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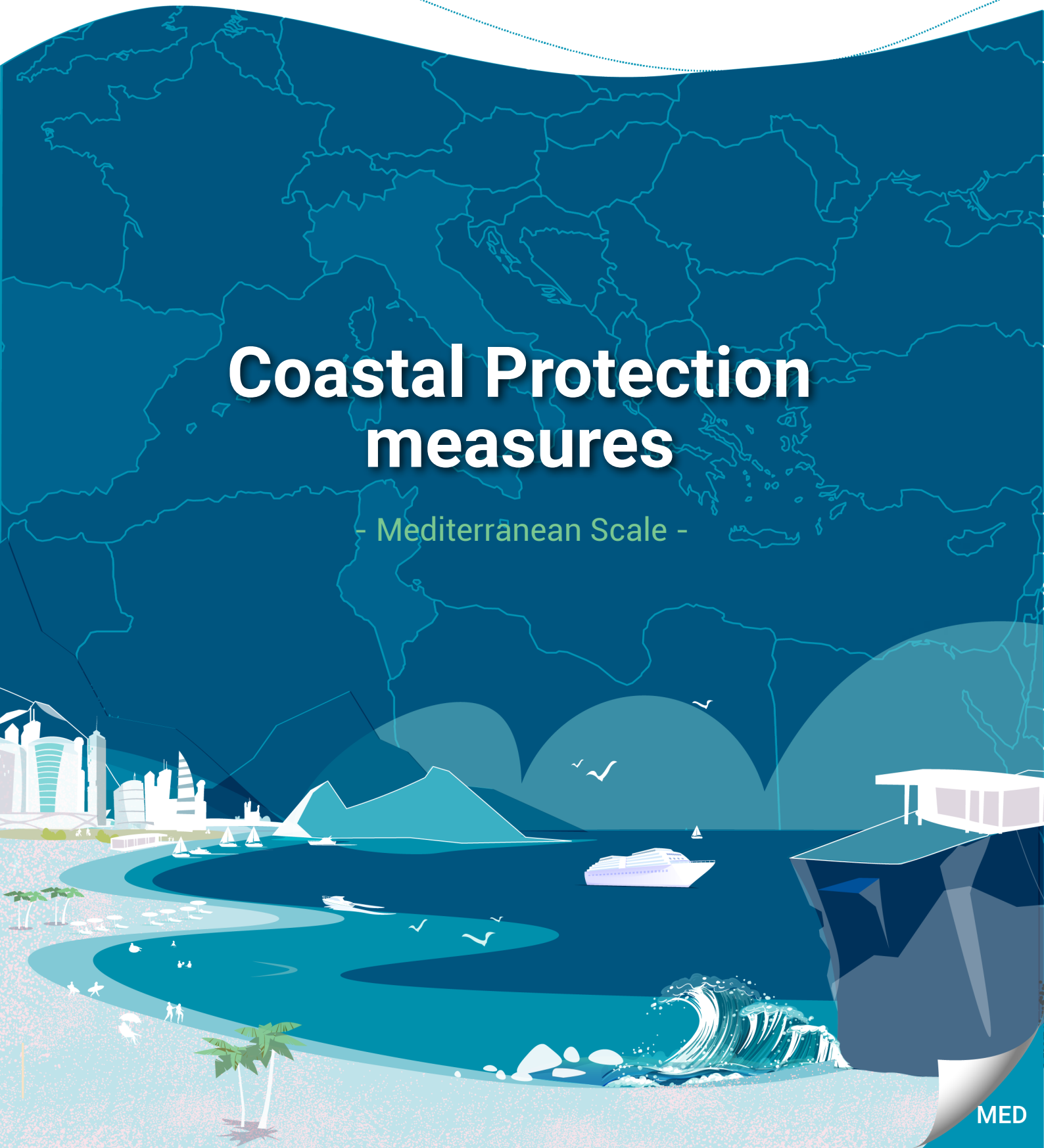
Co-Evolve4BG

Coastal Protection measures

- Mediterranean Scale -



MED

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OVERVIEW

The present document was produced in the framework of **Co-Evolve4BG** project "*Co-evolution of coastal human activities & Med natural systems for sustainable tourism & Blue Growth in the Mediterranean*" in relation to Threats and Enabling Factors for maritime and coastal tourism development at a national scale" Co-funded by ENI CBC Med Program (Grant Agreement A_B.4.4_0075).

