Larache's Coastal in Morocco: Evaluating Dredging's Impact on Fisheries and Shorelineevolution

Mohammed Saddik[1], Ilham Zoubeidi[2], Khaoula Lagrini[3], Hasnae Achchab[4]

1 Université Chouaib Doukkali
2 Abdelmalek Essaâdi University
3 University of Hassan II Casablanca
4 Université Moulay Ismail

Funding: No specific funding was received for this work.
Potential competing interests: No potential competing interests to declare.

Abstract

Rapid urban growth, with its construction and infrastructure needs, leads to an increased demand for sand, putting pressure on marine resources. Marine dredging is a response to this demand, but it is not without consequences. The delicate balance that Morocco must achieve lies in its ability to manage urban expansion and increasing urbanization while minimizing negative impacts on the marine ecosystem and meeting the socio-economic needs of its population. The quest for a balanced solution to this issue is crucial to ensure sustainable economic development, the preservation of valuable marine ecosystems, and the fulfillment of the housing and infrastructure needs of the Moroccan population. This intricate approach is essential for securing a sustainable future in Morocco by harmonizing economic, environmental, and social imperatives.

The primary objective of this article is to thoroughly examine the consequences of dredging activities on the Larache coastal area from both a physical and biological perspective. This comprehensive evaluation will shed light on how the marine ecosystem and the coastal environment are affected by these activities.

Furthermore, the article will not merely stop at highlighting the problems but will also put forward a range of practical measures and solutions designed to alleviate and mitigate the negative impacts that dredging may have on the Larache coastline. These measures may encompass strategies such as responsible dredging practices, habitat restoration efforts, and the implementation of environmental safeguards.

By offering a well-rounded assessment of the situation and proposing actionable steps for minimizing the repercussions of dredging, this article aims to contribute to the responsible management of coastal resources, ensuring that the Larache region can strike a balance between development and environmental preservation.

SADDIK Mohammed[1], ZOUBEIDI Ilham[2], LAGRINI Khaoula[3], ACHCHAB Hasnae[4]

[1] *Earth Sciences department, Faculty of Sciences – Chouaib Doukkali University, El Jadida, Morocco*

[2] *Earth Sciences department, Faculty of Sciences & Technique – Abdelmalek Saidi University, Tanger, Morocco*

[3] *Laboratory of Applied Geology, Geomatics, and Environment, Faculty of Sciences Ben M'sik - Casablanca*
[4] *Biology department, Plant and molecular biology laboratory. Faculty of Sciences, Moulay Ismail University, Meknes, Morocco*

Keywords: Marine sand dredging, environmental impacts, fishery resources, Larache, Morocco.

1. Introduction

The effects of extracting marine aggregates on the natural environment are multifaceted, covering both physical and biological aspects. These impacts are interrelated and frequently stem from the initial changes made to the environment (Duclos 2012).

1.1. Coastline Impacts of Dredging

The physical effects can be categorized into two types: direct impacts that occur immediately during the extraction of marine aggregates, such as the removal of sediment and alterations in seabed topography, and indirect physical impacts, which result from the physical environment's reaction to the direct impacts. These indirect effects encompass changes in wave dynamics, tidal currents, concentrations of suspended matter, and the transport of sediment. (Tillin et al. 2011).

Dredging can have a significant impact on the evolution of the coastline. The impact depends on various factors, including the depth and location of dredging, the quantity of sediments extracted, and the characteristics of the coastal area in question. Here are some of the main impacts of dredging on the evolution of the coastline:
Coastal erosion: Dredging can lead to an increase in coastal erosion by altering the dynamics of waves and currents. When dredging is carried out near the coast, it can disrupt the natural transport of sediments by waves and currents, which can result in a reduction of the beach and a retreat of the coastline.

Modification of underwater topography: Dredging alters the topography of the seabed, which can influence how waves break near the coast. This can lead to changes in the distribution of sediments along the coastline, which, in turn, affects the evolution of the coastline.

Sediment redistribution: Dredging can disrupt the natural distribution of sediments along the coast. When sediments are extracted from one area and deposited elsewhere, it can have effects on coastal morphology and contribute to changes in the coastline.

In Morocco, a similar situation is observed, where the intensive dredging of the tidal delta at the mouth of the Sebou River and within it raises concerns regarding its potential effects onThe cause of a significant retreat of the northern part of Mehdia Beach (-4 m/year), especially between 1997 and 2007, even though the blocking of littoral drift from the north by the Sebou dikes may partly account for this retreat (Hakkou et al. 2011).

1.2. Biological Impacts of Dredging

Dredging can have a significant impact on benthic fauna, which includes organisms that live at the bottom of the water, such as marine animals, crustaceans, mollusks, and aquatic plants. The primary impacts of dredging on benthic fauna include:

Displacement and habitat destruction: The dredging process can lead to the destruction of benthic habitats, especially when sediments are extracted from the seabed. This can result in the death or displacement of benthic organisms residing there, thus disrupting the ecological balance of the area (Newell et al. in 1998).

Changes in species composition: Benthic organisms are often specialized to live in specific habitats. Dredging can alter these habitats, favoring certain species at the expense of others. This can lead to changes in the composition of benthic species, with potential consequences for the food chain and the ecosystem as a whole.

Disruption of reproduction and development processes: Dredging can disturb the reproduction and development processes of benthic organisms by destroying spawning areas, disrupting marine currents, and altering water quality (Garrad & Hey in 1987).

In summary, dredging activities have profound impacts on marine ecosystems, affecting biodiversity, water quality, and the health of marine species. This underscores the need to implement stringent environmental management measures to minimize these impacts.

