensation and living conditions for the affected population.

On long term, coastal management must be sustainable over the entire coastline (at national if not regional scale), and involve all active sectors so that the defined long-term vision of the coastal zone is integrated into their development plans. This vision must define the big projects to achieve plus the aspects of maintenance and monitoring.

To achieve this objective, it is thus required to take the necessary flanking measures, such as setting up performant institutional, legal, financial and research tools.

The considered solutions on short and long terms are briefly described in sections 7.2.1 to 7.2.4. More details are given on project sheets in Appendix 5. The proposed measures are diverse. They are compared with each other and with other pre-cited ongoing/planned projects while relevant via an MCA whose results are summarized in Appendix 7.

The flanking measures are described in section 7.2.5. Some of them will be essential for the final development of selected projects.

### **7.2.1 West Zone (BJ1-a and BJ1-b)**

#### **From Hillacondji to Grand-Popo (BJ1-a)**

The study conducted by Norda Stelo (preliminary design) details several technical solutions possible in Hillacondji, valid on both short and long term (Norda Stelo, 2016). This study confirms that hard engineering structures are not recommended in this segment, for they would shift the problem eastwards. That study states that the most economic and environment-friendly solution consists of important and regular beach nourishment operations (every 5 to 6 years) from marine sources. The possibility of building a sand motor, such as the pilot one in Ter Heijde (Netherlands) but smaller (3.5 million m<sup>3</sup>) is also under consideration. For the present study, the various propositions of Norda Stelo are compared with each other (see Figure 7.1):

- Beach nourishment every 5 – 6 years (marine/terrestrial sources) (sheet A1.1),
- Sand motor (sheet A1.2),
- 73 short groynes (sheet A1.3),
- 30 long groynes (sheet A1.4).



**Figure 7.1 Compared propositions for the segment Hillacondji – Grand-Popo.**

**From Grand-Popo to the Bouche du Roi (BJ1-b)**

In order to decrease food risks from the Mono river on the site of the Bouche du Roi without negatively interfering with the sedimentary dynamics along the coastline, the option already used of digging an artificial breach at regular interval (every 3 to 5 years) is kept (sheet A1.5). This is a simple measure that does not provoke negative impact and that provides a small stock of sediment that can be reused somewhere close. It should be coupled to the relocation of populations of the villages located along the migrating path of the Bouche du Roi : Hokoué and Docloboé (see Figure 7.2).

About the strip of land between Grand-Popo and Avlo-Plage along which the vaudou site (“Place du Dix Janvier”) is located, the option of planting and nourishing the southern bank (through annual dredging) (municipality of Grand-Popo, sheet A1.6) is compared to that of evacuation of the vaudou site (sheet A1.7).

In addition, various other measures are proposed for a better management of the development and land use of the coast (sheet A1.8).



**Figure 7.2 Compared propositions for the segment Grand-Popo - Bouche du Roi.**

### 7.2.2 Center West Zone (BJ1-c and BJ2-a)



**Figure 7.3 Propositions for the Center West zone.**

Because the Center West zone is not highly risky, only measures of good management of land development and use are proposed in this zone:

- Local management conventions of natural areas (sheet A1.9),
- Maintenance/rehabilitation of roads perpendicular to the coastline (sheet A1.10),
- Local land use regulation and communication (city of Ouidah) (sheet A1.12).

The idea behind these measures is to avoid destabilizing the shoreline along the Center West zone, which is now in a rather equilibrium state (depending on the location), and to limit the development of vulnerable infrastructures in high hazard areas (see Figure 7.3).

Next to this, the Center West zone is intended to be dedicated to touristic development. Therefore, it is proposed to study the possibilities of protection in case of destabilization. This could eventually happen if substantial modifications occur in the west (e.g. it is expected that the future Adjarala dam causes a significant reduction in sediment supply). The study would contain the determination of the risky zones, the protection levels associated with these risk levels and subsequently, a spatial distribution of possible development (sheet A1.11), that would be consistent with the land use regulations (sheet A1.12). Due to the current equilibrium state of this zone, it is advised to focus on possibilities of soft engineering protection, less expensive and less invasive than hard engineering techniques.

### 7.2.3 Center East Zone (BJ2-b to BJ2-d)

#### From Fidjrossè to the Sifato groyne (BJ2-b et BJ2-c)

To reduce siltation, the PAC has carried out regular important dredging operations (annual dredging). The extension of the West groyne has been efficient to reduce the dredging needs and to create additional land west to it. The option of groyne extension is again considered by the PAC (sheet A1.14). It is compared to the possibility to install a sand bypassing system from west to east of the port (sheet A1.15), and to dredging at sea at the level of the accretion zone (sheet A1.16).

Concerning the hot spot between the Channel of Cotonou and the Sifato groyne (« quartier Jak »), emergency measures are proposed and compared:

- Local injection of sand (sheet A1.16),
- Geotextile bags parallel to the coastline (sheet A1.22),
- Rock material along the coastline (sheet A1.21).

These proposed measures are strictly palliative and aim to spare the remaining land until a global solution is chosen.

On the long term, the following measures are considered, though some of them are conflicting with the needs of the port to reduce siltation:

- Hydraulic sand bypassing from west to east of the port of Cotonou (sheet A1.15),
- Regular beach nourishment via dredging at sea in front of the accreting area (sheet A1.16),
- Hard protection with a series of 8 short groynes (sheet A1.17),
- Hard protection with one short groyne and a short revetment (sheet A1.18),
- Managed retreat of the threatened quarter (let the coastline evolve) (sheet A1.19),
- Hard protection with a seawall (sheet A1.20).

In any case, no strategy can be selected along the sensitive stretches of the Center East zone before a long-term vision of Cotonou (urban quarters and flood prone areas) is first set up, conjugated with the long-term vision of the Port of Cotonou. Indeed, when considering the cost estimates and the constraints implied by each of the propositions, it is of utmost importance that the Municipality of Cotonou and the PAC work together on their future development. If maintaining the coastline is the chosen option along the hot spot, the associated investment must be justified, for instance within the context of the development of an attractive seafront. Therefore, as a prior measure, a long-term land planning strategy of the city of Cotonou must first be set up (in particular for risky areas), that would take into account the long-term vision of the port development (sheet A1.13), and that will include the analysis of the various possible scenarii with the help of numerical tools.



**Figure 7.4 Propositions for the segment Fidjrossè – Siafato groyne.**

#### **From the Siafato groyne to the SIBEAU site (BJ2-d)**

The advanced project of building two additional groynes among the existing ones, and more important of providing consequent beach nourishment (800,000 m<sup>3</sup> per year!) to rebuild the beach in each cell between two groynes will start shortly (sheet A1.23). Before considering any additional modification in this sector, it is preferable to wait and observe how the new conditions will affect the dynamics (see Figure 7.5).

This choice is also justified by the planned construction of the future commercial Port of Sèmè-Kpodji. Similarly to the example given by the Port of Cotonou, it is likely that the erosion on this segment would decrease in intensity, to the condition that sufficient supply of sediment is brought and maintained in time.

Other technical options are also possible, again always combined with sufficient supply of sediments, like rebuilding the beach with help of submerged breakwater (concept of perched beach). In any case, protection of this segment must be supported by quantitative studies (simulation of scenarii, cost-benefit comparison) and be attributed sufficient financial means to pursue the maintenance of existing and future protection structures.



**Figure 7.5 Propositions for the segment Siafato groyne – SIBEAU site.**

In order to deal with the alarming erosion rate east to the last groyne, emergency propositions of beach nourishment (sheet A1.24) and of managed retreat of the most threatened residential and industrial areas (sheet A1.26) are compared. In addition, the wastewater treatment SIBEAU site must be evacuated as soon as possible (sheet A1.25).

#### **7.2.4 East Zone (BJ2-e)**

On the long term, necessary measures will strongly depend on the impact of the rest of the measures chosen at west of the East zone, in particular if these manage to efficiently compensate the sediment shortage caused by the obstacles along the natural drift (ports, dams, structures, etc.). The East zone is mainly eroding, with intermittent accretion pockets (see Figure 7.6).

The construction of the port of Sèmè is going to impact that state. The measures planned to mitigate its impact consist of temporary nourishment (using the sediments extracted from the construction of the port) until a sand bypassing system from west to east becomes operational (sheet A1.27).

In reaction to the actual erosion (and most probably to the future erosion, depending on the effects of the new port and of climate change), the following measures are considered to adapt the rest of the coast up to the Nigerian border:

- 30 short groynes from the future port to the Nigerian border (sheet A1.28),
- Managed retreat of activities and houses, and setting up a natural buffer area between the coast and the interstate road (sheet A1.29).

Next to that, due to the proximity of the interstate road from the coastline near the Nigerian border, it is also proposed to rebuild a section (6 km) of this road further landward (sheet A1.30).



Figure 7.6 Proposition for the East zone.

### 7.2.5 Flanking measures

Beside the measures describes in the previous section, a series of flanking measures is proposed in the plan, in response to conclusions extracted from the analysis of Chapters 0 and 6 and from results of the participative workshops.

These flanking measures aim to strengthen the local projects proposed in order to guarantee their coherence and continuation. They address to lack of knowledge, management practices and regulations that concern the Beninese coastal zone. These measures are detailed on project sheets A2.1 to A5.1 of Appendix 5 and are divided into 4 themes:

- Strengthening of the legal and institutional framework: this theme englobes the legal and institutional needs for coastal management,
- Maintenance aspects of adaptation and protection strategies: this theme concerns the measures to implement to guarantee the long-term maintenance and monitoring of the selected local measures,
- Strengthening of knowledge and communication: this theme comprises measures to provide and maintain a technical support to coastal management, as well as the diffusion of information,
- Strengthening of international collaboration: this theme concerns the collaboration between West African countries, to prevent potential conflicting situations and to elaborate strategies at international scale.

## 7.3 Selection of projects for the plan

The table of Appendix 6 is the list of all measures considered in sections 7.1 (planned projects only) and 7.2 to elaborate the investment plan. When several options are possible for a given stretch, they are confronted with each other by an MCA analysis. This analysis allows to compare visually and, in this study, quantitatively the various options regarding to several criteria: social impact, economic impact, environmental impact, infrastructural impact, costs and feasibility.

The MCA is based on weighting factors equal for all criteria. A ranking of the solutions can then be extracted. Nevertheless, the weighting process is a question of strategic choice. It is important to consider results for each criteria separately. Therefore, the chosen option is not always the highest ranked one in overall, not if it is not in line with the main strategic vision of development in the considered zone. For instance, if an option scores best in overall (e.g. due to a very low cost) but very poorly for economic impact, it has less chances of being selected in the end.

The discussed results of the MCA for each comparison are described in Appendix 7. By default, all flanking measures are kept in the final plan. In addition, there are no comparable options in the Center West zone (only complementary projects are proposed in this zone).

The final projects presented in Chapter 0 are the results of this analysis, guided by the main strategic axes associated to each zone. However, changes in the choice of these projects can be motivated by a change of vision from (local and/or national) authorities. The plan contains the “preferable” propositions within the framework of this study. The other options can thus still be considered.

## **8 Multi-sectoral investment plan**

---

### **8.1 Introduction**

As described in Chapter 7, adaptation projects and measures have been and are being implemented to confront or mitigate the damages. In Benin, many of these measures are isolated, because of a lack of financial and/or technical resources and of coordination between stakeholders. Therefore, their impact is often temporary, very local and sometimes even detrimental for the rest of the coast.

Several ambitious projects have already been implemented but always in order to maintain the coastline only along a very short length, with results that were sometimes positive, sometimes disastrous, often a mix. In addition to the very high costs of implementation, the almost systematic absence of maintenance and monitoring has significantly reduced the structures' efficiency. Furthermore, compensation plans for people and companies suffering a negative impact because of these structures are rarely applied. The absence of an integrated vision, in coordination with the neighboring countries, limits the possibilities to reduce natural erosion and provokes the apparition of hot spots.