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REVIEW

Authors

Ons GAHTAR, Master's degree

Hanene SAIDI, PhD
Faculty of Sciences of Tunis

Reviewers

Martina BOCCI, PhD
t-ELIKA, Venice – Italy

Harry COCOSSIS, PhD
International consultant

Hatem KANFOUDI, PhD
National Engineering School of Tunis

Editor

Béchir BEJAOUI, PhD
National Institute of Marine Sciences and Technologies
http://www.instm.agrinet.tn/index.php/fr/

Arnaldo Marin ATUCHA, PhD Biology
University of Murcia
https://www.um.es/

Contributors to the report

Béchir Béjaoui, Khouloud Athimen, Mahmoud Moussa, Rafik Ben Charrada, Saber Amira, Raghda Mestiri, Giuliano Tallone, Erica Peroni, Carolina Pozzi, Serena Muccitelli, Stefano Magaudda, Paraskevi Chouridou, Maria Chamitidou, Pantelis Pekakis, Dafni Delioglani, Arnaldo Marin Atucha, Nuria Garcia-Bueno, Pedro Martinez-Baños, Alberto Ortiz, Nahed Msayleb, Sana Abi Dib, Talal Darwish, Amin Shaban, Myriam Lteif, Myriam Ghsoub, Anthony Ouba, Malek Ghandour.

LAYOUT

Houaida BOUALI, Engineer
National Institute of Marine Sciences and Technologies

Mohamed Ali BRIKI, Engineer
Coastal Protection and Planning Agency, Tunisia

Laura PÉREZ, Graphic Designer
Fundación Valenciaport

Emma CASANOVA, Technician
Fundación Valenciaport

Carolina NAVARRO, Engineer
Fundación Valenciaport

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Abstract

The Co-Evolve4BG project aims to strengthen and analyze the coastal evolution of entropic activities and natural systems in coastal regions, highlighting the impact of the Sustainable Development Goals on tourism based on the (ICZM)/Marine Spatial Planning (MSP) approach and thus promoting blue growth in the Mediterranean. It focuses on the conditions for costal evolution. Coastal protection infrastructure is held responsible for changes in coastal systems. These impacts affect both the evolution of the shoreline, the morpho-sedimentology of intertidal zones and benthic organisms. Natural disasters may threaten people, properties and infrastructures. Several protective structures will be installed in the coasts to reduce the risk of flooding and protect exposed vulnerable elements. These structures are important interdependent systems with several components that deteriorate over time due to severe phenomena that have been experienced since construction. Damage propagation is affected by dependencies between the different failure modes and between the structure itself. These cascading events reduce the effectiveness of system-wide protection. Therefore, if they are not maintained on a regular basis, the level of protection of these structures will be reduced. (These Nour Chahrour, 2021)

I. Introduction

The Mediterranean coastline constitutes the border between the maritime space and the terrestrial and atmospheric space, it is the interface of the environment with particular properties whose complex traces make it possible to trace the coastline which stretches for approximately 46000 km, it is also distinguished by a high percentage of insularity. Eleven coastal countries have island territories. Among them there is Albania and a part of the islands belong to two countries of the western basin (Spain, Italy) and to two countries of the eastern basin (Greece, Tunisia) (Coudert,1996). Its morpho-dynamic stability has been disturbed in recent decades by geological, geomorphological, hydrodynamic factors and a series of developments leading to flooding, marine intrusion.

Erosion is a natural phenomenon linked to the impoverishment of the sedimentary stock inherited from the last ice age, gradually nibbling the shore, more or less quickly according to its nature: sandy beaches and chalk cliffs retreat sharply while erosion is much slower on granite (www.un.org/fr/climatechange/cop26). This phenomenon is aggravated locally by antropic and industrial activity as well as the extraction of sand or pebbles, dams that block sediments in rivers and dikes or harbour jetties that disrupt their natural circulation.

The effects of climate change can be seen in the release of greenhouse gases into the atmosphere. This causes water to expand and leads to the melting of the polar ice caps in Greenland and Antarctica (CAR/ PAP, 2018). As a result, there has been an increase in the relative sea level in various coastal regions around the globe, as reported by the IPCC in 2001 (IPCC, 2001).

In addition, pressures are becoming more and more intense with only 1/3 of people living in the coastal regions of the Mediterranean countries because of the artificialization of 40% of it and the combined impacts of pollution and loss of biodiversity. It is estimated that 420,000 people work in the fisheries and aquaculture sector in the Mediterranean and 550,000 in maritime transport on these coasts and also 30% represent tourist arrivals (CAR/ PAP, 2018).