2. Description of the Study Area

2.1. Physical Environment

2.1.1. Coastal Geomorphology of Larache

From the exterior to the interior, the coastal geomorphology of Larache is composed of the following sequence:

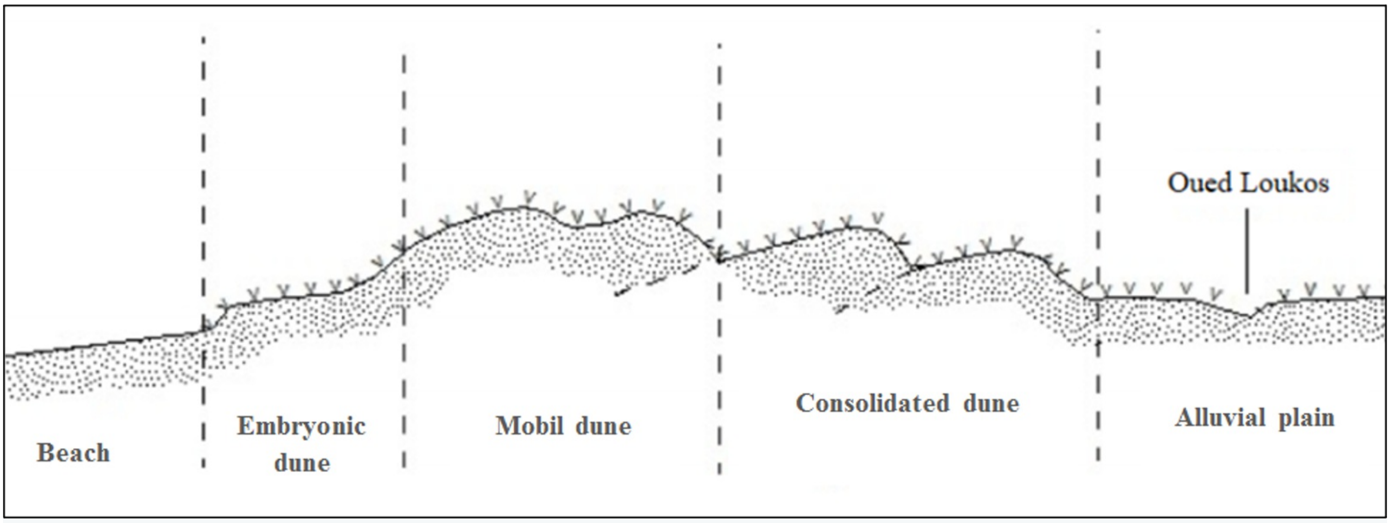


Figure 1. *Sedimentology and Distribution of Sedimentary Facies Three major sedimentary facies have been identified in this area (JAAIDI, E., 1994).*

- A sandy beach ranging from 50 to 150 meters wide;
- A consolidated Quaternary dune cord;
- A cliff shaped from a live dune of a few meters in height;
- An estuarine alluvial plain where numerous Dayas of varying dimensions develop. (Mohamed Dahmani et al. 2018)

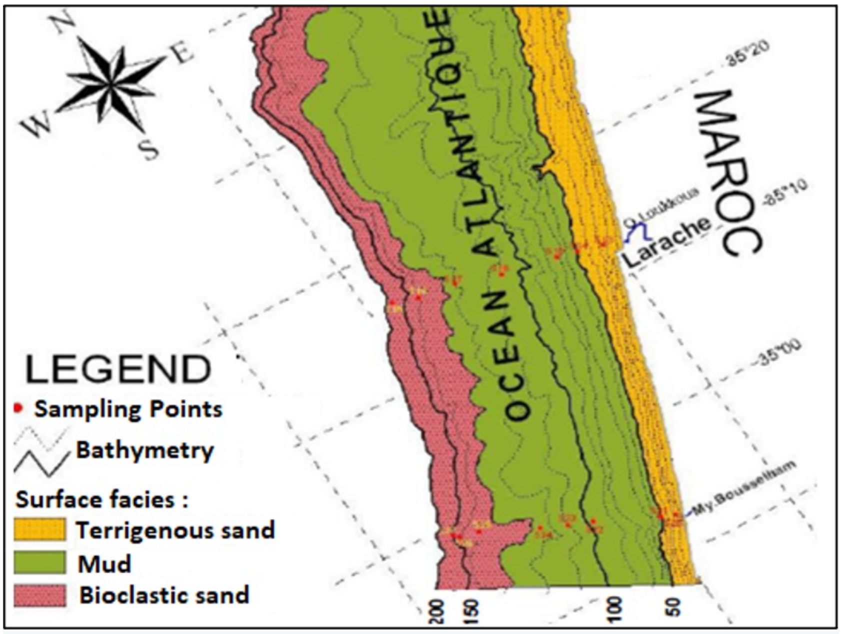


Figure 2. *Map of the distribution of various sedimentary facies on the continental shelf between Tanger and Moulay Bousselham (ANDRE and EL GHARBAOUI, 1973)*

Terrigenous Sand Facies: The terrigenous sands, consisting of medium to very fine sands in some places, are distributed on the inner shelf where they form the littoral accretion prism. These sands occupy the inner shelf between the coastline and the -50 m isobath.

- Bioclastic Sand Facies: The fine to medium bioclastic sands, occupying a relatively narrow band on the outer edge of the shelf, are characterized by a carbonate content exceeding 50%, and locally, up to 70%.
- Mud Facies: The muds cover the mid-continental shelf (between -50 m and -120 to -150) and form an elongated North-South mudflat. They are characterized by silt content exceeding 70% with 10 to 30% carbonates. (ANDRE and EL GHARBAOUI, 1973).

2.1.2. The Climate

The combination of latitude and the location on the Atlantic coast gives the middle and lower reaches of the Loukkos River a subhumid Mediterranean climate. (Antonio Román et al., 2013). In terms of bioclimatic classification, the region falls within the subhumid thermomediterranean level with mild to temperate winters. (Aziz BALLOUCHE, 2013).