Several actions at national and regional scales are being undertaken. Scientific research about coastal dynamics is already very active in universities and research centers. Benin participates in several regional and international programs. Coastal management is covered by some national laws and regulations, though there is still much to do about this.

A comprehensive view cannot be limited to the reduction of hazard but also of vulnerability and exposure of people, infrastructures and land. At the same time, it must account for all stakeholders and for the natural evolution of the coastline. In addition, the severe hazard in local, critical, locations require emergency actions.

On the short term, the situation must not get worse, in particular at the identified hot spots, with help of palliative measures (eventually temporary in case the hot spot could not be saved on the long term) and to provide acceptable compensation and living conditions to the affected populations.

On the long term, coastal management must be achieved as a whole and in a sustainable way over the entire coast (at national and even regional scale) and encourage all active coast sectors to integrate a long term vision in their development plans. This vision must fix both the big actions to achieve and their maintenance and monitoring conditions.

To achieve this goal, flanking measures are necessary to set up performant institutional, legal, financial and knowledge tools.

The investment plan proposed in this chapter is focused on 5 axes :

- Axis 1    *Local strategies***
- Axis 2    *Strengthening the legal and institutional framework***
- Axis 3    *Maintenance and monitoring of adaptation and protection strategies***
- Axis 4    *Strengthening knowledge and communication***
- Axis 5    *Strengthening the regional collaboration***

The selection of projects was performed among the list of all projects mentioned in the previous chapter, with help of a multi-criteria analysis and of expert judgment of the measures. The results of the MCA are graphically depicted in Appendix 7.

## **8.2 Hypothesis of the investment plan**

### **8.2.1 Global vision and objectives**

The plan presented in this chapter and summarized in Table 8.1 (page 89) is aimed to achieve a sustainable and integrated coastal management. It is mainly focused on the reduction of coastal risk : coastal erosion and floods. If technical measures were sufficient to reduce these risks without generating side effects, the multi-sectoral aspects of coastal development could be managed separately.

However, traditional methods to deal with the sea progress are not efficient enough, too expensive and/or harmful on the long term or downstream their locations. These lacks must then be compensated by coastal management techniques able to reduce the exposure to the risks.

Coastal management becomes then a much broader subject, that involves and affects all activities of the coastal zone and beyond. In this context, land use and development are major factors. One can choose to see the new constraints as opportunities instead of challenges, integrating the necessary modifications within a broader development project, such as the main strategic axes of land management and/or economic development.

When ambitions are big, so are the required adaptations, but options are also wider. Within this study, strategic choices were guided by the main development directions defined in the Master Plan for Littoral Development (SDAL), written in 2000-2002, while taking into consideration the current situation. The SDAL makes the distinction between four zones along the coast, expected to develop various sectors:

- West zone: agricultural, natural and touristic development,
- Center West zone: natural and touristic development,
- Center East zone: port and urban development, and
- East zone: industrial and natural development.

These orientations have been directing the big investments injected in the coastal zone for the last fifteen years.

Due to the probable significant sea level rise and increasing frequency and intensity of extreme events like sea surges, induced by climate change, it is essential to provide careful maintenance of infrastructures directly exposed and to limit the construction of new fragile infrastructures in risky areas. The adaptation to climate change and to its highly uncertain consequences requires to privilege no-regret interventions, i.e. interventions that can be adapted to changes in physical conditions. Soft engineering interventions and land zoning in function of the current and future risks (to further study) are generally more interesting than hard engineering options regarding to this aspect.

### **8.2.2 Temporal approach**

The plan describes actions that extend over about thirty years. Only this long-term horizon allows to consider high investment and maintenance costs, spreading them over several decades.

However, many of the proposed measures can (must) already be triggered within a much shorter time-frame (less than 5 years). This concerns mainly technical and decision-making measures.

Beside this, the severity of local erosion rates in some hot spots require imminent intervention. Several projects are already being undertaken to release pressure on these hot spots. The present plan partly concerns to these emergency measures, though they are not always in line with the main strategic axes of development. An emergency project can sometimes be advised in order to buy time to implement a more sustainable strategy.

### 8.2.3 Geographical approach

The plan is focused on the needs of the coastal zone *stricto sensu*, which means a strip of about two kilometers from the current coastline position. But the intervention area considered is the coastal zone *lato sensu*, much broader.

A part of the plan concerns overall projects, i.e. concerning the whole Beninese coast. Most of these measures are essentially non-technical.

Local adaptation projects presented are selected based on a chosen objective, considering the natural context (hazard characterization) and the main development axes chosen by the Beninese State. For each segment, four objectives are possible:

- Do nothing: let the natural processes act, accept the loss of land without any particular adaptation action (interesting concerning the costs, or in case the area is accreting),
- Rebuilding the beach: provoke accretion or taking advantage of natural accretion (interesting for new developments),
- Maintain the coastline: prevent the sea progress (interesting to maintain the land use and activities on existing land),
- Go with nature: let the natural processes act while develop mitigation strategies: reduce vulnerability, compensate for the loss of land (interesting if integrated within a strategic development plan).

The choice between these objectives has to be made by the decision-makers. In this proposed plan, this choice was guided by the main strategic axes of development of each zone, the current level of risk and the threatened developments at stake.

The main objectives associated to each zone are:

Zone	Main thematic sectors		Selected objectives
West zone	Agriculture, nature, tourism	→	Maintain the coastline
Center West zone	Nature, tourism	→	No action zone, sustainable land use and development
Center East zone	Développement urbain, port	→	Conflicting objectives: Sustainable land use and/or maintain the coastline (Cotonou) Maintain the coastline (Sèmè)
East zone	Industrie, nature	→	Go with nature, sustainable land use and development

### 8.3 Main strategic axes of intervention

Project sheets associated with the projects described here are presented in Appendix 5. (highlighted by green background).

#### Axe 1 Local strategies

##### A. West zone (BJ1-a and BJ1-b)

###### From Hillacondji to Grand-Popo (BJ1-a)



**Figure 8.1 Interventions in the West zone - segment Hillacondji - Grand-Popo.**

The stretch between the Togolese border and the city of Grand-Popo is a well-known weak area (hot spot), mainly occupied by fishermen communities (and farmers a bit more landward). Because fishery is the main activity of the inhabitants, and territorial waters are threatened, the chosen strategy in this area is to maintain the coastline.

To achieve this goal, the area will benefit from important **sand nourishment**, implemented as one big injection operation to build a sand motor, estimated to 3.5 million m<sup>3</sup> (sheet A1.2). These sediments will preferably be dredged from sea after identification of a source site with bathymetric means. It is the most advantageous option with regards to costs and lifetime. In addition, one sole sand injection, instead of regular sand nourishment, is less harmful to biodiversity. To set up this innovative measure, the design must be very careful. While determining the most adequate source site, due to the emergency of the situation, sand from terrestrial sources can also be imported from close quarries (this is less economic and more polluting, not advised on the long term).

In addition, it is essential to set up and apply strict regulation over land use in sensitive areas (sheet A1.8). The actions of the municipality of Grand-Popo are already directed to this direction and should be pursued. Land on the beach should preferably be used for fishery activities and small scale tourism.

The idea behind this is to keep forbidding the construction of new hard infrastructures too close from the coastline (applying the “Cent pas du Roi”) and to develop recreational activities accessible via rehabilitated tracks.

The development of the fishery sector is limited in space, it is thus important to evaluate the potential of the city and of the marine waters (in terms of number of fishermen and of fish stocks). Professional reconversion, already very common, will be supported to encourage the construction of hard structures only beyond the interstate road, when access to the sea is not essential.

The long-term objective is to maintain the beach to a certain width, wide enough to allow a reasonable community of fishermen to pursue their activities (depending on fish and space resources available), in healthy and sustainable conditions. Professional reconversion should help boosting agricultural and tourism sectors.

#### **Grand-Popo to the Bouche du Roi (BJ1-b)**



**Figure 8.2 Interventions in the West zone - segment Grand-Popo – Bouche du Roi.**

The sand supply in Hillacondji should normally help decelerating erosion up to Gbècon. Further east, a thin strip of land is used to connect Avlo-Plage with Gbècon. This strip is rapidly eroded by the Mono river in the north and by the ocean in the south. It is a regular phenomenon linked to the dynamics of the Mono river. Because of the current narrowness of the track (less than 100 meters sometimes) and of the low occupation rate, the chosen objective here is to let natural processes act. It is not recommended to take any technical measure to protect it.

To reduce the effects of floodings from the Mono on the people living in the lagoons, the **digging out of an artificial breach** every 3 to 5 years (sheet A1.5), already being applied for several decades, will be pursued. The sand dug out will be evaluated and, if adequate, transported to close local erosive stretches to help nourishing them.

On (middle to) long term, the track connecting Grand-Popo and the village of Avlo-Plage could be interrupted, which would cause the loss of the voodoo site. **This site will be relocated** so that a new location can be used for the voodoo events (sheet A1.7). Similarly, **the villages of Hokoué and Docloboé**, which will systematically be on the migration path of the mouthing, **must also be evacuated** and the population relocated (about 40 houses). This must be organized with a relocation program that will take care of providing equivalent to better life conditions to the relocated people (sheet A1.5).

The narrow strip of land (place du 10 Janvier and the Gbècon-Avlo-Plage road) is characterized by important challenges for infrastructure and socio-cultural sectors on one hand and technical difficulties to combat erosion on the other. In the present state of knowledge, it's not possible to claim that these two characteristics can be reconciled, that is maintaining this coast segment with engineering solutions, within a reasonable budget and with the help of "no regret" measures.

The decision regarding protection or no protection of this segment should rely on a much more deepened analysis, based on a **detailed technical and economic study of the possibilities of the conservation of the coast segment** compared to the consequences of its abandonment (sheet A1.7B).

Finally, it is important to preserve the natural site of the Bouche du Roi. The existing management convention already covers the aspects of maintenance and restriction access. Other measures are not necessary yet.

## **B. Center West zone (BJ1-c and BJ2-a)**



**Figure 8.3 Interventions in the Center West zone.**

The Center West zone (from the Bouche du Roi to Fidjrossè) is generally at equilibrium, except for some local erosion spots. The objective selected for this zone is to go with nature. Sub-objectives are: limit artificialisation of the coastline, limit exposure of future constructions to coastal hazards, preserve as much as possible access to sea for communities of fishermen, preserve and promote natural areas.

Therefore, **no large scale technical measure is recommended** to protect the coastline. However, there is no guarantee that the equilibrium/accretion state will be maintained, considering the expected increasing frequency of extreme events. Indeed, the beach profile is abrupt here and there along the coast, which makes it more vulnerable to high-energetic waves. At the moment, it is difficult to predict the long-term evolution of the coastline in this zone because it could be destabilized by local perturbation. The continuous monitoring of the coastline position and of wind and wave regimes (in fact over the entire coast) will help detect changes in the dynamics.

Local measures concern are mostly preventive and concern land development and occupation. **Hard constructions must be restricted directly on the seafront** (seafront hotels, marina). Promotors must be aware of the current and future risk levels before the sale of lands. They must also be conscious that, in case the sedimentary balance gets naturally disrupted (without it being the consequence of human intervention on the shore), no hard-engineering construction is planned to protect future development (sheet A1.12). To apply this measure, a clear and high-resolution map of coastal risks is needed. Finally, a coordination between risk level, protection possibilities and authorized development must be achieved. Therefore, a **feasibility study of the protection of this stretch** is proposed, focused on future touristic developments. This study will help determine which protection options are feasible and consequently, what land use can be authorized (and where) (sheet A1.11).