On 9 December 2021, the Antalya Declaration was adopted as strong political support under the UNEP/MAP-Barcelona Convention system to achieve the establishment of a healthy Mediterranean coast in the framework of sustainable development (COP22, 2021). In this context, protective structures have played a key role in maintaining the Mediterranean coastline of marine erosion for global tourism prosperity.

II.
Overview of coastal protection measures in the Mediterranean Sea

II. Overview of coastal protection measures in the Mediterranean Sea

II.1. Definition of defense measures

Following the problems of active erosion of the cliffs and terraces of the Mediterranean beach ; Tunisia in collaboration with Albania, Italy, Spain and Greece recommend the establishment of coastal protection structures and repair of damaged structures (Albania. (2019), Italian Ministry for the Environment, Land and Sea. (2017)). In general, sedimentary transport is a natural phenomenon generated by natural forces ; winds, currents and swells induce the transit of sand along the coastline or to larger areas. It is impossible to act on these agents but there are ways of blocking the transit at the local level and thus the on-site storage of the marine sands. These are the hard defensive measures that have the particularity of freezing the dimensions, such as concrete structures, stone block rip-rap or slats, head of frontal dikes, etc. (Camargue Environmental Directorate, 2006).

II.2. Classification of Works

For the purpose of coastal defense, it is often necessary to combine different types of structures with high beach maintenance methods.

II.2.1. Heavy protective structures

Aim: Minimize the action of marine dynamism to position the coastline line and protect assets in the background

Transversal structures : which stop or define coastal transport. Short ears are influenced by river stream transit and are generally used for windward beaches.

The long spikes that descend to the flow line, also affect the transit through the coastal current. They are used on sandy beaches. These measures have virtually no effect on the movements in the profile of water column.

Longitudinal structures fall into two natural categories:

High riparian : composed of breakwater batteries that reduce the energy of the swell in the breaking zone, thus modify the conditions of erosion and allow the creation of tombolos.

Top of range: Allows the attachment of the rib line and the protection of the rear rib. They can generate secondary consequences by increasing the reflection of the waves ; they are spread at sea at tide.

II.2.2. Flexible works

Finally, we must add the methods of shoreline maintenance, the reloading of beaches or the restoration of coastal transit, cobs, dunes, ganivelle (Jean Bougis, 2000).

II.3. Construction Methodology for Selected Works

Breakwaters are typically built using sunken boulders sourced from quarries, and the rip-rap, also known as “lost stones,” is subsequently arranged according to technical specifications, allowing for some degree of variation during the construction process. According to Bernard Forest of Bélidor, it consists of superimposing layers of rubble and mortar, referring to a pile without any bond disorder. In 1788 a second option was concentrated on the construction of the Cherbourg dike after the failure of an underwater foundation method by filling conical wooden crates. The influence of Cherbourgeois practices is such that the immersion of dry stones 6 are used again in the Channel for the Plymouth Pier (1812-1841) (Fabien Bartolot, 1830-1870)

III.
Defense measures taken at the Mediterranean scale

III. Defense measures taken at the Mediterranean scale

In Tunisia, the coastal zone and beaches are subject to a very high pressure : 70% of the total population lives on this strip. This translate into 76% of the tourist activities and 87% of the industrial activities of the country are located on the band above.

It is considered to be one of the main tourist destinations of the South Mediterranean with an average of more than 5 million tourists a year, or about 17 million overnight stays. At the end of the 1970s, the action of defense of the littoral began with the old means of hard protection works. After, in the early 1980s, violent storms caused considerable damage to the coast of the Tunisian city.

In Spain, as a strategy, Europe recommends an ICZM with actions at local and regional levels supported by a national perspective. The EU should support these actions through the dissemination of coastal information, data and knowledge.