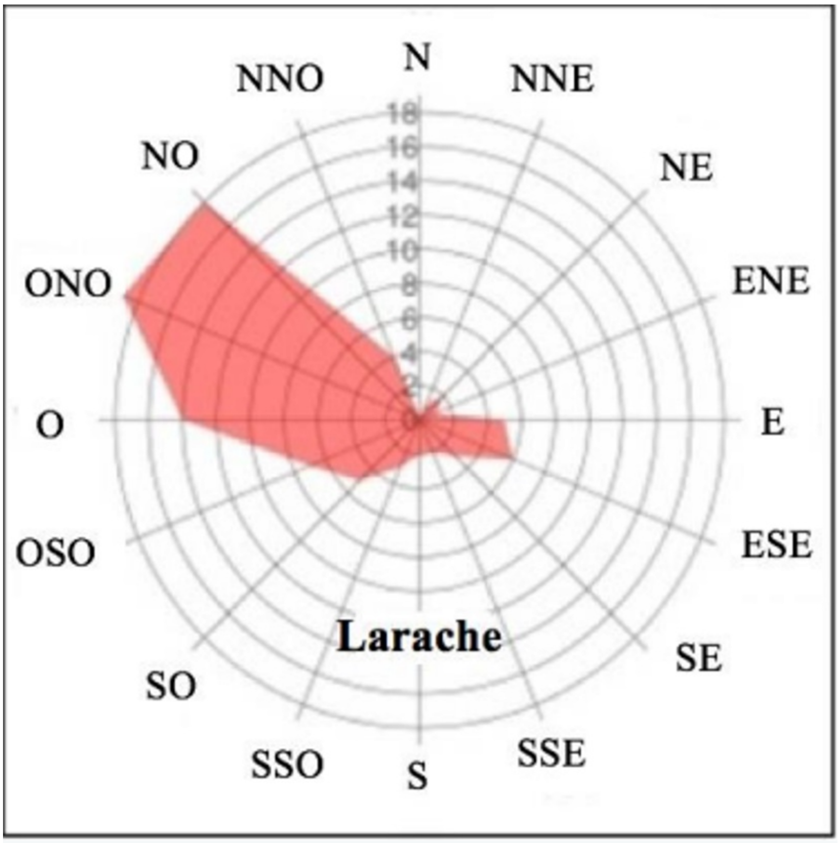


Figure 3. *Wind Rose*

The wind rose indicates a predominance of marine winds from the WNW (19%), NW (18%), and W (14%) sectors (Mohamed Dahmani et al., 2018), highlighting the oceanic nature of the climate. These marine winds alternate near the coast in the summer with the Chergui and Foehn, of continental origin, blowing from the East and North and leading to significant evapotranspiration (Aziz BALLOUCHE, 2013). Offshore and at the river mouth, wind speeds and directions significantly influence the directions of marine currents and wave direction (EL MORHIT, 2009).

2.1.3. Wave Regime

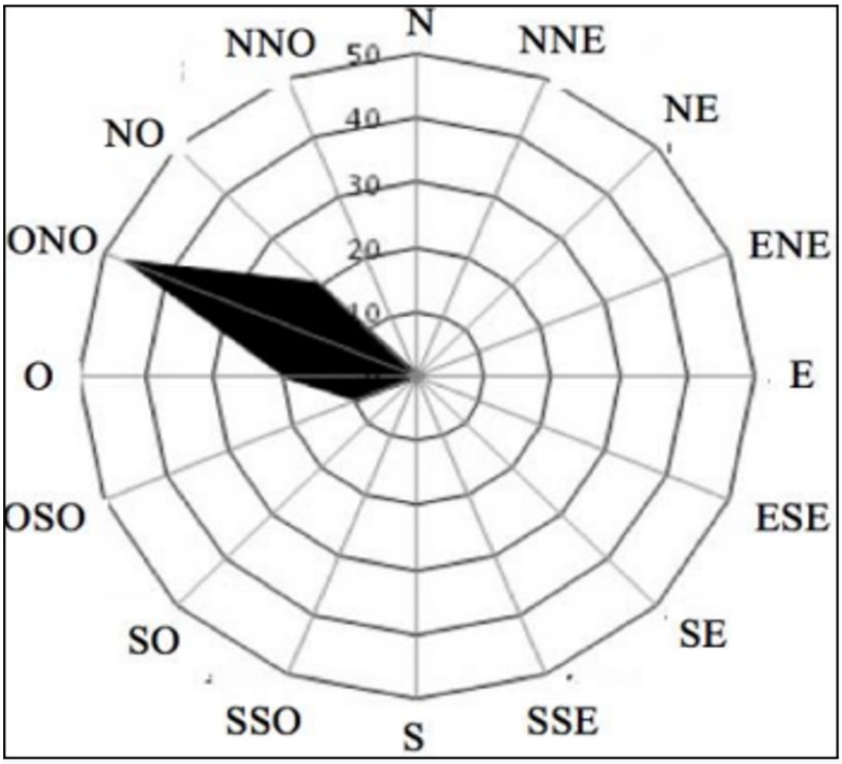


Figure 4. *Wave Direction at Larache*

The predominant wave direction is from the W to NW, with a prevalence of NW waves, accounting for 47%. The significant wave height for the ten-year period varies between 0.5m and 3m. (Mohamed Dahmani et al. 2018)

The number of days per year with wave amplitudes exceeding 3 meters is relatively low, ranging from 14 to 25 days, and in 70% to 75% of the time, wave amplitudes do not exceed 1.50 meters. (DRAPOR 2020).

2.2. Natural Environment

2.2.1. Flora

The regional vegetation primarily falls under the cork oak series, belonging to the "sub-humid suberaries on sand" group (SAUVAGE C., 1960). The main forest massif nearby is the cork oak forest of Larache, which has been significantly opened up due to clearing and grazing and is locally replaced by reforestation with eucalyptus, pine, and acacia. (S. HAMMADA, 2007).

2.2.2. Fauna

Among the most remarkable individuals in the study area, the following species are notable.

Benthic fauna:

The number of species per station varies between 7 and 16. Abundance (number of individuals per square meter) ranges from 220 to 730 ind/m², while biomass (dry weight without ash per square meter) fluctuates between 0.1 and 5.2 g/m².

The diversity index H' varies between 2.2 and 3.7 bits.