In addition, to encourage development further land inward and promote lagoon tourism, it is important to perform **maintenance (even rehabilitation) of the road network perpendicular to the coastline** (sheet A1.10). The construction of the Fishery road must keep a reasonable security distance from the coastline (the current track is less than 50 meters away from it here and there, which is not sufficient).

The planned green areas within the touristic project will be protected by **local management conventions**, as well as the other natural areas, which will define the vulnerable locations, the access restrictions and usage conditions (sheet A1.9). **Activities increasing the appeal for these valuable areas** will be performed (walking and exploring circuits, communication and awareness, maintenance and surveillance, training about sustainable environmental management) (sheet A1.12).

About social aspects, the local municipalities (Ouidah, Abomey-Calabi) and national authorities (MCVDD, ministry of Intern Affairs, ministry of Tourism) will make sure that the Plan for Reinstallation Action (*Plan d'Action de Réinstallation – PAR*) elaborated in the framework of the touristic project of the Fishery Road will be applied, to guarantee a safe and fair development of the area.

### C. Center East zone (BJ2-b to BJ2-d)



Figure 8.4 Interventions in the Center East zone – Cotonou.

#### From Fidjrossè to the Sifato groyne (BJ2-b and BJ2-c)

The beach is growing with a rather high accretion rate west to the port of Cotonou, due to the presence of the sand-blocking groyne. As it is almost filled, siltation in the port is expected to increase. In addition, the extension of this groyne has provoked a significant intensification of erosion between the Channel of Cotonou and the Sifato groyne (Quartier Jak). This segment is now more exposed to incident waves (high vulnerability to storms) and the west-east sediment current is now drastically reduced. This hot spot requires emergency measures.

On the very short term, the protection program of the coast east of Cotonou (MCVDD) foresees the **construction of a short groyne and a partial coating** of the hot spot in order to protect a part of the installations. These works will be completed by an initial sand nourishment (sheet A1.18). The present plan takes into account these planned developments. These should also be consolidated in the medium term by extra beach nourishment operation if they are necessary (sheet A1.16), while waiting for the definition of a long term plan. In addition, **mechanisms must be set up to provide compensation** as soon as possible (sheet A2.3).

No long-term strategy has been determined yet to address this stretch. Indeed, to choose an objective, it is crucial that the city of Cotonou defines in its territorial development plan a vision for its coast, in collaboration with the PAC.

Indeed, the pressure from the ocean is such that, to save this stretch from erosion, only hard technical options seem adequate, like a series of groynes, submerged breakwaters, seawall or continuous sand nourishment (through sediment bypassing from west to east of the port, or via dredging from sea). These propositions are very costly and can only be justified if the stretch becomes highly valuable.

But before choosing the option, a model of sediment transport is essential. It must be precise enough and able to predict the impact of various scenarios over (at least) 10 kilometers east to the port. Only then can impacts of various options be assessed in this segment, where hydrodynamics is complex.

The priority is thus to have the Municipality of Cotonou, the PAC and the Civil Society collaborate to **elaborate a long-term land planning strategy of the coastal zone of Cotonou** (sheet A1.13), in which reciprocal impacts are accounted for, as well as quantitative results of numerical simulations.

#### From the Siafato groyne to the SIBEAU site (BJ2-d)

This segment is partially being protected by a series of seven groynes and is occupied by residential areas (spreading from the urban area of Cotonou towards Sèmè-Kpodji). Since this protection is already existing, the selected objective here is to maintain the current position of the coastline, and even rebuild a part of the eroded beach if the sedimentary dynamics allows it.



**Figure 8.5 Interventions in Center East zone – Siafato to SIBEAU site.**

**Confortative works** are already planned to increase protection from the Siafato groyne to groyne #7 in the coming months, consisting of two intermediate groynes (between groynes #1 and 2, and between groynes #6 and 7), and modification and extension of the existing revetment between groynes #6 and 7. Furthermore, the area will be provided significant beach nourishment. For these works to be efficient, it is essential to **maintain nourishment operations** (sheet A1.23). An annual volume of 800,000 is estimated by Roche (2015). It is a long-term measure that must be integrated within a sediment management plan and could be implemented based on a long-term contract, in order to reduce costs. This important volume of sand will most probably be dredged from the sea. But while waiting that bathymetric assessment is achieved to identify one or several source sites, sand can be purchased from terrestrial sources on the short term.

There are other technical possibilities, provided that there is sufficient sediment supply, for example by reconstructing the beach through submerged breakwaters. In any case, the protection of the segment should be supported by quantitative research (simulation of scenarios, cost-benefit analysis) and will benefit from a thorough and well-financed maintenance program to ensure the maintenance of current and future works.

Downstream of the 7th groyne, the common effect of the groyne causes the alarming erosion of the residential and industrial areas (car parks), and of the fecal sludge treatment site SIBEAU. **A strategic relocation of all activities on this segment** should be carried out as fast as possible (approx. 1.9 km needs to be evacuated, including 1.2 km of residential areas, 300 meters of car parks and 400 meters of sludge treatment site) (sheets A1.25 and A1.26). The closure of the SIBEAU site has already been planned, simultaneously with the construction of a new station in the same Sèmè-Kpodji commune. The relocation of the site provides the opportunity to install innovative sludge treatment facilities in a secured and protected (against soil contamination) area. There are new treatment methods that give maximum value to the purification products (fertilizers, energy products).

In the probable case of constructing and completing the new Sèmè deepwater harbour within ten years, the surface that needs to be evacuated will be relatively reduced (approx. 30 ha of residential areas, 18 ha of industrial areas, due to the 30m erosion/10 years rate). In the long run, the presence of the new port will have a positive effect on this coast segment, in a way similar to the effect of the Cotonou Port on the Fidirossè beaches. The beach nourishment operations within the groyne system will decline and the coast line in this area should become stable.

The SIBEAU site (fecal sludge) constitutes a significant point source pollution. **The evacuation of this site** is one of the most urgent proposed measures. It's important to cut off the inflow of fecal sludge to this site immediately, to find a new appropriate site away from the coast and protect it (from soil contamination), and to **proceed to the mechanical removal of the sludge layer** on the beach that is currently washed away by the sea (sheet A1.25). The options for the recovery of fecal sludge will be researched.

#### D. East zone (BJ2-e)



Figure 8.6 Interventions in the east zone.

#### Future Sèmè-Kpodji Port

The new deepwater port project will take off in 2018. In view of the current progress, we can state that the port will be constructed within 20 years from today. In order to do that, it is imperative (and indeed expected by the environmental and social impact assessment) to install a **sediment by-passing system from west to east**. The installation needs to be carried out simultaneously with the landscaping projects of the port and should be included in the same budget. Moreover, the project includes the reuse of dredged materials during the construction for beach nourishment of the west (1 million m<sup>3</sup>) and east coast (6 million m<sup>3</sup>) for a period of 8 to 10 years, the amount of time needed for the by-passing system to become operational (sheet A1.27).

#### Krakè

The construction of the Sèmè Port will inevitably lead to the artificialisation of the 7 kilometers of coastline that will be affected by the project. The current state of erosion in the most eastern coast segment will probably become much more unstable.

Even if the by-passing system turns out to be sufficient, a long-term gradual erosion, that is already active at present, is expected.

In this area, mostly inhabited by fishing communities, taken into account the unpredictability of the dynamic behavior of the zone (influence of the new port and the consequent beach nourishment in

the western part), the selected objective is to adapt to nature, which means no investment in large protection procedures.

Indeed, any permanent protection measure is recommendable, at the risk of shifting the erosion towards Nigeria and creating international conflicts. Instead, **we recommend the establishment of an important natural « buffer » area** between the future port and the border (approx.. 10 km), south of the inter-State road (sheet A1.29). The surface will be reforested, preferably with species that are most likely to slow down the marine transgression. With these much-needed measures, the area will gain value and can even attract small scale tourism, which will contribute to boost the restauration areas near the inter-State road. In addition, the development of this area will compensate the loss of natural areas due to the port construction.

This measure implies that the safeguard of the fishing villages near the Nigerian border will be abandoned. This will have significant effects on the living environment of these communities and on formal/informal economy. The current speed of sea progress allows a spreading of these displacements, but not indefinitely. The commune of Sèmè will have to organize a **strategic relocation of part of these fishing communities** as part of their management plan (sheet A1.29).

Instead of imposing an extensive strategic relocation operation, the Sèmè commune will have the opportunity to spread the relocation (between one or two generations), to integrate it in its development and to link it to other activities. The commune needs to take full advantage of the big projects set up to boost its economy (port, industrial areas, new touristic attractiveness) so they can adapt the working population to the transfer of the available jobs and to develop no-risk areas. The population will receive material, financial and social aid in order to adapt to their new living environment. Professional retraining will be organized. Job finding help will be set up for the relocated inhabitants.

Eventually, **a section of the inter-State road (approx. 6 km) should be relocated** inland (sheet A1.30). Near the border, the distance between the road and the sea is less than 500m. Given the disturbed dynamics of the coastline, it is recommended to relocate the road towards the north, while raising its height to protect it (and to protect the adjoining houses) from potential lagoon floods. Cooperation with the Nigerian authorities could support the coordination of the relocation, which seems equally needed for the Nigerian part of the road.

## ***Axe 2 Strengthening of the legal and institutional framework***

### **A2.1 Loi Littoral**

All coastal risk reduction strategies should be solidly supported by a strong legal framework that is well defined and integrates all aspects of coastal zone management. This is the main objective of the **Loi Littorale** (coastal law) (sheet A2.1). It is a priority to pass this law and the necessary amendments. It will define the rules concerning coastal activity in the coastal zone in order to assure a rational and sustainable use. Apart from protective measures regarding the environment, general and by sector, the coastal law will also provide the creation of a coastal management agency (see below) and the development and following of the masterplan of coastal planning (Schéma Directeur de l'Aménagement de la zone Littorale) and of the masterplan of communes planning (Schémas Directeurs d'Aménagement des Communes). Several elements will reinforce the current law text (possibly in the form of subsequent amendments, in order to prevent even more delay in the adoption of the law). This concerns:

- A definition of the safety standards (levels of protection):
  - In accordance with a precise risk thresholds map (hazards and vulnerability/exposure),
  - Determine the security standards for each risk threshold accordingly,
  - Determine the acceptable land use for each of the risk thresholds.
- Coast protection and management agency :

- Define its mandates and decision-making capacities,
- Ensure that this agency holds legal power to manage delicate aspects such as landed property and land use restrictions.
- Mechanisms to compensate victims in case of damaging effects of the activities performed in the coastal zone
  - Definition of the agency responsible for the execution,
  - Definition of the sources of funding.

Simultaneously, the Coastal Planning Masterplan (Schéma Directeur d'Aménagement du Littoral) will be updated and will contain a 2D map, sufficiently precise at the level of risk, which will provide a base for the definition of security standards and support spatial planning. This Coastal Planning Masterplan will be consistent with the Master Plan for Urban Development (Schéma Directeur d'Aménagement et de l'Urbanisme).

## A2.2 Creation of a National Coastal Management Agency

In accordance with the future Coastal Law, coastal management and protection will be provided by an agency that only exists for this purpose (sheet A2.2). The establishment of this agency (by order) will be carried out by the MCVDD, which will need to respect following demands:

- Autonomy regarding its operation: its existence, functioning and actions are not limited by any change in policy,
- Autonomy regarding its funding : it has to generate enough income to ensure its own funding (a « coastal tax », applicable to all accommodations along the coast, is recommended),
- Decision-making authority : it holds the decision-making authority on any activity in the coastal zone or any activity that might have an impact on it,
- Represent all actors of the coastal zone : as well as public stakeholders; private, industrial and social stakeholders will be involved.
- Sufficient (human, financial, material) resources to successfully carry out its tasks.