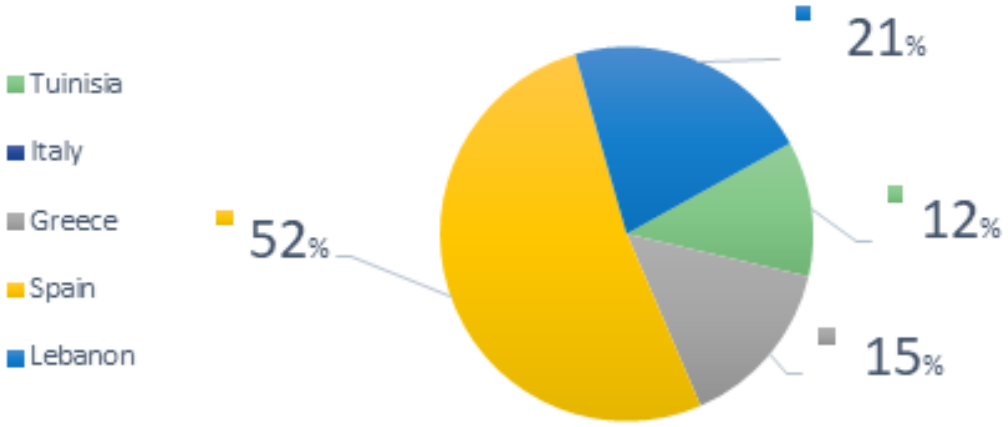

Figure 1. Total number of Protection measures already installed.

Across the Mediterranean region, various measures have been implemented, as depicted in Figure 1 and 2, to safeguard coastal areas and buildings against the damaging effects of sea swells and erosion, which can lead to severe flooding - a common natural disaster. These measures have been introduced by five different countries, with Tunisia leading the way by installing approximately 52 protective structures along its entire coastline, from the North to the South. This has resulted in the restoration of 10% of the affected beaches, subsequently boosting the tourism industry and increasing occupancy rates in nearby hotels.

In Italy, there was no data to indicate the number of measures placed on the coast,

whereas in Spain 231 measures were used to preserve about 2378.80 ha of the shoreline area. In Lebanon, there were 95 measures of protection equivalent to 15% in percentage, thus the restoration of more than 50% of the coast of the countries involved in the tourist development and the rehabilitation of 52% of the coasts. In addition Greece put in place 66 measures at the edge of these beaches without any data reflecting whether there are beaches restored down or not.

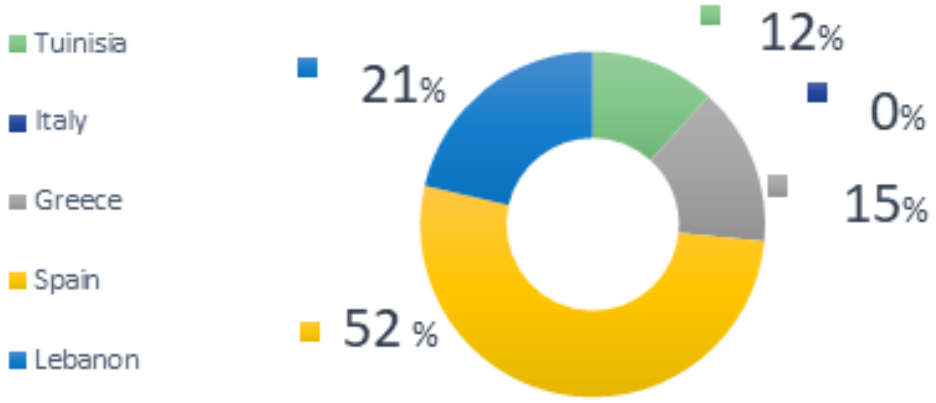

Figure 2. Restored area (Beach) after the implementation of the protection measures

III.1. Protection measures in Tunisia

In Tunisia, protection works and port works are unevenly installed all along the coastline of each region, depending on the need to avoid the dangers of SLR or human activities including loading beaches or trembling the equilibrium of sedimentary transits causing erosion in regions that are no longer fed by the contribution of transport such as Yassmine Hammamet (APAL) also for the contribution of tourism prosperity. The objective of the dune installation in the northern Tabarka region is to reduce the intensity of sea winds and facilitate sediment transport, thereby preventing extensive erosion over time. To this end, a protective coating has been implemented to safeguard the area against erosion.