Seabirds:

The area is mainly frequented by Larids. No species remarkable on a national, regional, or global scale is specific to the region.

Marine mammals:

Three species of cetaceans are fairly common in the sector between Asilah and Larache. These species include the common dolphin (Delphinus delphis), the striped dolphin (Stenella coeruleoalba), and the bottlenose dolphin (Tursiops truncatus). These species can be observed near the coast as well as offshore, especially in the continental shelf area.

Fishery resources:

There are several economically valuable species for Morocco's fishing industry. Four pelagic fish species are essential to the Moroccan fishery economy: sardines (Sardina pilchardus) first and foremost, followed by mackerel (Scomber colias and Scomber scombrus), horse mackerels (Trachurus trachurus and Trachurus trecae), and sardinellas.

Two pelagic fish species are commercially exploited off the coast of Larache: sardines and, to a lesser extent, anchovies (Engraulis encrasicolus).

A large number of demersal species are also present along the entire Atlantic coast of the northern Moroccan shore, including European hake (Merluccius merluccius), pink shrimp (Parapenaeus longirostris), cuttlefish, sparids, meagres, red mullets, sea bass, soles, whiting, and capelans. (DRAPOR 2020).

3. Evaluation of the Impact of Dredging on the Coast of Larache

3.1. Evaluation of the Physical Impact of Dredging on the Larache Coastline

The coastline is a curve or line representing the intersection of land and sea at high tide under normal weather conditions. By extension, it is the boundary between land and sea.

In the context of our environmental impact assessment of dredging, we will analyze the evolution of the coastline of the Larache coast, particularly the Ras R'mel beach. This beach is located north of the city, between the main port breakwater to the south and the Punta Negra cliff to the north. The 1.7 km long Ras R'mel sandy beach is straight and oriented to the northeast.

For this purpose, we conducted a comparison between the current situation of the area and an older situation to deduce the various changes that have occurred.

The software used for this purpose is Google Earth Pro, which allows the visualization of the study area.

3.2. Methodology Adopted

Google Earth is a Geographical Information System (GIS). All GIS systems fall within the realm of information and communication technologies. A GIS is a computer system that, based on reference maps and attribute data, enables the representation, study, and management of geographic space at different scales and across various thematic layers.

Google Earth is software that allows the visualization of the Earth through an assembly of multiple satellite or aerial photographs. This multitude of photographs comes from various sources, including aerial image companies and governments. Once assembled, they reconstruct the entire surface of the Earth in its "spherical" form, creating a virtual globe. (Antoine PEREDA BUSTAMANTE 2017).

1. Open Google Earth: Start by launching the Google Earth application or accessing it through a web browser.
2. Type the name of the region concerned by our study in the search bar: Use the search bar to enter the name of the specific region you are interested in studying. Google Earth will take you to that location.
3. Use the compass, hand, and zoom tools to locate the study area: Once you are in the general vicinity of your study area, you can use the compass for orientation, the hand tool to pan across the map, and the zoom tools to zoom in or out to get a closer view of your study area.
4. Trace a route using the route tool in the toolbar at the top of the image: Click on the "Add Path" or "Add Line" tool in the toolbar at the top of the Google Earth image. This will allow you to draw a route on the map.
5. Before completing the window that opens, trace the route step by step: After selecting the route tool, click on the map to set the starting point of your route. Then, continue clicking on the map to trace the route step by step, following the path you want to analyze.
6. Then name the route: After you've completed tracing the route, a window will open. You can name the route by entering a descriptive title that represents the route's purpose or location.
7. Define its characteristics (style, color, width): In the same window, you can choose the style, color, and width of the line representing your route. This helps differentiate it from other elements on the map.
8. Save it: Once you've defined the characteristics and named the route, be sure to save it so you can access it for future reference.
9. Subsequently, to carry out a diachronic study, you must change the date and repeat the same steps previously mentioned: To conduct a diachronic study (examining changes over time), you can change the date using the historical imagery feature in Google Earth. Then, repeat the same steps to trace and save routes for different time periods, allowing you to compare changes in your study area over time.