The numerous assignments of the Agency will include :

- The definition of acceptable risk thresholds for coastal erosion,
- Update of the Coastal Planning Masterplan, adapting it to the restrictions imposed by the Loi Littorale (coastal law), and of the development lines defined by the National Agenda and SDAC,
- Participation in the EIA assessments of different projects concerning the coast
- Establishment, coordination and maintenance of a data-sharing platform (possibly as a payed service),
- Implementation of a **periodic coastal maintenance program**
  - measuring efficiency criteria of different protection strategies,
  - monitoring and maintenance plans for each protective structure along the coast,
  - if required, adapt « soft » measures.
- Development and application of a Sediment Management Plan
- Coordination of the continuous coastline monitoring
- Continuous and permanent training of its employees and of other agencies in need of expertise,
- Support the communes with the implementation of plans and conventions of sustainable management.

The periodic coast maintenance program will allow adaptations on a regular basis, based on the measured results, the selected strategies (in the case of reversible adaptations). The task that includes the maintenance and follow-up of protective coastal structures is of utmost importance. As a matter of fact, this represents the biggest weakness of previous protection projects. The State will be responsible for the budget for these maintenance works.

To this day, there is no such thing as an unique governmental structure entirely dedicated to the integrated management of the coastal area. Its functions are spread over numerous existing structures who manage the different aspects in a way that is too sectoral (DAT, ANDF, communes, ABE, DABC, PAC, MEEM, etc.) and don't represent the non-governmental actors with low influence, who are nonetheless of high interest. However, there are numerous ongoing initiatives aiming at a more integrated management. In this project, it is proposed to use the steering committee of the current study as an embryo for the future agency (arrêté de creation du groupe de travail multisectoriel chargé de la coordination du programme – juin 2015), who works since several months in an integrated way and gathers representative of numerous actors of the coast. This committee and its functions can expand by decree while waiting for an institutional study to make a proposition for the formation of an effective and autonomous Agency and the determination of its roles and mandates.

### **A2.3 Release of compensation mechanisms**

Even though this is not a protection or adaptation measure regarding coastal risks, it is important to ensure the effective compensation of the current victims (inhabitants, economic activities), provided by the State (for victims of the sea) and by those responsible for the deterioration of erosion-related risks (for victims of the protective structures), applying the “polluter pays principle” (sheet A2.3).

This is a significant burden on the State's budget. Nonetheless, this measure is essential in order to restore the trust of the victims towards the State. Moreover, it will stimulate the actors responsible for the deterioration of coastal risks to be more rigorous throughout the impact studies of future projects, as their own budget will suffer an impact as well.

A spreading of the compensation over a period of 10 years is recommended to reduce the burden on the State budget and other funding resources. In order to allow an effective compensation, the following activities should be carried out:

- Inventarization of the victims and of the total sum of compensations via a socio-economic assessment of the damage – identification of the victims is ongoing at MCVDD,
- Post-completion impact assessments (and therefore the possible financing sources),
- Implementation of a compensation plan spread over 10 years and the proper execution of this plan.

*Note* : the actual amounts of the compensation for victims of the project and of the sea are not included in the final cost of the plan at this time. The estimate and refund of the compensation depends entirely upon the State.

## ***Axe 3 The maintenance of adaptation and protective strategies***

### **A3.1 Program for regular maintenance of the coast**

A program for regular maintenance of the coast will be carried out and updated by the MCVDD (coast management agency) (sheet A3.1). This program will schedule all activities that need to be carried out for:

- maintenance of protective structures,
- consistency and adaptability of soft protection measures,
- Respect of spatial planning and land use measures.

The MCVDD will be responsible for the execution of the maintenance of the works. Surveillance, spatial planning and light maintenance activities can be executed by local authorities and NGO's.

### **A3.2 Continuous monitoring of the coastline and hazard and vulnerability mapping**

The evolution of the coastline should be continuously monitored. At present, this monitoring is financed by external agencies. The measuring network is currently expanding. In order to ensure the

consistency of this activity that is vital for coast management, the State will allocate a budget for the measuring equipment and its maintenance, and the processing, validation and dissemination of data.

Simultaneously, using meteorological and land-use data, a map of coastal risks and vulnerabilities will be elaborated and kept updated. This will serve as the basis of security norm definition and required levels of protection that need to be inserted in the Loi Littorale (sheet A3.2).

The structures involved in this monitoring are the MCVDD, the ministry of Scientific Research, the IRHOB, the Beninese Observatory of the Coast (l'Observatoire Béninois du Littoral).

### **A3.3 Sediment management plan**

The major cause of the coastal erosion and of the growing vulnerability of the situation in Benin is the lack of sediments arriving by natural drift (Togo) and through the big rivers (Ouémé, Mono). Natural drift is indeed severely blocked by various ports and existing protective structures. The sediment transit coming from the rivers is mainly affected by the presence of hydroelectric dams and fish traps (« acadja »). The recommended beach nourishment at the local level applies to the main cause of erosion. A sediment management plan will be set up in order to ensure these beach nourishments (sheet A 3.3), which will aim to:

- set the sediment budget for each coastal zone (supplies from natural drift and rivers),
- identify and adapt the need for refills (volumes, frequency, injection sites),
- identify sediment sources and resources,
- economic analysis (cost-benefit, compromise),
- environmental assessment (vulnerable areas),
- establish acquisition, distribution and transport logistics.

It is important that the management plan is updated through the gradual incorporation of new data. Therefore, the developed model needs to be made available of the agency responsible for the implementation of the plan, and the staff will be trained to adapt this model. The adaptation of the base model can form part of the activities in the context of the coastal maintenance periodic program.

## ***Axe 4 Strengthening of knowledge and communication***

### **A4.1 Manufacturing and updating baseline maps**

Benin needs to acquire precise baseline maps, that are geo-referenced, validated, updated and accessible in a typical GIS format (examples: shapefile, raster, tiff, TIN) (sheet A4.1). These baseline maps will have the advantage of being updated on a regular basis if consequent changes are found and will provide validated data. These will provide a reliable basis for the design and impact study and for research.

The important maps in the context of coastal management are:

<b>Data</b>	<b>Current availability</b>	<b>Recommended format</b>	<b>Recommended resolution</b>	<b>Recommended update frequency</b>
Land use	large scale maps (regional, global), lack of precision, national maps ?	Shapefile, raster, tiff	1 : 100 000	1x/5 years + each time a consequent modification is reported by the local authorities
Population density	Distribution by commune, based onRGPH4	Shapefile	Per administrative sub-district	After every census
Soil type	Existing map (format ?)	Shapefile	Training	1x

<b>Data</b>	<b>Current availability</b>	<b>Recommended format</b>	<b>Recommended resolution</b>	<b>Recommended update frequency</b>
Bathymetry	Local data, measured for studies (Roche, Baird, ...), no immediate availability	Raster/TIN	Variable	1x/20 ans
Numerical land model	New NLM under development (EU-UNDP project)	Raster	≤ 5m	1x

These baseline maps will provide a basis for the elaboration of many other products and reduce the double effort in the case of studies. There are multiple applications in the fields of research, engineering, planning, insurance, etc. The maps will help reduce the amount of time for the study and will ensure the reliability of the used data. Their use will be determined by a contract, of which the income will serve to maintaining the products updated in the long term.

The production and provision of these maps will be organized by IGN-Benin. Research centers, universities, ABE, INSAE and local authorities will help with the collection and compilation of the information resources.

#### **A4.2 Strengthening of knowledge regarding the coastal area**

There are numerous ongoing research projects in order to strengthen the knowledge about the environment in different aspects: physically, socially, economically, environmentally, institutionally, legally, etc. It's important to ensure the support to research activities carried out by universities and research centers, particularly the promotion of projects in line with the big strategic orientations of development of the country (sheet A4.2).

In compensation for the financial and technical aid, the researchers will provide expertise to the decision makers, will contribute to the communication and popularization of the progress within their field towards the less informed communities, emphasize the progress in Benin at an international level and participate in the continuous training of the staff local and national authorities.

#### **A4.3 Data collection and distribution**

A large number of data collected by measuring and observation may offer technical support to coastal management. However, these are spread over different public and private organizations, which measured them, stocked without record keeping and without any indication of their existence. This significantly slows down the analysis activities on several levels. This is why one of the objectives of this axis is to collect and bring together all existing data within one big, online accessible platform. This platform will ensure data storage, validation and distribution (possibly as a paid service) (sheet A4.3).

Such a platform should be set up by linking the numerous organizations responsible for data collection (universities, IGN, météo-bénin, INSAE, antenne béninoise MOLOA, IRHOB, ministries, etc). This will include various types of data: time series, maps (reusable format), reports and publications, real-time data, etc.

The platform can also contribute to the communication about the progress of big projects. Several examples of this kind of platform already exist for different domains (examples: Ordinafrica – fishery research, SNIEAU – water resources). This project could possibly be added to one of this existing platforms or create a new one, but the stability of the funding will be a major aspect in order to ensure the continuity and quality of this service. Therefore, the platform needs to be self-sustaining, through the creation of its own measuring network or charging some data. However, a basic service should be

made available for everyone, concerning real-time risk assessment (in case of extreme events) (the elaboration of this service can be coordinated with the activities of the ongoing SAP-Benin project).

#### **A4.4 Support for communication strengthening between the different coastal stakeholders**

Communication activities between the stakeholders of the coastal area of all levels will be promoted (sheet A4.4). The communication between following actors needs to be encouraged in particular:

- Interdepartmental (regular meetings),
- Between national authorities and the population (distribution of notice of public hearing, civic representation in important meetings),
- Between local authorities and the population (distribution of new regulations, transmission of complaints to competent authorities),
- Between local authorities and the buyers of parcels : whether for private use or professional use, the buyers should be informed prior to the purchase about the risk level of the parcels they want to purchase, about the restrictions on their use and strategies applying to them (especially if the State has decided to not provide any protection within the concerned segment).

Various communication channels will help improve the communication : public hearings, public announcements, production of brochures, press releases, informative sessions, internet, local meetings, interdepartmental meetings, etc.

### ***Axe 5 Strengthening of regional cooperation***

#### **A5.1 Platform for international cooperation**

An international cooperation platform (sheet A5.1) for an integrated, regional scaled coast management will enable the coordination of the efforts of multiple countries in their battle against coastal risks :

- assure the consistency of the selected technical options,
- develop adaptation and protection projects on several countries,
- prevent conflicts related to the negative consequences of certain options,
- map out an international legislation.

The neighboring countries will have to show a great deal of effort and work together to set up this project. This means an event will be organized each 1-2 years, gathering the institutions responsible for coastal management and the different stakeholders. The platform can be based on the transnational river commission. The main strategic focusses of coastal development of each country will be presented. New projects (protection projects in particular) will be presented and discussed.

The networks installed during the execution of the follow-up study on the entire coastline of West Africa, of the SDLAO development and the establishment of MOLOA can be reused to serve as a framework for this new platform. Integrating this activity in the MOLOA calendar is another option.

## 8.4 Summary table

Table 8.1 Summary of the multi-sectoral investment plan.