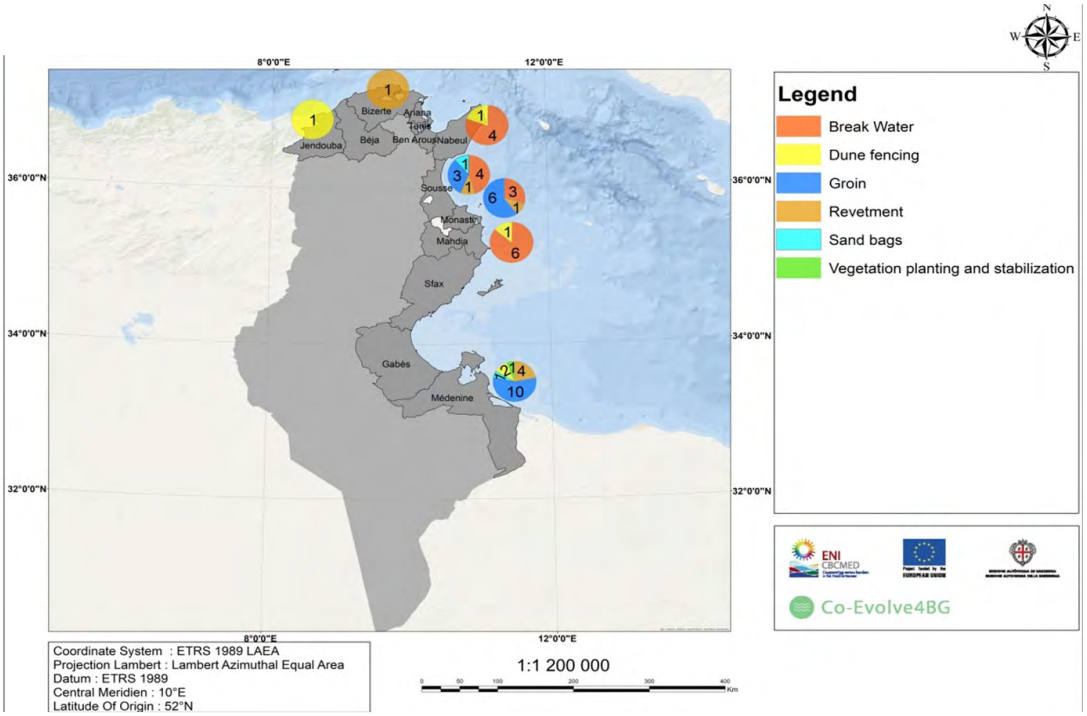

Figure 3. Number and types of coastal protective measures in Tunisia

The coastal protection structure in Bizerte, particularly along the cornice, was constructed in 1992. This structure spans a length of 650 meters and comprises two primary components: a protective fill made up of rip-rap measuring 0.5 to 2 tons, and a reinforced concrete back retaining wall measuring 385 meters in length, which serves as an additional protective measure.

Thus a jumper of 200 ml has been developed in order of protection against marine erosion within the caves of Bizerte. (APAL, 2019).

Currently the ISTNM through EU funding and in collaboration with the Tunisian Ministry of Environment has applied the procedures of defense in the form of coastal coating in Bizerte also contributing to the prevention of the region of Rafraf which was exposed to a massive erosion by the creation of a sandy beach of 300m in length. Thus around the region of Nabeul 4 waves are set up for the creation of beaches and the restoration of hotels. Thus at this one and Jendouba there are two dune barriers on the beach which are installed in order to create the beach of Hammamet and coastal protection using the flexible and hard defense methods in Soliman beach. Practically there would be the location of a rock jumper with a length of 850 m as well as isolated breakers in addition to the installation of sets of five breakers 590 m long insulated blades and 5 dipping peaks of a length between 350 and 370 and in addition to that

there was an artificial recharge of the beach with an amount of 520.000 m3 which led to the removal of the five breakersblades and then the development of the Cranks on 7 km of beach. Thus at the beach Sidi Jehmi there is the location of a rider of 350m.