4. Results

4.1. Evolution of the coastline between 2011 and 2016

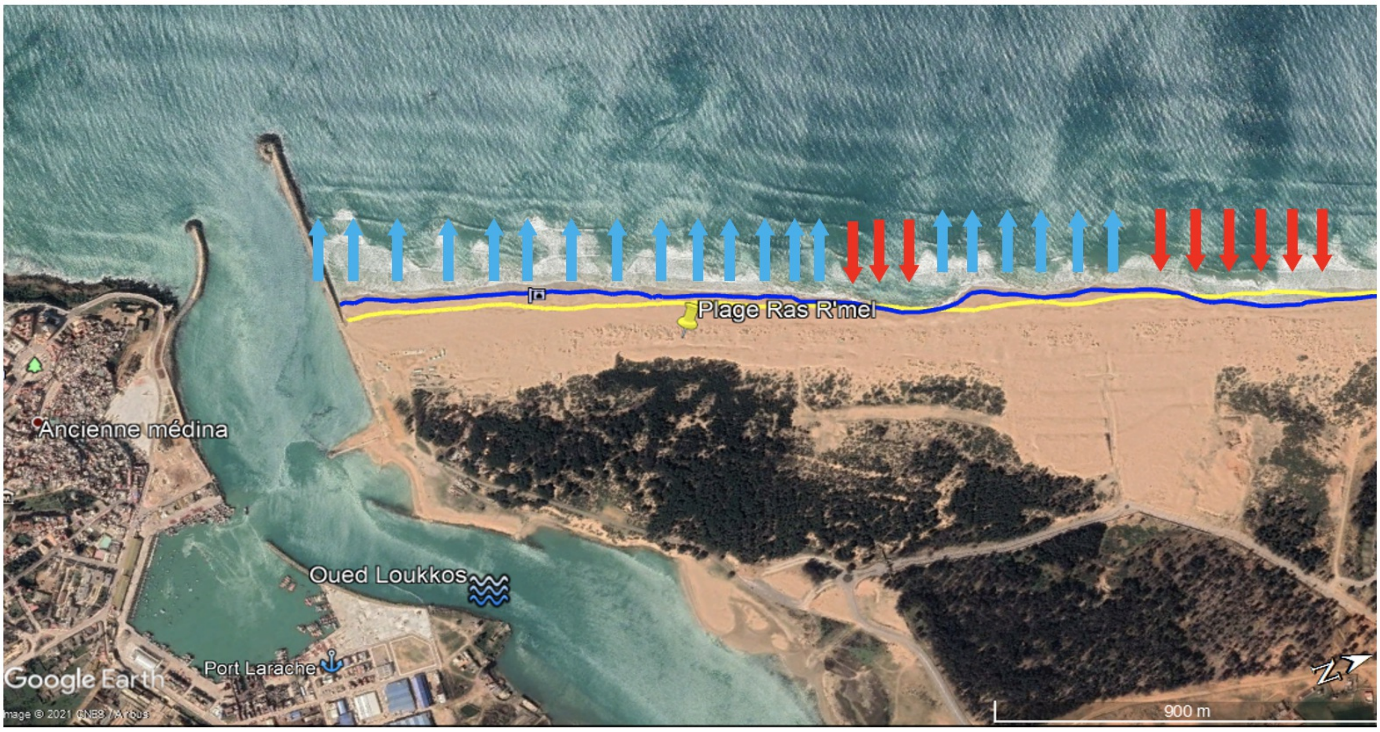
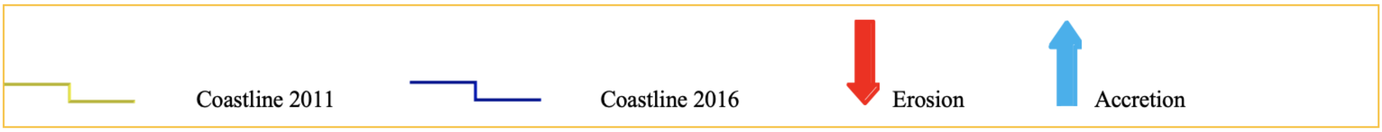


Figure 5. *State of the Larache coastline 2011-2016*

Legend:



Observing the evolution of the coastline in this area reveals that during the period 2011-2016, Larache's coastline experienced accretion in the southwest, ranging from +5 to +45 meters, or +0.83 to +7.5 meters per year.

In contrast, there was erosion in the northeast, ranging from -3.5 to -38.6 meters in 6 years, which is equivalent to -0.58 to -6.43 meters per year.

This study covers a 2630.05-meter stretch of coastline, distributed during this period as follows:

Table 1. *Distribution of the coastline during the period 2011-2016*

Accretion (en m)	**1858,08**
Erosion (en m)	**771,97**

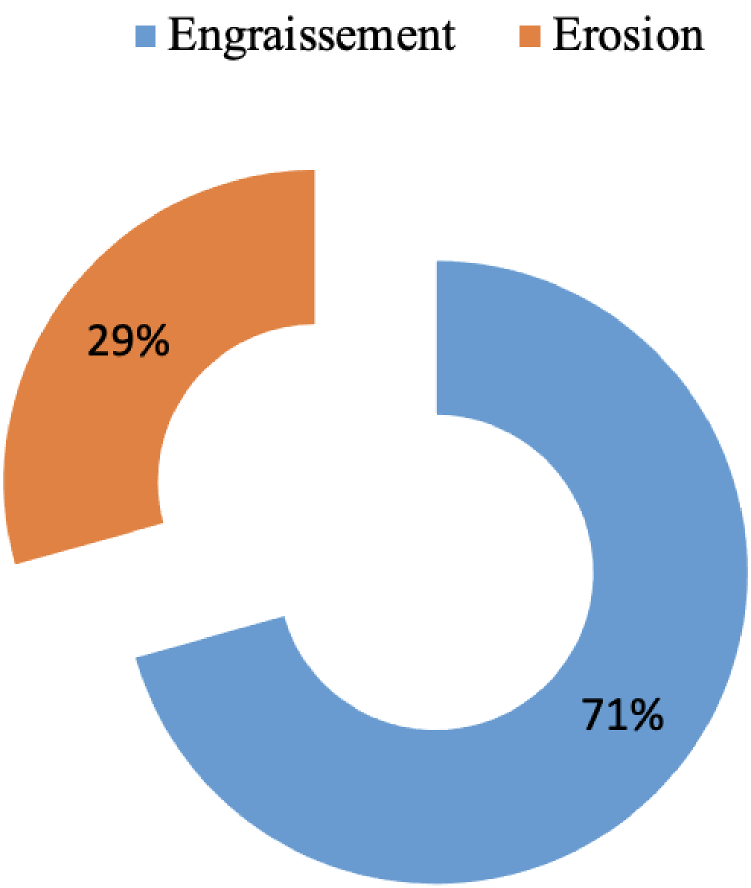


Figure 1. Representation of Accretion and Erosion During the Period 2011-2016

It can be observed that 71% of the coastline is experiencing accretion, while 29% is undergoing erosion. The period from 2011 to 2016 is generally characterized by accretion in this segment, although erosion has been active in certain areas.