N° sheet	Activities	Responsible stakeholders	Initial investment		Maintenance/follow-up/surveillance	
			FCFA	€	FCFA/year	€/year
<b>Axe 1 : Local strategies</b>						
<b>West Zone</b>						
A1.2	Sand motor at Hillacondji	MCVDD, Municipality of Grand-Popo, OBRGM (MEEM)	23,500,000,000	35,720,000	900,000,000	1,368,000
A1.5	Regular opening of the river mouth of Mono and evacuation of the population of the Hokoué and Docloboé villages	Municipality of Grand-Popo, DGFRN (MCVDD), DG-Eau (MEEM), MAEP	1,500,000,000	2,280,000	11,000,000	16,720
A1.7B	Technical study for the long-term protection of the road between Gbècon and Avlo-Beach and the vaudou site of the Place du Dix Janvier	Municipality of Grand-Popo, ANDF (MEF), ANPC (MISP)	100,000,000	152,000	0	0
A1.8	Local spatial planning measures (Grand-Popo)	MCVDD (DABC), municipality of Grand Popo	89,000,000	135,280	0	0
<b>Total Axe 1.1</b>			<b>25.2 billion</b>	<b>38.3 million</b>	<b>0.91 billion</b>	<b>1.4 million</b>
<b>Center West Zone</b>						
A1.9	Local planning and conventions concerning the management of natural areas (Ouidah)	Local authorities (mainly municipality of Ouidah), MCVDD (ABE, DGFRN)	900,000,000	1,368,000	35,000,000	53,200

N° sheet	Activities	Responsible stakeholders	Initial investment		Maintenance/follow-up/surveillance	
			FCFA	€	FCFA/year	€/year
A1.10	Maintenance of perpendicular roads along the coastline	MIT, municipality of Ouidah and Abomey-Calavi, ABE (MCVDD)	18,000,000,000	27,360,000	430,000,000	653,600
A1.11	Feasibility study on the coastal protection of the Center West area	MCVDD (ABE, DABC)	100,000,000	150,000	0	0
A1.12	Local spatial planning and communication measures (Ouidah and Abomey-Calavi)	Municipality of Ouidah and Abomey-Calavi, MCVDD, ANPC (MISP), ANDF (MEF)	52,000,000	79,040	0	0
<b>Total Axe 1.2</b>			<b>19.1 milliards</b>	<b>28.8 millions</b>	<b>0.47 billion</b>	<b>0.71 millions</b>
<b>Center East zibe</b>						
A1.13	Long term spatial planning strategy (Cotonou)	MCVDD, ANPC (MISP), ANDF (MEF), mun. of Cotonou	275,000,000	418,000	0	0
A1.16	Beach nourishment (with marine materials) in Jak area (long term)	ABE (MCVDD), OBRGM (MEEM), Mun. of Cotonou	0	0	690,000,000	1,049,000
A1.18	Construction of a short groyne and coating + initial beach nourishment in Jak area	MCVDD (ABE, DABC), Municipality of Cotonou	12,300,000,000	18,696,000	90,000,000	137,000
A1.23	Groyne field : 2 intermediate groynes + regular coating and refill + maintenance of all constructions (9 groynes and revêtement)	MCVDD (ABE, DABC), municipality of Cotonou, ANPC (MISP)	13,000,000,000	19,760,000	620,000,000	943,000
A1.25	Évacuation of the SIBEAU sludge treatment site	MEEM, municipality of Sèmè-Kpodji, ABE (MCVDD)	3,850,000,000	5,852,000	0	0
A1.26	Strategic relocation of the houses and car parks after groyne n°7	MCVDD, ANPC (MISP), ANDF (MEF), muni. of Sèmè-Kpodji	4,000,000,000	6,080,000	0	0

N° sheet	Activities	Responsible stakeholders	Initial investment		Maintenance/follow-up/ surveillance	
			FCFA	€	FCFA/year	€/year
	<b>Total Axe 1.3</b>		<b>33.5 billion</b>	<b>50.8 millions</b>	<b>1.4 billion</b>	<b>2.13 millions</b>
<b>East zone</b>						
A1.27	By-passing on both sides of the future Sèmè-Kpodji harbour, and temporary refillings	MIT, ABE (MCVDD), OBRGM (MEEM)	12,200,000,000	18,544,000	500,000,000	760,000
A1.29	Natural buffer zone between the future Sèmè-Kpodji port and the Nigerian border	MCVDD (ABE, DGFRN), municipality of Sèmè-Kpodji	16,500,000,000	25,080,000	18,000,000	27,360
A1.30	Relocation of a part of the inter-State road RNIE1 (6 km)	MIT, ABE (MCVDD), ANPC (MISP), ANDF (MEF)	6,000,000,000	9,120,000	0	0
	<b>Total Axe 1.4</b>		<b>34.7 billion</b>	<b>52.8 millions</b>	<b>0.52 billion</b>	<b>0.79 millions</b>
	<b>Total Axe 1</b>		<b>112.4 billion</b>	<b>170.8 millions</b>	<b>3.3 billion</b>	<b>5.0 millions</b>
<b>Axe 2 : Renforcement des capacités institutionnelles et juridiques</b>						
A2.1	Adoption and content of the Coastal Law	ABE (MCVDD) in partnership with all concerned ministries	231,000,000	351,120	0	0
A2.2	National Agency of Coastal Protection and Management.	MCVDD	4,200,000,000	6,384,000	225,000,000	342,000
A2.3	Release of compensation mechanisms	MCVDD, ANDF (MISP), concerned municipalities	20,000,000	30,400	0	0
	<b>Total Axe 2</b>		<b>4.5 billion</b>	<b>6.8 millions</b>	<b>225 millions</b>	<b>0.35 millions</b>
<b>Axe 3 : Maintenance des stratégies d'adaptation et de protection de la côte</b>						
A3.1	Periodic coast maintenance program	MCVDD	65,000,000	98,800	10,000,000	15,200

N° sheet	Activities	Responsible stakeholders	Initial investment		Maintenance/follow-up/surveillance	
			FCFA	€	FCFA/year	€/year
A3.2	Continuous monitoring of the coastline and risk and vulnerability mapping	Météo-Bénin, UAC, IRHOB (MESPRS)	750,000,000	1,140,000	41,000,000	62,320
A3.3	Sediment management plan	MCVDD, MEEM, universities, research centers	165,000,000	250,800	22,000,000	33,440
<b>Total Axe 3</b>			<b>1.0 billion</b>	<b>1.5 millions</b>	<b>73 millions</b>	<b>0.11 millions</b>
<b>Axe 4 : Renforcement des connaissances et de la communication</b>						
A4.1	Production and update of baseline maps	IGN, MCVDD	600,000,000	912,000	15,000,000	22,800
A4.2	Strengthening of knowledge about the coastal area	MESRC, MCVDD, universities and research centers, social and environmental NGO's	660,000,000	1,003,200	135,000,000	205,200
A4.3	Data collection and provision (online platform)	MCVDD	1,350,000,000	2,052,000	0	0
A4.4	Support to the strengthening of communication between coastal stakeholders	MCVDD	530,000,000	805,600	53,000,000	80,560
<b>Total Axe 4</b>			<b>3.14 billion</b>	<b>4.8 millions</b>	<b>203 millions</b>	<b>0.31 millions</b>
<b>Axe 5 : Renforcement de la collaboration régionale</b>						
A5.1	Regional cooperation platform	ABeGIEF (MISP), MCVDD, MOLOA, Ministries responsible for the coastal area (West Africa)	660,000,000	1,003,200	66,000,000	100,320
<b>Total Axe 5</b>			<b>660 millions</b>	<b>1 million</b>	<b>66 millions</b>	<b>0.1 millions</b>
<b>Total Cost</b>			<b>121.6 billion</b>	<b>184.8 millions</b>	<b>3.9 billion</b>	<b>5.9 millions</b>

## 9 Conclusion

The Investment Plan detailed in the last chapter is one of the WACA program stages for Benin coastal adaptation to coastal risks, in particular for those related to climate change. It describes briefly the main activities to conduct for a sustainable and coherent management of Benin coastal zone, in order to allow coastal risk reduction, while stabilizing the coastline when manageable, or by reducing population and facilities vulnerability and exposure in the opposite case.

The next steps will require a thorough examination of the options proposed in the plan. This plan (and the project sheets in Annex 5) gives the outline of the different aspects of each project, mentioning in particular an idea of the costs to invest, of possible financing sources, of bodies in charge of relevant actors, implementation time and of the pros and cons of each project.

WACA's action plan has the possibility to set up a coastal risk adaptation mechanism, which combines technical protection, rational use of space and good management. Because knowledge is not sufficient to determine in a certain manner the impact of climate change and of several installation changes on the coast, it is primordial that the coastal zone is being managed in an adaptive manner. The proposed plan participates to this coastal zone adaptive management. It is a work environment which combines strategic vision of the coastal system, planning, execution, monitoring and data collection, in an iterative way (see illustration in Figure 9.1). It is essential to continuously improve management policies and practices, based on operational program results.

This will be the main mission of the Coastal Protection and Management Unit, through in particular a periodic littoral maintenance program: protection strategies towards risks are evaluated on a regular basis, failures are identified and brought back to the administration in charge, which has the duty to evaluate efficiency, relevance and adaptability of a particular strategy.

Large and recurring failures may require a deeper adaptation need (legal, institutional, planning) than casual maintenance need, or a full revision of the process, depending on the new data collection and analysis. The adaptive management also allows avoiding over-investments in ineffective strategies.

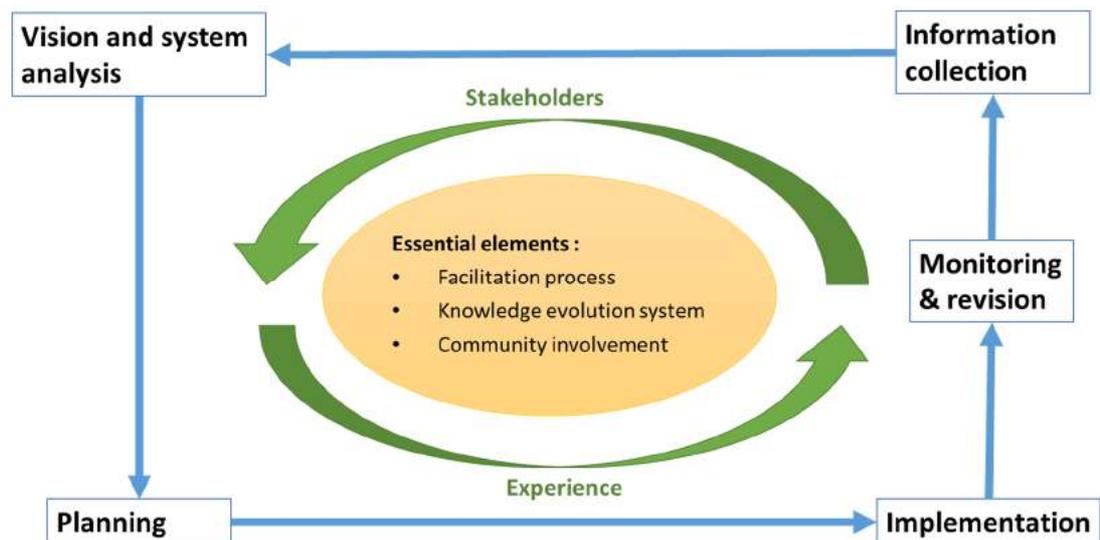


Figure 9.1 Adaptive management framework (adapted from Bennett and Lawrence, 2002).

### 9.1 Action prioritization – bundling in packages

In chapter 8, multi-sectorial investment action plan was presented, spread in strategic axes or topics.

Within all these actions, some are undeniably more urgent than others. In the context of giving priority to start the most urgent actions, they will be distributed in different packages, also distinguishing local measures (or field measures, axis 1) with overall measures (or support measures, axes 2 to 5).

The actions sorted by packages are presented in the Tables 9.2 to 9.4.

Packages 1A and 1B include the high priority actions. Regarding local actions (package 1A), it is mainly about projects addressing the hot spots previously identified. Several of these actions are actually already being implemented. Regarding support measures, package 1B contains projects that will allow a legal framework for the coastal zone management for all future actions, as well as institutional and knowledge reinforcement to apply this legal framework. Actions of package 1 are spread over the first 5 years.

