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Innovative Method of Carrying Out Coastal Protection Works: Monitoring Coastal Risks and Soft Solutions in Benin

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ABSTRACT

Coastal erosion is a phenomenon of natural or anthropogenic origin that affects many coastal regions around the world. In response to its worsening over time, adaptation strategies have been developed: construction of dikes, operations to re-silt beaches, rock structures, etc. Among these strategies, the establishment of sand dunes is a territorial entity which fluctuates in space and time depending on natural (tide, erosion, sedimentation, etc.) and human factors (dams, etc.). The Beninese dune cord in the sector of the mouth of the Mono River in the commune of Grand Popo is in a state of lamentable degradation: due to anthropogenic pressure, mainly through urbanization, tourism, illegal sand extraction and even all the agricultural activities practiced in the area, something which has favored wind erosion and the invasion of the Mono River by sand. Faced with this alarming situation, the French Fund for the Global Environment (FFEM) initiated a project "Soft solutions and monitoring of coastal risks in Benin" with a view to restoring the dune system in the sector of the mouth of the Mono River in the commune of Grand Popo to safeguard the ecological and ecosystem role of this area. The objective of this work is to consolidate and sustain the advances in coastal observation mechanisms, at the regional and national levels, to influence public policies on the issues of coastal risks and the management of coastal areas but also to initiate a series of field, pilot activities for the implementation of soft solutions for coastal protection. The results obtained concerning the installation of typhavelles and Epis Maltais Savard (SEMS)

for fixing mobile dunes at the Grand Popo wetland are very encouraging for the preservation of this site of international importance.

Keywords: Coastal risks; Soft solutions; Climate, Coastal erosion.

INTRODUCTION

Coastal dunes are terrestrial ecosystems located in the transition between the continental and marine environments, which serve several unique functions such as coastal protection and riparian control. In addition, coastal dune systems provide another type of service: they allow the accumulation of sand for beach regeneration [1].

Nowadays, and like most coastal dune ecosystems in Benin, the dune cord in the sector of the mouth of the Mono River in the commune of Grand Popo is in a state of lamentable degradation: due to anthropogenic pressure, mainly through urbanization, tourism, illicit sand extraction and even all the agricultural activities practiced in the area, something which has favored wind erosion and the invasion of the Mono river by the sand.

Figure 1: Village of Avlo threatened by erosion and lagoon coastal "Bouche du Roi" [2]

Figure 2: Strip of land between sea the mouth of the Mono River [2]

Faced with this alarming situation, the French Fund for the Global Environment (FFEM) initiated a project "Soft solutions and monitoring of coastal risks in Benin" with a view to restoring the dune system in the sector of the mouth of the Mono River in the commune of Grand Popo to safeguard the ecological and ecosystem role of this area. This restoration will be carried out using pioneer plants of the sand dunes such as casuarinas, mangroves, chrysobalanus icaco and palm trees (Borrassus sp). The project combines targeted strengthening of the skills of key players in coastal risk management in Benin with demonstrative field activities for the implementation of soft solutions, on pilot sites, while promoting French expertise.

It aims both (i) to consolidate and sustain the advances in coastal observation mechanisms, at the regional and national levels, to influence public policies on questions of coastal risks and management of coastal areas but also (ii) to initiate a series of field, pilot activities for the implementation of soft solutions for coastal protection.

This work is structured around four (04) parts:

- presentation of the study area.

- the different soft solution techniques carried out on dune fixation.
- the materials used, and the methods applied for the implementation of gentle solutions for fixing the dunes.
- the results obtained and discussion.

PRESENTATION OF THE STUDY AREA

Also called the South Benin region, the administrative coastal zone is between the parallels 6°10' and 6°40' of northern latitude and the meridians 1°40' and 2°45' of eastern longitude (ABE, 2004). It extends over approximately 8,692 km2 or 7.7% of the national territory. The coast of Benin brings together five municipalities which open onto the sea: Sèmè-Kpodji, Cotonou, Abomey-Calavi, Ouidah and Grand-Popo. It is divided into four (04) zones (Figure 3): the East zone, the Central East zone, the Central West zone and the West zone. The area of our research is the West zone, the description of which is detailed in Table 1.