4.2. Evolution of the coastline between 2016-2020

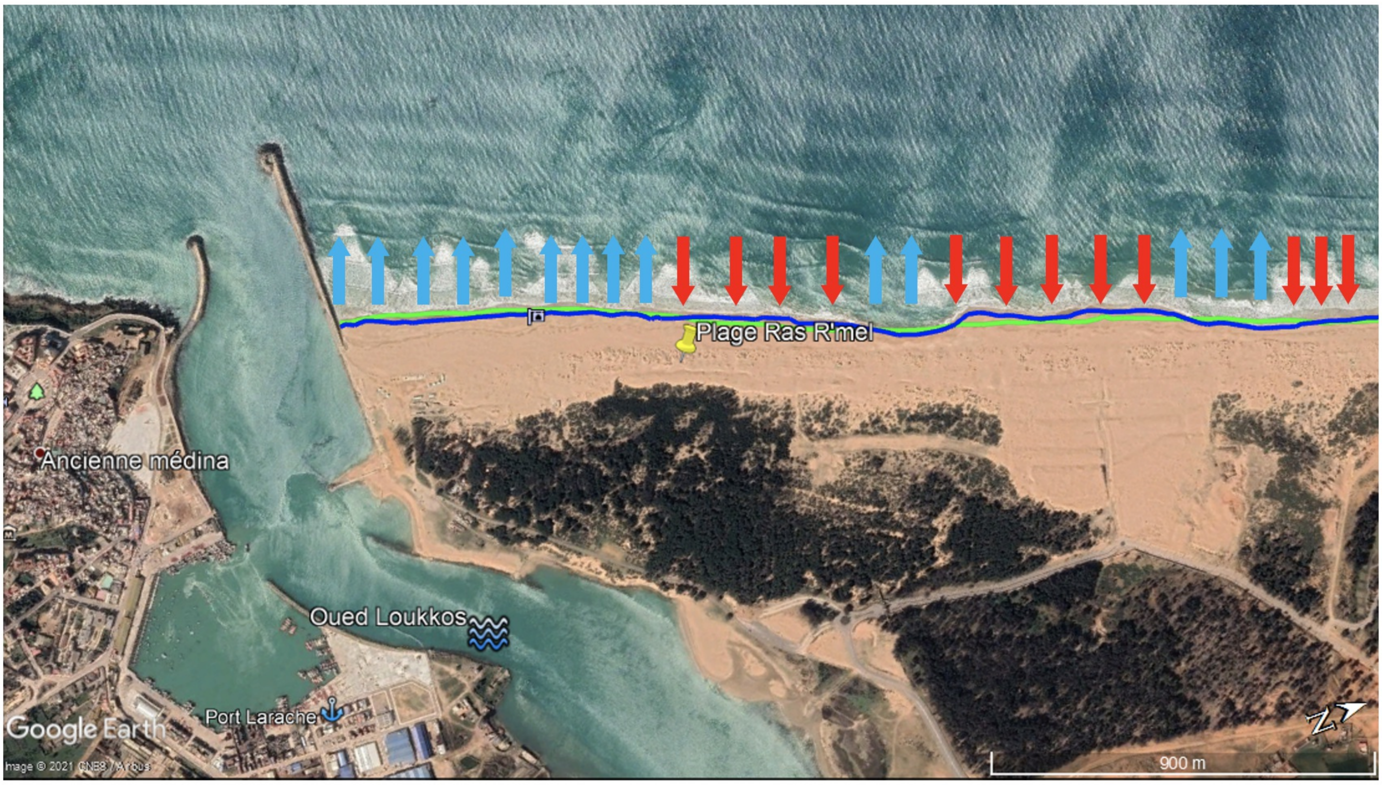


Figure 7. State of the Larache coastline 2016-2020

Legend:

The evolution of the coastline indicates that the years 2016-2020 are marked by shoreline accretion in the southwest, ranging from 1 meter to 18.65 meters, which corresponds to a rate of 0.25 to 4.66 meters per year. This accretion is relatively mild compared to the previous years.

On the other hand, these years are characterized by a retreat of the coastline, indicating erosion estimated to be between 0.95 and 29 meters over 4 years. This erosion corresponds to a rate of recession ranging from 0.24 to 7.25 meters per year.

This study covers a coastal stretch of 2630.05 meters, which is distributed during this period as follows:

Table 2. *Coastal Distribution during the Period 2016-2020*

Accretion (en m)	1337,22
Erosion (en m)	1292,83

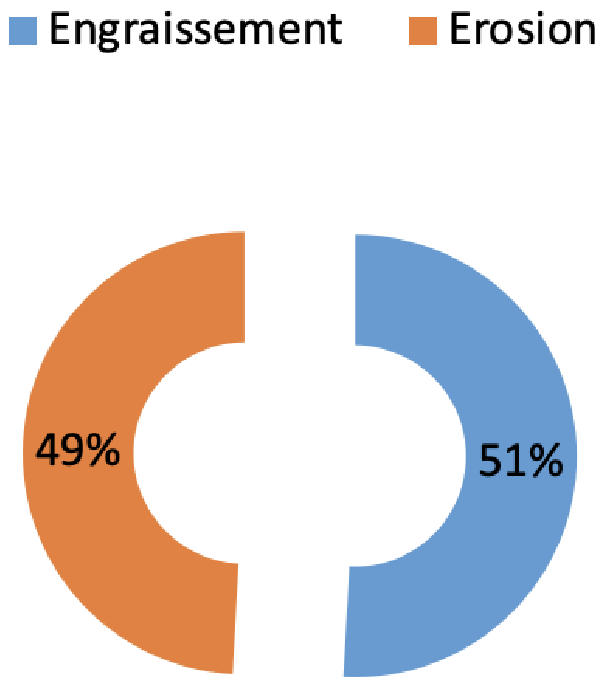


Figure 8. *Representation of Accretion and Erosion during the Period 2016-2020*

The results reveal that 51% of the studied area is undergoing accretion, while 49% is experiencing erosion. These years have marked an increase in the coastal area that has been eroding in recent years, while the accretion zone has decreased. Several factors could be the reason for these changes.

5. Discussion of the Results Obtained

The evolution of the coastline of Larache Beach, recorded between 2011 and 2020, may have two causes: a natural cause and an anthropogenic cause, and probably both at the same time. The natural factors that continuously control the coastline are environmental factors, such as changes in bathymetry, the nature of the studied terrain, which is in our case a very uncohesive and very fine sandy-silt terrain, making it highly susceptible to erosion. There are also meteorological and marine factors, such as hydrodynamic and meteorological parameters. During winter storms, beaches typically undergo marine erosion caused by direct wave impact that erodes unprotected areas. These various factors modify the morphology of sandy coasts, marked alternately by erosion and accumulation phases visible on a seasonal scale. On the other hand, there are anthropogenic factors, mainly dredging operations that take place annually and cause a decrease in the topo-bathymetric slope, as already mentioned in the bibliography. Alternatively, the construction of dykes disrupts marine currents and the natural movement of sediments; they retain the sediments brought by littoral drift from the north, which may be the cause of sediment accumulation.