Packages 2A and 2B include the most important actions. Projects of package 2A relate to coast as a whole and are mainly about land use planning soft engineering measures. Projects in package 2B are mainly related to the development of technical tools and knowledge necessary for an operational management of the coastal zone. Actions in package 2 are spread over the first 10 years.

Finally, package 3A and 3B contain long-term actions. Quite logically, they are mainly maintenance and monitoring actions, based on previous packages (technical measures of which the implementation isn't a priority yet but which will be necessary based on future projections of the hazard and development of the challenges). An adaptive management of the coastal zone will also allow re-evaluating the needs depending on effective achievements and their impacts. The actions start of package 3 is planned after 5 years.

The allocated costs between the different packages are summarized in Table 9.1. Packages 1 and 2 costs are calculated for all of the actions (including maintenance activities). The costs of package 3 are divided between initial costs (for technical measures, to be done only once), and periodic costs of long-term maintenance, estimated annually. An overview of the allocated costs per activity is presented in Annex 8.

Remarks:

- Prices associated to each package don't include costs of measures already financed now by other projects.
- Maintenance/follow-up/monitoring/etc. costs of the first 5-10 years are included in packages 1-2 (see details in the calendar section 9.2).

**Table 9.1 Costs per action package**

	<b>Package 1A</b>	<b>Package 1B</b>	<b>Total Package 1</b>
<i>Total cost</i>	14.9 billion FCFA (22.6 million €)	5.2 billion FCFA (7.9 million €)	<b>20.1 billion FCFA</b> (33.5 million €)

	<b>Package 2A</b>	<b>Package 2B</b>	<b>Total Package 2</b>
<i>Total cost</i>	13.6 billion FCFA (20.7 million €)	4.0 billion FCFA (6.1 million €)	<b>17.6 billion FCFA</b> (26.8 million €)

	<b>Package 3A</b>	<b>Package 3B</b>	<b>Total Package 3</b>
<i>Initial cost</i>	52.5 billion FCFA (79.8 millions €)	-	<b>52.5 billion FCFA</b> (79.8 million €)
<i>Maintenance cost/year</i>	3.3 billion FCFA/year (5.0 million €/year)	0.5 billion FCFA/year (0.8 million €/year)	<b>3.8 billion FCFA/year</b> (5.8 million €/year)

Table 9.2 High priority packages.

<b>Package 1A</b>		<b>Package 1B</b>	
< 5 years  High priority – Local measures	<p><b>1.2 Sand engineering in Hillacondji</b></p> <ul style="list-style-type: none"> <li>↳ Technical studies (feasibility, economy, modeling, EIA)</li> <li>↳ Implementation of effective bilateral collaboration (Togo)</li> <li>↳ Pilot project</li> <li>↳ Continuous monitoring, pilot project evaluation and maintenance</li> <li>↳ Complete project technical studies</li> </ul> <p><b>A1.7B Coastal protection technical option studies ~ 10th January</b></p> <ul style="list-style-type: none"> <li>↳ Technical study and recommendations</li> </ul> <p><b>A1.11 Coastal protection feasibility study in the Central Western zone (→ new zoning of PDTRP)</b></p> <p><b>A1.13 Long term risk zones planning studies in Cotonou</b></p> <ul style="list-style-type: none"> <li>↳ Future spatial development mapping of threatened areas (participatory processes with related actors)</li> <li>↳ Integration in the SDAU Grand Cotonou framework (decision for a long term threaten zones strategy)</li> </ul> <p><b>A1.18 Emergency works between Cotonou canal and groyne de Sifato</b></p> <ul style="list-style-type: none"> <li>↳ Construction</li> <li>↳ Initial refilling</li> </ul> <p><b>A1.23 Works in the Ambassadeurs sector</b></p> <ul style="list-style-type: none"> <li>↳ New structure constructions (coating)</li> <li>↳ Initial refilling</li> </ul> <p><b>A1.25 SIBEAU site evacuation</b></p> <ul style="list-style-type: none"> <li>↳ New site identification</li> <li>↳ New station building</li> <li>↳ Current site clearance</li> </ul> <p><b>A1.26 Strategic housing and park slots after groyne n°7</b></p> <ul style="list-style-type: none"> <li>↳ needs identification, relocation plan</li> <li>↳ Progressive strategic step back</li> </ul>	High priority – Support measures	<p><b>A2.1 Coastal law and regulation</b></p> <ul style="list-style-type: none"> <li>↳ Coastal law vote</li> <li>↳ Regulation documents preparation</li> <li>↳ ASDAL update</li> <li>↳ SDAL integration in other planning</li> </ul> <p><b>A2.2 Coastal Protection and Management Unit</b></p> <ul style="list-style-type: none"> <li>↳ Steering committee maintenance and enlargement</li> <li>↳ Institutional studies and economic feasibility</li> <li>↳ Institution set-up</li> <li>↳ Operational phase</li> </ul> <p><b>A3.2 Shoreline continuous monitoring and vulnerability risk mapping</b></p> <ul style="list-style-type: none"> <li>↳ Activity maintenance</li> <li>↳ Risk and vulnerability mapping</li> </ul>
	<b>Initial cost</b>	14.9 billion FCFA	<b>Initial cost</b>

Note : text in grey relates to actions already financed and being implemented. Their cost is not included in the total coast of the package.

Table 9.3 Priority actions packages.

		<b>Package 2A</b>	<b>Package 2B</b>
<i>&lt; 10 years</i>	<i>Priority – Local measures</i>	<p><b>A1.5 Regular openings of Mono estuary</b></p> <ul style="list-style-type: none"> <li>↳ SDAC Grand-Popo measure integration</li> <li>↳ Mono estuary operation (2x)</li> <li>↳ Docloboé and Hokoué relocation (PGES, relocation)</li> </ul> <p><b>A1.8 Land-use local measures (Grand-Popo)</b></p> <ul style="list-style-type: none"> <li>↳ SDAU Grand-Popo integration of results [vulnerability and risk mapping, Coastal law and regulation, SDAL, natural zones regulation]</li> <li>↳ New regulation implementation</li> <li>↳ Awareness and monitoring</li> </ul> <p><b>A1.9 Natural zones local convention management improvements (Ouidah)</b></p> <ul style="list-style-type: none"> <li>↳ Natural zones identification and needs and constraints evaluation</li> <li>↳ Elaboration of local management convention documents</li> <li>↳ Planning</li> </ul> <p><b>A1.12 Communication and land-use planning local measure (Ouidah and Abomey-Calavi)</b></p> <ul style="list-style-type: none"> <li>↳ Integration of results in the SDAU Ouidah/AC [vulnerability and risk mapping, Coastal law and regulation, SDAL, natural zones regulation]</li> <li>↳ New regulation planning enforcement, surveillance and awareness</li> </ul> <p><b>A1.29 Natural buffer zone (Sèmè-Kraké)</b></p> <ul style="list-style-type: none"> <li>↳ Inception phase (preliminary zoning, impact studies, preparation of necessary regulation)</li> <li>↳ Participative approach and communication</li> <li>↳ Progressive strategic step-back (adaptive)</li> <li>↳ Natural zone planning</li> </ul>	<p><b>A2.3 Victim compensation release</b></p> <ul style="list-style-type: none"> <li>↳ Needs and victims identification</li> <li>↳ Compensation plan elaboration (amount, debtor, beneficiaries)</li> </ul> <p><b>A3.1 Coastal periodic maintenance program</b></p> <ul style="list-style-type: none"> <li>↳ Effective methodology implementation with involved stakeholders</li> <li>↳ Local and national reports writing at different time intervals</li> </ul> <p><b>A3.3 Sediment management plan</b></p> <ul style="list-style-type: none"> <li>↳ Technical study : sources, needs and impacts identification</li> </ul> <p><b>A4.1 Base maps update and production</b></p> <ul style="list-style-type: none"> <li>↳ Existing data collection and harmonization in validated reference maps</li> <li>↳ Needs evaluation for measure campaigns (ToR writing, launch of studies)</li> <li>↳ Base map creation for the ones not available yet</li> <li>↳ Mapping update trainings for relevant stakeholders</li> </ul> <p><b>A4.2 Research support</b></p> <ul style="list-style-type: none"> <li>↳ Bid solicitation, targeting of project financing</li> </ul> <p><b>A4.3 Data sharing platform</b></p> <ul style="list-style-type: none"> <li>↳ Existing data collect and uniformization</li> <li>↳ Data sharing agreements</li> <li>↳ Platform implementation</li> <li>↳ Platform management stakeholder trainings</li> </ul> <p><b>A4.4 Coastal stakeholder communication reinforcement support</b></p> <ul style="list-style-type: none"> <li>↳ Regular meetings between inter-sectorial ministries and local communities</li> </ul> <p><b>A5.1 Regional collaboration platform</b></p> <ul style="list-style-type: none"> <li>↳ Regional collaboration integration in existing structure</li> <li>↳ Regular meetings between regional stakeholders</li> </ul>
		<i>Priority – Support measures</i>	
		<b>Initial cost</b> 13.6 billion FCFA	<b>Initial cost</b> 4.0 billion FCFA

Table 9.4 Long term actions packages.

<b>Package 3A</b>		<b>Package 3B</b>		
<i>Long term</i>	<i>Long term actions – Local measures</i>	<p><b>A1.2 Sand engineering in Hillacondji</b>            ↳Pilot project extension to final dimensions            ↳Continuous monitoring and evaluation</p> <p><b>A1.5 Regular openings of Mono estuary</b>            ↳Regular openings, continuous surveillance</p> <p><b>A1.9 Natural zone management and local conventions (Ouidah)</b>            ↳Monitoring and maintenance activities</p> <p><b>A1.10 Maintenance of the main roads perpendicular to the shoreline</b>            ↳ Works to associate with road map renewing</p> <p><b>A1.16 Regular refilling in the Jak area</b>            ↳Reloading operations every 5 years</p> <p><b>A1.18 Emergency works between Cotonou canal and the groyne de Sifato</b>            ↳Works maintenance and monitoring</p> <p><b>A1.23 Comforting works in the Ambassadeurs sector</b>            ↳Necessary regular reloading between the groynes            ↳Maintenance and monitoring of works</p> <p><b>A1.27 By-passing system and maintenance in SP future harbor</b>            ↳By-passing system in SP future harbor (during construction)            ↳System maintenance</p> <p><b>A1.29 Natural buffer zone (Sèmè-Kraké)</b>            ↳Progressive strategic step-back (adaptive)            ↳Maintenance and monitoring of work zones</p> <p><b>A1.30 Road 6km RNIE1 step-back</b>            ↳Preparatory phase (plans, discussions with Niger, land needs)            ↳Construction</p>	<p><b>A2.2 Coastal Protection and Management Unit</b>            ↳Operational phase</p> <p><b>A3.1 Periodic coastal maintenance program</b>            ↳Local and national report writing at given periods</p> <p><b>A3.2 Shoreline continuous monitoring and vulnerability risk mapping</b>            ↳Activity maintenance</p> <p><b>A3.3 Sediment management plan</b>            ↳Necessary updates</p> <p><b>A4.1 Base maps production and update</b>            ↳Updates (land-use, bathymetry, population density)</p> <p><b>A5.1 Regional collaboration platform</b>            ↳Regional stakeholders regular meetings</p>	
	<i>Initial cost</i>	52.5 billion FCFA	<i>Initial cost</i>	-
	<i>Maintenance cost per year</i>	3.3 billion FCFA/year	<i>Maintenance cost per year</i>	0.52 billion FCFA/year

The costs of the different packages (hence actions non financed yet) are not negligible for the budget of a state like Benin. It will be necessary to ensure this financing by creating partnerships with different funding bodies.