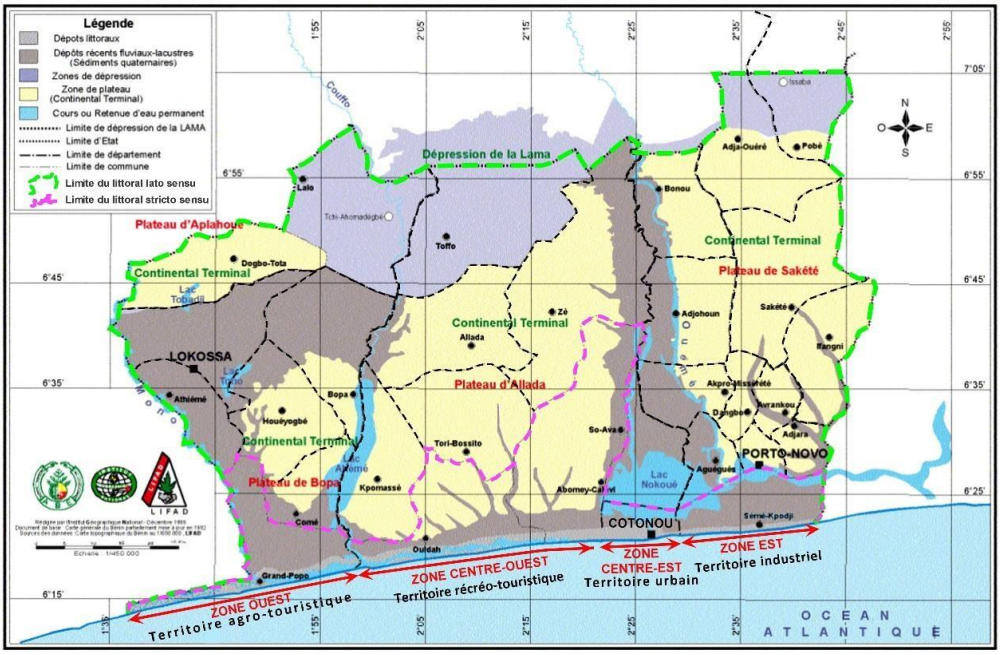

Figure 3: The geographical delimitation of the coastal zone of Benin [2]

Table 1: Description of the western zone of the coast of Benin [2]

Area	Western limits	Eastern limits	Area	Commune/municipality	Use
West	E 01°45’	E 01°48’	133 km²	Grand-Popo	Agro-tourism
	Togolese border	Aho Channel			

THE DIFFERENT SOFT SOLUTION TECHNIQUES CARRIED OUT ON DUNE FIXATION

Restoration

The restoration of degraded dune systems is achieved by eliminating the causes of alteration and by using topographic reconstruction and revegetation techniques with native species [3]. Since coastal dunes are very dynamic systems, restoration objectives can be achieved within a few years. Believes that to limit the advance of mobile sands, the basic principle of dune management will consist of moderating wind erosion by reducing wind speed using several

types of devices [4]. Thus, slowed down, the wind will be less erosive and will deposit the transported sand. We will see in the following, the different soft solution techniques used, as well as their advantages and their conditions of use.

Installation of Typhavelles to Reconstruct the Dunes in Accordance with The Recommendation of the Conservatoire du Littoral (CdL)

These are permeable fences made of typha australis palisades connected by twisted wire. Very effective for guiding the public, but also for combating wind erosion, they have multiple qualities: local renewable material, durability, biodegradability and good landscape integration.

Figure 4: Typha australis typha fences [2]

Figure 5: Installation of australis fences [2]

Installation of Epi Maltais Savard (SEMS)

The Maltais Savard Groyne System (SEMS) allows sediment to be deposited by slowing down the current that runs along a sandy coast, even if it is subject to wave action.

The Maltais Savard Epi System was developed at the end of the 90s. It has four (04) advantages:

- It uses natural local materials. Wooden stakes, branches to act as a brake for the current in the lower part.
- It resists waves because the branches are placed at the bottom initially. Indeed, it offers low resistance to waves. Then we increase the branches according to the rise of the sand until we reach the top of the stakes.
- In addition, its shape is extensible depending on the observation of the effects on the beach profile. They can be extended at the top or bottom, add two or 4 wings, etc.
- Finally, the stakes disappear once the sand accumulates. The accumulation on the beach varied between 1 and 3 meters depending on the situation and the size of the piles.

Figure 6: Materials used for the SEMS of Grand-Popo (Eucalyptus, palm, coconut) [2]

Figure 7: Epi Maltais Savard (SEMS) of Grand-Popo [2]

ADAPTATION TECHNIQUE AND MATERIAL USED

Material Used

- Typha australis fences of 1m/1.20m.
- Hardwood stakes 1.60 m pointed.
- Galvanized wire.

Creation of an Installation Plan

To determine the exact location of the installation of the typha australis palisades and wooden stakes, the creation of an installation plan was essential where we carried out a field study by taking measurements. Among these we can cite:

- topographic survey and coastline measurement.
- topo-bathymetry survey.
- distance between the lake and the coastline.
- GPS survey.
- lifting of the orientations of the angles by the Compass (Azimut).
- use of satellite images (Google Earth).