5.1. Identification of Mitigation Measures

- Respect the limits and depth of the dredging area.
- Dredging activities should not be concentrated in a small area.
- It is highly recommended to extract material in axes parallel to the shoreline.
- Periodic monitoring should be conducted to ensure control of the evolution of the dredging site (topo-bathymetric profiles).
- Limit dredging to shallow layers and do not exceed 0.5 m in thickness during each pass.
- Monitor changes that occur on the coastline (beaches, bathymetry, and general coast morphology).
- Progress campaigns should be conducted to monitor the progress of the project and the seabed: check the target depth of the dredging area to see if it aligns with the initially defined depth.
- Bathymetric control should be carried out before and after each dredging activity to accurately determine the volume extracted.
- Beach replenishment.

5.2. Evaluation of the Impact of Dredging on the Fishery Resources of Larache

Evolution of the Quantity of Fish Landed in the Larache Region Between 2010 and 2020 In Morocco, the national production of coastal and artisanal fishing is measured monthly by the National Fisheries Office, which publishes annual statistical reports. The objective of our study is to reveal the impact of dredging on fishery resources. To achieve this, we will analyze the statistical reports from the period 2010-2020.

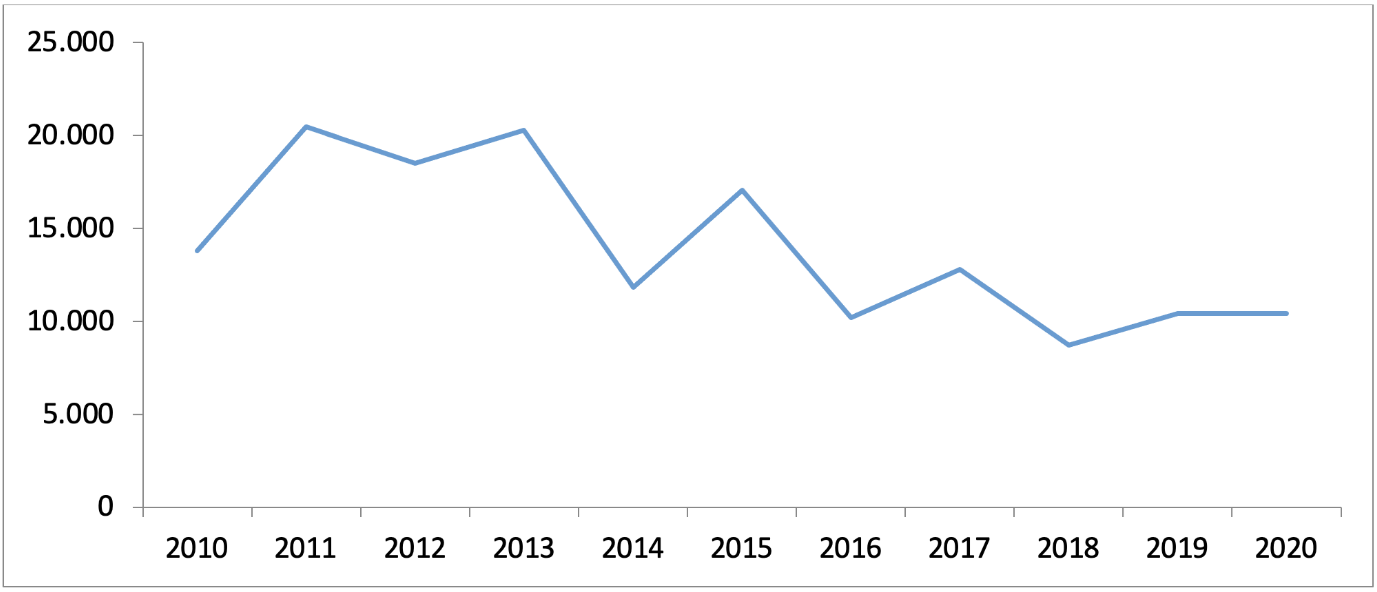


Figure 9. *Evolution of the Quantity of Fish Landed in the Larache Region (2010-2020) Source: Annual statistical reports from the ONP on the national production of coastal and artisanal fishing*

The figure shows the trend of the curve for the quantity of landings from coastal and artisanal fishing in Larache over the last decade, dominated by crustaceans, cephalopods, whitefish, and pelagic fish. There was a decrease in fishery resources landed at the port of Larache at the end of the study period compared to the beginning, and this decrease occurred irregularly with significant variations.

Table 3. *Variation in the Quantity of Fish Landed in the Larache Region*

Années	Variation poids
2010-2011	48%
2011-2012	-10%
2012-2013	10%
2013-2014	-42%
2014-2015	44%
2015-2016	-40%
2016-2017	25%
2017-2018	-32%
2018-2019	19%
2019-2020	-15%

6. Discussion of the Results

The average weight of fish landed decreased from 17,129.5 tons in the years 2010-2011 to 10,423 tons in 2019-2020, with fluctuations of up to ±40% of the weight during the decade. Exploring explanatory hypotheses, climate change is considered one of the causes of this decline.

According to a report from the "Programme d'Appui Analytique à la Stratégie Changement Climatique du Maroc," Morocco is highly sensitive to the impacts of climate change on marine and coastal ecosystems, with low adaptive capacity. Climate change has led to deteriorating weather conditions, with intense and prolonged periods of "bad weather" negatively impacting fishing productivity and profitability.

Weather conditions play a significant role in limiting fishing in Larache, as fishermen are reluctant to venture into rough seas with strong winds and waves exceeding two meters (World Bank, 2013). These adverse weather conditions affect water temperature, pH, and oxygen levels, impacting the life, growth, reproduction, and survival of fishery resources.