On the short term, the use of external donators in the framework of large programs (like *African Climate Business* of which WAXCA is part of) is advised. The large fund availabilities allow considering innovating strategies on the long term, in the respect of strict requirements, guarantees of good follow-up on the long run.

On the long term, it is preferable that the coastal zone management as a whole frees from that financing, which would be sign of stable and strong economy. This is one of the reasons why development plans in the coastal zone (local and national plans) and large coastal zone development projects have a critical role: the definition and the respect of a clear long term vision of the coast is one of the key steps of good adaptive management.

The progressive measure adaptation in the coastal zone management may highly influence the long-term costs.

Table 9.5 give a non-exhaustive list of potential funding bodies (from the list of bodies often involved in this type of projects). The potential funding bodies are sorted in categories relative to their type.

**Table 9.5 Potential funding bodies.**

Category	Project type	Donor example
National budget	Funding bodies (human resources), maintenance and monitoring, compensation	All ministries, in particular those in charge of the environment, of natural resources, infrastructures, transport, water, energy, industry, urbanism and habitat, agriculture, fishing, scientific research etc.
Local budget	All types, except large protection and construction projects	All relevant municipalities: Grand-Popo, Ouidah, Abomey-Calavi, Cotonou, Sèmè-Kpodji, and potentially those more North if they are concerned by the measures
Multi-lateral cooperation	All types	World Bank, UEMOA, ADB, DAOB, AEDAB, DIB, EIB, UN (UNDP, UNESCO, FAO), ...
Bi-lateral cooperation	All types	Embassies, GIZ, NFD, AFD, CTB, FFEM, USAID, EU, etc.

Category	Project type	Donor example
International NGO's	Technical, legal and planning support Research support Natural zones protection Social support measures Capacity building and communication projects	IUCN, WWF, FAO, IRD, ...
National NGO's and civil society	Technical, legal and planning support Research support Natural zones protection Social support measures Capacity building and communication projects	Nature Tropicale ONG, Bees ONG, Eco-Ecolo, Eco-Bénin, FULAM Riparian associations (Jak-Rehab)
Private funds	Land use, communication and training projects	Trade associations: fisheries (UNAPECAB, UNAPEMAB), hotels, etc. Private companies, promoters, ...

## 9.2 *Planning draft*

The priorities for local interventions (package 1A) are the identified hot spots. The other coastal segments are nonetheless not to neglect, because the risks are usually high there. Relevant institutions will need to be proactive in order to get the necessary funding in order to work efficiently. Local authorities' role, direct link between the most impacted actors and the State, is a deciding factor to ensure that no coastal segment is indefinitely postponed. A good communication strategy will ensure the follow-up of actions made ; which will engage the participation of all groups of actors with high interests.

A draft of planning is presented in Table 9.6, with the major steps of each project selected, and assigns them to short or longer term.





Planning											Legend		Currency conversion		Round cost		Originalcost	
											Inception phase	1 FCFA						
											Implementation phase	0,00152 €						
											Monitoring and maintenance phase	0,00162 US\$						
											Current							
Action	Year					Year					Initial cost	Maintenance co	Initial cost		Maintenance cost			
	1	2	3	4	5	6	7	8	9	10	11 à 30	fcfa	fcfa/year	€	fcfa	€/year	fcfa/year	
Package 3A	A1.2					Pilot project extension towards the final project												
						Continuous monitoring and evaluation						12.100.000.000	900.000.000	18.300.000	12.039.473.684	1.360.000	894.736.842	
	A1.5					Regular openings, continuous surveillance							10.500.000			15.382	10.119.737	
	A1.9					Monitoring and maintenance activities							35.000.000			50.000	32.894.737	
	A1.10					Works to associate with road map renewing						17.500.000.000	435.000.000	26.599.504	17.499.673.692	655.571	431.296.958	
	A1.16					Reloading operations every 5 years						1.100.000	690.000.000			1.046.600	688.552.632	
	A1.18					Works maintenance and monitoring						140.000	90.000.000			133.902	88.093.421	
	A1.23					Necessary regular reloading between the épis							620.000.000			934.841	615.027.238	
	A1.27					Maintenance and monitoring of works												
	A1.29					By-passing system in SP future harbor (during construction) + maintenance						12.200.000.000	500.000.000	18.540.000	12.197.368.421	760.000	500.000.000	
	A1.30					Preparatory phase						4.700.000.000	14.500.000	7.095.302	4.667.961.623	25.944	17.068.421	
						Construction						6.000.000.000		9.089.498	5.979.932.895			
					Costs						52.501.240.000	#####	79.624.304	52.384.410.315	4.982.241	#####		
Package 3B	A2.2					Operational phase							225.000.000			337.778	222.222.222	
	A3.1					ProduLocal and national report writing at given periods							10.000.000			14.026	9.227.632	
	A3.2					Activity maintenance							41.000.000			61.285	40.319.079	
	A3.3					Necessary updates							22.000.000			33.333	21.929.825	
	A4.1										Updates		15.000.000			22.493	14.798.026	
	A4.2										Call for tender, targeted projects financing		132.000.000			200.000	131.578.947	
	A5.1										Regular		70.000.000			100.000	65.789.474	
					Costs							515.000.000			768.915	505.865.205		

### **9.3 Main key actors involved**

Because of the land intensive use, the institutional landscape of Benin's coastal zone is complex.

Each new project will engage different groups of actors; hence the challenge will be to reach equilibrium between the stakeholders interests. The actors' implications will vary depending on the geographic reach of the project, its impacts on their respective interests, as well as the roles and global responsibilities of the actors.

The public or governmental stakeholders have global objectives to reach, which is why they will have a role in most of the projects. For example, the « Agence Béninoise pour l'Environnement du MCVDD » intervenes in each impact evaluation, or the « Agence Nationale de Protection Civile », which determines the protection limits as well as the actions to ensure public security in case of natural disasters. Other sectors intervene at much more local scale, like riparian and trade associations.

Overall, the public stakeholders have a transversal role in all the projects. The main relevant services and departments are:

- Agence Béninoise pour l'Environnement (MCVDD),
- Agence Nationale de Protection Civile (MISP),
- Mairies des communes du littoral,
- Direction Générale de l'Eau (MEEM),
- Université d'Abomey-Calavi.

However, it is from all the stakeholders involved (key and non-key actors, mainly with high interests) that proactivity will need to come from, necessary to the combination of different projects, in order to find the most profitable win-win conditions to the entire coastal zone.

### **9.4 Complementarity with the other challenges and projects of the coastal zone**

The struggle with coastal risks isn't independent from other action plans, which are the source of current projects in Benin. In order to manage the coastal zone in an integrated manner and to avoid doubling the effort, the actions will be inserted as much as possible in the framework or in partnership with other projects than WACA. Some examples of those projects are listed in Table 9.7.

The other main challenges that coastal stakeholders will have to coordinate between the different large action plans are (by order of priority): flood risk, solid waste management, land use planning, demographic pressure reduction, economic and urbanization development towards the center of the country, poverty fighting, technical modernization, inter-institutional and sectorial communication.

In the same way win-win deals can be found between different coastal stakeholders, some action of this plan are complementary with those other projects, and could become a common program.

As concrete example we can cite (i) the closing and reconstruction of the waste water treatment plant (World Bank project), (ii) the integrated management and the long term vision of urban planning with the Delta Ouémé plan as well as the Epine Dorsale project, (iii) the sustainable management of available space and of natural zones in the framework of the transboundary tourism competitiveness project, (iv) the recovery of dredged materials in the port for other uses (coastal refilling, Delta plan), and (v) the legal authority, institutional, stakeholder communication, knowledge development and environmental protection (with the PGIECC of ABE, etc.) reinforcements.

**Table 9.7 Project examples dealing with other challenges related to Benin’s coastal zone.**

<b>Current projects</b>	<b>Challenges addresses</b>	<b>Possible joint action areas</b>
PUGEMU	Grand Cotonou flooding Water treatment Solid waste management Drainage networks	Pollution fight Spatial planning Living condition improvements
Delta Ouémé plan	Nokoué lake flooding	Pollution fight Spatial planning Living condition improvements
FAE – Sludge treatment management improvement of Grand-Nokoué in a public/private partnership framework	Sludge treatment in Sèmè-Kpodji	Pollution fight
Transboundary tourism competitiveness project	Route des Pêches touristic valuation	Urban planning Environmental protection Living condition improvements
Epine Dorsale project	Transports development (railway, Sèmè harbour)	Spatial planning Demographic pressure reduction
Climate Change and Environmental Management Program (PGIECC) in Benin (ABE)	Protection/adaptation to environmental risks	Institutional reinforcement Legal reinforcement Communication and inter-sectorial awareness reinforcement Research promotion

## **9.5 Restraining and favorable conditions**

The major challenges to address are coastal demographic pressure reduction and territorial rational planning (little effective as of now). These challenges are not only about coastal risks. We need to keep in mind that long-term success of coastal management will depend on several crucial external factors that are not directly addressed in this plan:

- Stabilized demography (direct cause of coastal demographic pressure)
- Stable political context (which ensures that one government actions won't be dissolved by the next one)
- Urbanism development towards the inside land of the country (via economic, infrastructures and telecommunication development)
- High enough economic growth
- Effective international cooperation

Despite those limitations, Benin also has major assets that will help implementing the country's long term vision, and in particular its coast: its geographic location, favoring exchanges with countries without access to the sea, its relatively young population, able to adapt to change, and its will to collaborate with other West African countries, which allows to avoid conflict situations and to develop ambitious large-scale projects.

## 9.6 Overall conclusion

WACA program aims to implement strategies sustainably and coherently between the different intervention scales (local and regional scales), in order to ensure long-term improvement of living conditions of all actors in the West African coast.

In order to promote appropriate action for a good coastal zone management in Benin, a multi-sectorial investment plan for coastal risk adaptation towards climate change in Benin was done. The plan presented includes the description of current and future risks, the inventory of capacities and responsibilities of coastal stakeholders, as well as the analysis of the legal framework of Benin's coastal management.

The options presented were indexed, presented and debated in a participative way with the coastal stakeholders. The selected projects for the plan are detailed on different aspects like: cost, stakeholders involved, actions details, temporality, multi-sectorial implications, etc.

At the end of the work, the study concluded that:

- (i) Coastal erosion issues are particularly serious on the majority of Benin's coast, compared to other West African countries, and are partially from natural origin, and partially cause by anthropogenic factors,
- (ii) There are hot spots which need an urgent attention, even considering implementing temporary measures, waiting for a sustainable solution,
- (iii) A clear definition of acceptable risk limits and necessary protection levels is missing in the current legislation (this lack should be filled with the future coastal law and its applications documents),
- (iv) The unavailability and the messy space use are in the heart of the long term problem, and the long term solution will require inland development,
- (v) Inter-sectorial, inter-institutional and international communication is not enough and causes the coordination lack (hence the effectiveness) between the different actions,
- (vi) The knowledge status on coastal dynamics is advances, despite data dispersion,
- (vii) There are many ways of combining coastal risk reduction with existing large projects currently being implemented for Benin's development,
- (viii) There are win-win opportunities to defend and value the coastal zone.

The investment plan coming from analyses, meetings with stakeholders, participative workshops, documentary analyses, is articulated in 5 strategic axes:

**Axis 1 Local strategies**

Technical and regulatory actions to implement, which target directly coastal risk reduction.

**Axis 2 Legal and institutional framework reinforcement**

Legal and institutional framework adaptation, to coordinate and protect coastal zone value.

**Axis 3 Adaptation and protection strategies maintenance**

Tools implementation in order to ensure continuity of actions taken along the coast.

**Axis 4 Knowledge and communication reinforcement**

Development of the supervision and the knowledge of mechanisms, which determine coastal dynamic.