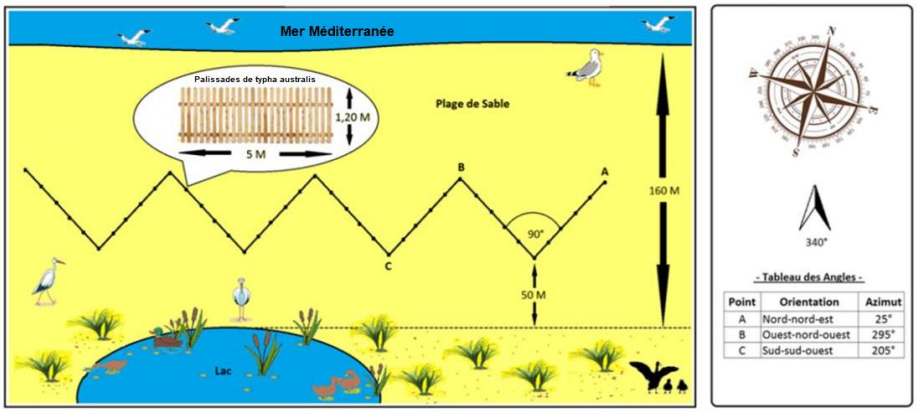

Figure 8 : Installation Plan [5]

RESULTS AND DISCUSSION

Results of the Installation of Typhavelles to Reconstitute the Dunes in Accordance with the Recommendation of the Conservatoire du Littoral (CdL)

The first results obtained began to appear after three months of installing typhavelles. The results observed between three months and one year are shown in Figure 9.

Figure 9: Result of the installation of typhavelles: return of vegetation [2]

The two-month period is sufficient to allow the sand to accumulate, stabilize and pile up.

Figure 10: Measurements of sand accumulation on typhavelles. [2]

To follow up on these measurements, we noted an average fortnightly sand accumulation of 13 cm. Please note that 120 cm corresponds to the maximum height (pallet height).

The fortnightly measurements of the thickness of the accumulated sand layer are presented in Figure 10.

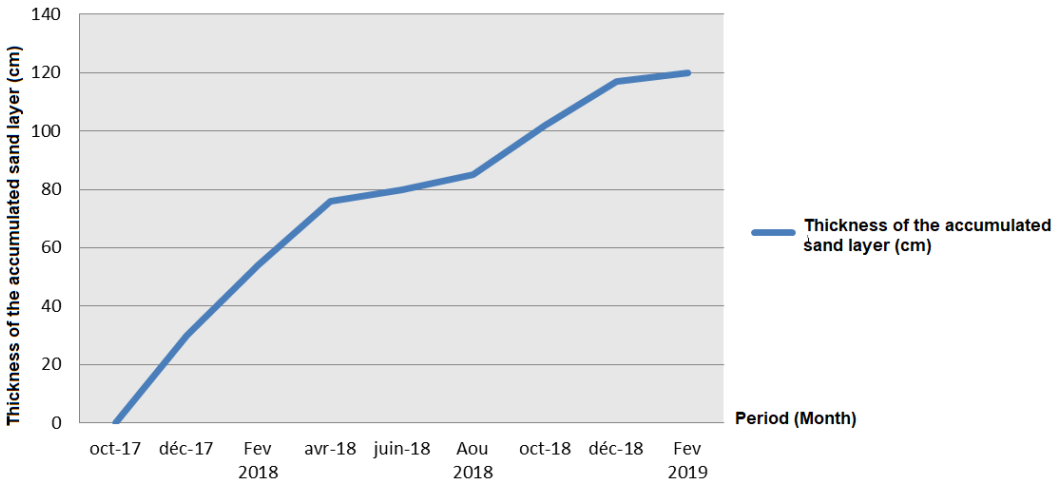

Figure 10: Bimonthly measurements of thickness of the accumulated sand layer.

Results of the Installation of Epis Maltais Savard (SEMS)

At the end of the installation of the groynes, a monitoring committee composed of agents from the Departmental Directorate of the Ministry of Living Environment and Transport in charge of Sustainable Development, the Mayor of Grand-Popo and the populations was set up. This monitoring consisted of measuring every 15 days the quantity of sediment trapped by the structure by measuring the height of the quantity of sand trapped.

Figure 11: **Measurements of sand accumulation by the groyne** [**2**]

Table 2: Height of trapped sand in centimeter (cm)

ALONG THE EPI	**Height of accumulated sediment (cm)**					
Stakes	1	2	3	4	6	7
11 july 2022	4	3	4	6	5	4
25 July 2022	6	7	5	9	8	7
ALONG THE BEACH	**Height of accumulated sediment (cm)**					
Stakes	1	2	5	2	6	7
11 july 2022	2	3	6	3	9	1
25 july 2022	4	1	2	3	0	0

CONCLUSION

The phenomenon of silting has always existed in the area studied, a phenomenon linked to the physical and socio-economic conditions particularly favorable to the process, but the risk to the environment has become much more pronounced in recent decades. The approach also allowed us to analyze the process more acutely to arrive at solutions that could reduce this risk. Man, also participated in the triggering of this phenomenon through their pressure and bad practices over time (overgrazing, land clearing, sand extraction).

The results obtained concerning the installation of typhavelles and Epis Maltais Savard (SEMS) for fixing mobile dunes at the Grand Popo wetland are very encouraging for the preservation of this site of international importance.

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