Besides climate-related factors, non-climatic stressors, such as dredging operations, have an immediate and significant impact on fishery resources. Dredging directly alters resources and their habitats during dredger operation and causes suffocation during disposal. Species with low mobility, such as crustaceans, are particularly vulnerable to these damages, leading to resource depletion not only in the dredged area but also beyond (Benmohammadi et Labraimi, 2011).

Dredging activities also result in increased water temperature, turbidity, and sedimentation, negatively affecting the functional structure and diversity of benthic communities, both animal and plant.

Recent cessation of sand dredging in Larache due to the pandemic is highlighted as a potential explanation for a slight increase in the quantity of pelagic fish caught off the Atlantic coast, spanning from Moulay Bousselham to Cap Spartel (Tangier). This could confirm a causal link between dredging and the decline in fishery resources.

Table 4. Quantity of Pelagic Fish Caught 2019-2020 Source: Annual statistical reports from the ONP on the national production of coastal and artisanal fishing

	2019	2020
Larache	**8 561**	**8 330**
Assilah	**95**	**95**
Tanger	**4 218**	**4 511**
Total	**12 874**	1. **12 36**

6.1. Mitigation Measures

- Preferably conduct construction work outside the high fishing season or during periods of cultural activities in the project area.
- Monitor water and sediment quality during the operational phase annually to ensure the environmental health of the aquatic environment.
- Avoid dredging during periods of strong currents to limit the transport of suspended sediments (MES).
- Throughout the construction work, site operators will visually monitor to ensure no pollution disperses into the marine environment.
- Adhere to speed limits.
- If fauna is observed, inform the vessel's captain and adjust maneuvers accordingly.
- Implement regular bio-sediment monitoring, especially for the benthic component, to better track and understand the effects of dredging.
- Dredging operations should not be prolonged.
- Consider the breeding seasons of certain species, such as the Hake, and avoid dredging during the month of February.
- The dredging area is a passage zone for large pelagic fish, mainly the bluefin tuna, with its migration period occurring between May and June from the Atlantic to the Mediterranean for reproduction.

- In August, during the coral's breeding season, it is recommended to dredge in the southern half of the deposit or halt dredging activities.

January	February	March	April	May	June	July	August	September	October	November	Décember

(green)	Possible authorization of dredging activities
(red)	Mandatory cessation of dredging activities

Table 7. *Dredging Schedule*

7. Conclusion

The development of the marine sand dredging sector has emerged as a viable alternative for regulating the national sand market. (Mounir HAKKOU 2016) The extraction of sand from the continental shelf of the Larache (Loukos) region has been taking place since 2008 with an annual production of around 1,250,000 m3. (DRAPOR 2020) The results of the comparisons in our study do not indicate any major negative impact on the environment and marine resources. For the evolution of beaches, the dredging effect is considered negligible due to its low intensity, limited spatial extent, and temporary duration. There is a moderately significant impact on fishery resources due to its high intensity, limited spatial extent, and temporary duration. This impact can be observed on some fish species found in sandy areas, especially in the North Atlantic. Indeed, the changes recorded between 2010 and 2020 may be due to natural factors specific to the environment (bathymetry, terrain nature) or weather and oceanic factors (hydrodynamic and meteorological parameters), in addition to dredging operations. A low negative impact of dredging activity can be ensured from the beginning by choosing the dredging area, respecting dredging conditions and tools, as well as the timing of dredging operations, and especially by applying the aforementioned mitigation measures.

Bibliography

- ANDRE & EL GHARBAOUI a, 1973. Aspects of the Coastal Morphology of the Tangier Peninsula, Rev. Geogr. Morocco.
- ANTONIO románm 2013 Study of the Natural Values of the Middle and Lower Sections of the Loukkos River. Larache. Morocco.
- Aziz BALLOUCHE 2013 Contribution to the Recent History of Vegetation in the Lower Loukkos (Province of Larache, Morocco).
- World Bank 2013 Climate Change and the Fisheries Sector: Impacts and Recommendations Kingdom of Morocco.

- BENMOHAMMADI A. & LABRAIMI M., 2011: Impacts of Coastal Bottom Dredging: Exploitation Dredging for the Commercialization of Sands, Defense of the Moroccan Coast for Sustainable Development, Final Report.
- ELMORHIT Mohammed (2009) Hydrochemistry, Trace Metal Elements, and Ecotoxicological Impacts on Various Components of an Estuarine Ecosystem (Lower Loukkos).
- Duclos P.A. 2012. Morpho-sedimentary Impacts of Marine Aggregate Extraction. Application to the Eastern English Channel Basin. Doctoral Thesis, University of Rouen, 272 p.
- Tillin H.M., Houghton A.J., Saunders J.E., Drabble R. & Hull S.C. 2011. Direct and indirect impacts of aggregate dredging. MEPF Report/10/p144, 41 p.
- Newell R.C., Seiderer J.L. & Hitchcock D.R. 1998. The impact of dredging works in coastal waters: a review of sensitivity to disturbance and subsequent recovery of biological resources on the seabed. Oceanography and Marine Biology: An Annual Review, 36, 127–78.
- Hakkou M., Castelle B., Benmohammadi A. & Zourarah B. 2011. Wave climate and morphosedimentary characteristics of the Kénitra-Bouknadel sandy coast (Morocco). Environmental Earth Sciences, 64, 1729–1739.
- Garrad P.N. & Hey R.D. 1987. Boat traffic, sediment resuspension, and turbidity in a broad land river. Journal of Hydrology, 95, 289–297.
- GEODE 2012. Environmental monitoring of dredging and disposal operations. Methodological Guide. Report 134 p.
- SAUVAGE, C. (1960). Biological types and distribution by bioclimatic zones of species and subspecies of the flora of Morocco. Unpublished Document, Inst. Sci. Rabat.
- HAMMADA S. (2007). STUDIES ON THE VEGETATION OF MOROCCO'S WETLANDS: Catalog and Analysis of Floristic Biodiversity and Identification of the Main Vegetation Groups.