Information sharing development and reinforcement between different stakeholders (public, private, etc.), at different scales.

**Axis 5 Regional collaboration reinforcement**

Regional scale collaboration promotion allowing coordinated and more ambitious actions.

Local strategies (Axis 1) take into account important sediment refilling measures to treat the most sensitive Benin areas, and which aim to compensate sediment lack (generated by different obstacles along the coast), as well as occupation measures, good land use and planning, which aim to both strengthen soils and to reduce occupation in risk zones.

The other axes (Axes 2 to 5) aim to develop coastal integrated management, regarding improvement ideas described earlier. The legal aspect, focused on the coastal law implementation, in project since 2001, is one of the most important actions of this plan, as well as the monitoring and maintenance improvement of the coastal zone. They open the door to a valuation of the coastal zones through social, economic and natural components.

The different measures are then divided in three packages, following a logical prioritization. The first package addresses emergency actions, mainly focused on hot spots treatment, and on legal and institutional improvements. The second package has measures to implement in the short term, in order to do the necessary works all along the coast, and to allow coastal zone management structures to be effective and operational. Finally, the third package also has important measures, but they don't need to be started on the very short term, and which may be adapted depending on the evolution of the coastal zone. The packages different costs are showed in the following table. It is an order of magnitude calculated from the sum of cost estimates of all proposed and selected measures.

	<b>Package 1</b>	<b>Package 2</b>	<b>Package 3</b>
<i>Initial cost</i>	<b>20.1 billion FCFA</b> (33.5 million €)	<b>17.6 billion FCFA</b> (26.8 million €)	<b>52.5 billion FCFA</b> (79.8 million €)
<i>Maintenance cost per year</i>			<b>3.8 billion FCFA/an</b> (5.8 million €/year)

In the short term, it is advised to ask external donors in large program frameworks (like the *African Climate Business* of which WACA is part). The large funds available allow to consider innovative strategies on the long term, in respect to strict requirements, in order to have a good long term follow-up. In the long term, it is preferable that coastal zone management as a whole frees from those funding, which would be sign of a strong and stable economy.

To conclude, the proposed projects in this plan will contribute to develop Benin's coastal zone integrated management, in a coherent way internally and with regional scale actions. They are focused on a rational use of land, on non-regret options and on valuation of the coast depending on local potential. This management will be successful and progress if collaboration and communication between the numerous coastal stakeholders is assured, as well as proactivity of responsible institutions and the provision of enough funds and time.

## References

---

- ABE (2004). Evaluation environnementale stratégique régionale du littoral stricto sensu (EES-R) – Volume 1. Rapport, 67p.
- ABE (2016). Programme de Gestion Intégrée de l'Environnement et du Changement Climatique (PGIECC) au Bénin. Rapport, 54p.
- Adjakidjè, V. (1984). Contribution à l'étude botanique des savanes guinéennes en République Populaire du Bénin. Thèse de 3ème cycle, Université de Bordeaux III, 245p.
- AFR CBP (2015). Accélérer un développement résilient au changement climatique et à faibles émissions de carbone : Business plan pour le climat en Afrique. Washington, DC : La Banque mondiale Licence : Creative Commons Attribution CC BY 3.0 IGO.
- Agassounon L. C. (2002). Evolution pédo-sédimentaire du géosystème margino-littoral de l'Ouémé-Sô au cours de l'Holocène (Bénin- Afrique de l'Ouest). Thèse de Doctorat en Science de la terre et de l'environnement. 425p.
- Akoègninou A. (1984). Contribution à l'étude des îlots de forêts denses humides semi-décidues en République Populaire du Bénin. Thèse de 3ème cycle, Université de Bordeaux III, 250p.
- Akoègninou, A., 2004. Recherches botaniques et écologiques sur les forêts actuelles du Bénin. Thèse d'Etat. UFR, Biosciences, Abidjan, 326p.
- Alapini (2016). Projet SOS Erosion Côtière. Présentation. 10p.
- Aninver (2016). Stakeholder and political economy analysis for Benin. Report Aninver InfraPPP Partners S.L for the World Bank, draft version of 23/8/2016. 25p.
- AWF (2012). Projet d'amélioration de la gestion des boues de vidange du Grand-Nokoué dans le cadre d'un partenariat public-privé. African Water Facility, Rapport final, 58p.
- Banque Mondiale (1999). Daniel Kaufmann, Aart Kraay, Pablo Zoido, *Aggregating Governance Indicators*. October 1999, World Bank Policy Research Working Paper No. 2195, PDF, 42 p.
- Banque Mondiale & Nations Unies (2011). Inondations au Bénin : Rapport d'évaluation des besoins post catastrophe. Rapport. 82p.
- Bennett, J., & Lawrence, P. (2002). Adaptive management framework for catchment and coastal management and decision making. In *Coast to Coast: Australia's National Coastal Conference*. Tweed Heads (pp. 4-8).
- CNEE (2016). Avis d'examen de l'EIES sur le projet de construction d'un port en eau profonde à Sèmè-Kpodji. Rapport Commission néerlandaise pour l'évaluation environnementale. 25p.
- Commune de Grand-Popo (2016). Arrêté municipal n°93/77/CC/SG-SADE. Convention Locale de Gestion des Ressources Naturelles de la Bouche du Roy. Version 17 septembre 2016. 20p.
- Credel-ONG (2010). Projet de Protection de la Communauté Urbaine du Grand Cotonou face aux Changements Climatiques (PCUG3C). Changements climatiques et inondations dans le Grand Cotonou : situations de base et analyse prospective. Rapport final. 100p.
- Crosnier et Berrit (1963). Extension du port de Cotonou. 1ère phase. Etudes préliminaires. Ministère de l'Équipement et des Transports et Direction de l'Hydraulique. Rapport dactylographié, non publié.
- DCN (2011). Deuxième communication nationale de la République du Bénin sur les changements climatiques. Rapport, 168p INTA (2010). Panel et conférence internationale sur l'aménagement du territoire et le développement urbain. Rapport, 76p.
- Deltares (2014). Human Interventions and Climate Change Impacts on the West African Coastal Sand River: A preliminary Quantitative Assessment – Technical and financial proposal. 15p.

- DG-Eau (2015). Détermination des seuils et niveaux d'alerte relatifs aux risques d'élévation du niveau de la mer et d'érosion côtière au Bénin. Rapport, 182p.
- Guilcher A. (1959). La région côtière du Bas-Dahomey occidental. Bull. Instr. Fr. Afr. Noire, Sénégal, t. XVI, sér. B, n° 34, pp. 357-424.
- INSAE (2002). Synthèse des analyses en bref du troisième Recensement Général de la Population et de l'Habitation. Rapport de la Direction des études démographiques, 48p.
- INTA, (2010). Panel et conférence internationale sur l'aménagement du territoire et le développement urbain. Rapport, 76p.
- LACKNER & Partners (1983). Etude de l'ensablement de l'accès au port de Lomé. Rapport d'étude, Bremen, Ministère de l'Equipement, Lomé.
- Laïbi R. A. (2011). Dynamique actuelle d'une embouchure fluviale estuarienne à flèche sableuse, la Bouche du Roi, Bénin, Golfe de Guinée : caractérisation hydrosédimentaire et géomorphologique. Thèse de doctorat Unique réalisée en alternance entre l'Univ. d'Abomey-Calavi (Bénin) et l'Univ. du Littoral Côte d'Opale (ULCO, France). 277p + Annexes.
- Laïbi R.A., Gardel A., Anthony E. et Oyédé L.-M. (2012). Apport des séries d'images Landsat dans l'étude de la dynamique spatio-temporelle de l'embouchure de l'estuaire des fleuves Mono et Couffo au Bénin, avant et après la construction du barrage de Nangbéto sur le Mono. Revue Télédétection, Vol. 10, n° 4, pp. 179-198
- Lang J., Paradis G. et Oyédé L.M. (1988). Le domaine margino-littoral du Bénin (Golfe de Guinée Afrique de l'Ouest) : âge holocène et mise en place des sables jaunes. Journal of African Earth Sciences, vol 7, n° 5-6, pp. 829-833.
- LCHF (1984). Projet Erosion Littorale du Togo. Rapport d'étude et propositions d'aménagement, 80p. Université de Lomé.
- Loi Littoral (2001). Avant-projet de loi relative à la protection, l'aménagement et la mise en valeur de la zone littorale. Rapport ABE. 31p.
- MEHU (2012). Etude de faisabilité de la protection de la côte entre Hillacondji et Grand-Popo. 195p.
- MEHU (2013). Etude technique de la stabilisation du fleuve Mono. Rapport, 77p.
- MEPN (2007). Rapport National sur l'Environnement Marin et Côtier du Bénin. Rapport CEDA, 68p.
- MOLOA (2016). Bilan 2015 des littoraux d'Afrique de l'Ouest : actualisation 2015 du schéma directeur détaillé. Rapport, 203 p.
- Mondjannagni, A., 1969. Contribution à l'étude des paysages végétaux du Bas-Dahomey. Annales de l'Université d'Abidjan, sér. G, 1. 191 p.
- MUHA (2015). Elaboration d'un Schéma Directeur du Littoral et de l'étude du suivi du trait de côte au Bénin. Rapport LGF Consulting, 103p.
- NEDECO (1975). Etude des causes de l'érosion sur les côtes de la République Togolaise. Phase 1, Pays-Bas. 294p.
- Norda Stelo & BCI (2016). Etude technique du projet de protection de la côte entre Hillacondji et Grand-Popo : avant-projet sommaire. Etude en cours (version temporaire octobre 2016). 102p.
- Oyédé L. M. (1991). Dynamique sédimentaire actuelle et messages enregistrés dans les séquences quaternaires et néogène du domaine margino-littorale du Bénin (Afrique de l'Ouest). Thèse Doctorat nouveau régime, Université de Bourgogne et Université Nationale du Bénin, 302p.
- Paradis G. (1980). Un cas particulier de zones dénudées dans les mangroves d'Afrique de l'Ouest: celles dues à l'extraction de sel. Bull. Mus. natn. Hist. nat., 4è série., n° 3, 227-261.
- PAZH (1997). Diagnostic de la gestion des Zones humides Rapport de synthèse. 177p.

- Pétrolin (2015). Port pétrolier, minéralier et commercial en eau profonde à SÈMÈ PODJI au Bénin. Étude d'impact environnemental et social. Version finale 01, chapitre 7. Rapport Roche et Best Ingénieur-Conseil. 259p.
- Pliya J. (1976). La pêche continentale et maritime dans le Sud-Ouest de la République Populaire du Bénin. Thèse de Doctorat de 3ème cycle de Géographie Appliquée. Univ. Paris X – Nanterre. 308p.
- RGPH4 (2013). Résultat du quatrième Recensement Général de la Population et de l'Habitation : que retenir des effectifs de la population en 2013 ? Rapport de la Direction des études démographiques de l'INSAE, 33p.
- Roche (2015). Projet de protection côtière à Cotonou : étude d'avant-projet détaillée (solution finale). Rapport final. 146p.
- SDLAO (2010). Etude régionale de suivi du trait de côte et élaboration d'un schéma directeur du littoral de l'Afrique de l'Ouest. Rapport, 48p.
- Sitarz J.A. (1960). Côtes africaines : Etude des profils d'équilibre de plage. Trav. Centre d'Etude et de Recherche en Océanographie, T3, fasc. 4, pp.43-62.
- Toffi Mathias (2008). La variabilité climatique, l'homme et la dynamique des écosystèmes côtiers du Bénin. Thèse de doctorat, Université d'Abomey-Calavi, Bénin. 378p.
- Tossou M. G. (2002). Recherche palynologique sur la végétation holocène du sud-Bénin. Thèse de doctorat unique, Université de Lomé, 133 p.