Figure 4. Rafraf Beach Protection Works, 2018

Lido beach protection work- Break waters

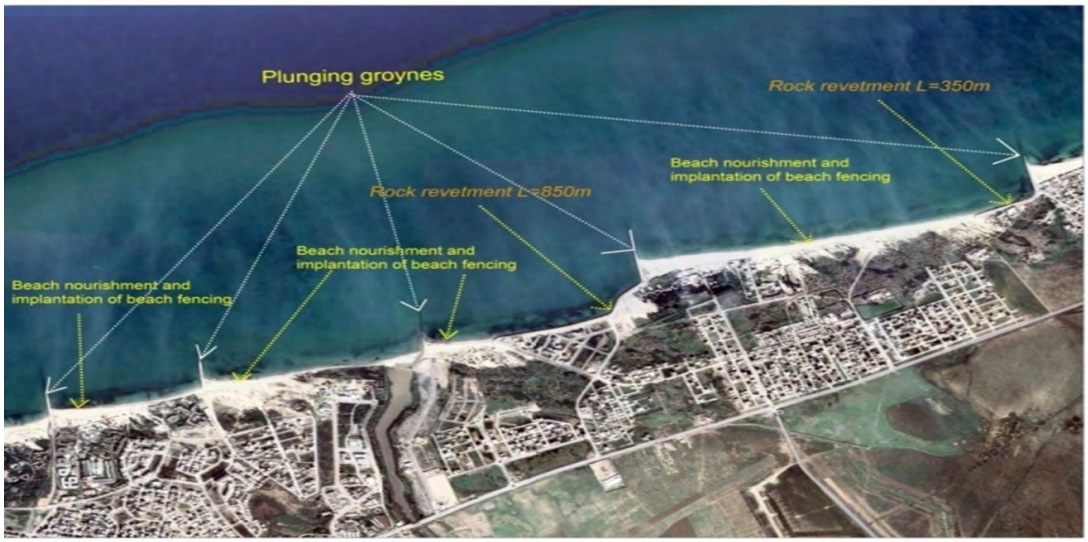

Figure 5. Protection works of the Soliman beach, 2016

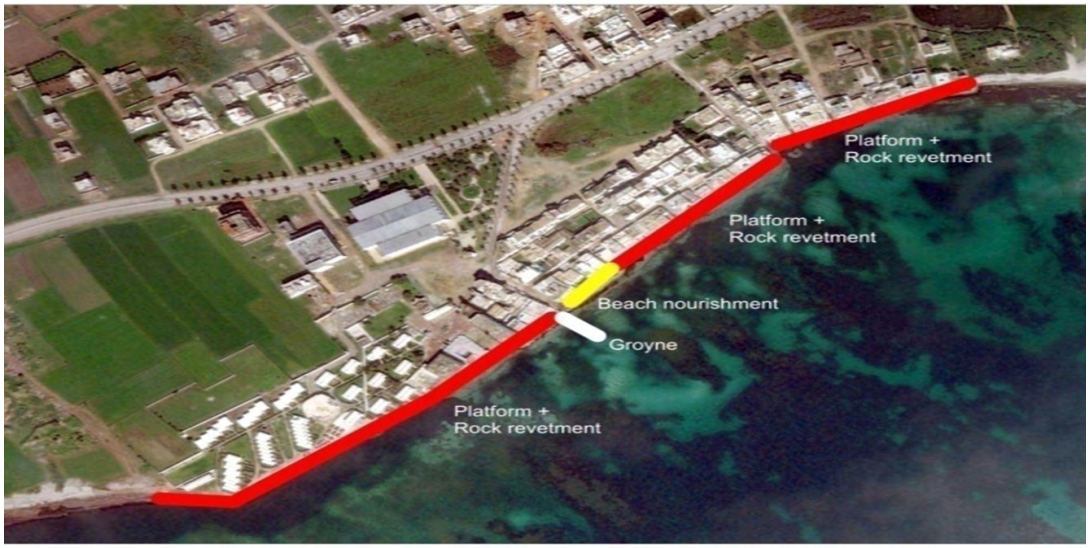

Figure 6. Protection works on the El Mamounia section in Kélibia, 2017

In Central Tunisia, especially in Sousse, Monastir and Mahdia 13 breakersblades are implemented in order to protect the beaches of which four submerged of 250ml each at Hammam Sousse three of 200 ml each at ChattMariem so in the South there are two of 90 m long and of which three a Monastir a Skanes are respectively from EAST to WEST with lengths of 160 m and 300 m. There was also the creation of two coatings in Sousse and Monastir and a dune development because of maintaining the beach of massive erosion and coastal transit and to slow the advance of the sea towards the coasts thus maintaining the stability of the coast line especially in El Kantaoui followed by the elaboration of three ears of which two of them are 80 m long and extend over a section of 500 m associated with a slope of 170m and a beach reloading of the sands with coarse grain size and six a Monastir of length 75 m laid so perpendicular to the rating also the installation of two Y seniors each of 90 m and especially a bag of sand due to the reloading of the beach of Sousse for the lasting contribution of accessibility to tourists . These measures are not applied to Sfax. (APAL, 2016).

In 1992 and 1993, on the coast of the island of Djerba, several protective measures of the rock bank type were established. Especially very short ears are built to protect the coast from erosion phenomena also on the northeast coast in order to avoid any marine progress near hotels such as Hotel El Jazira: Longitudinal protection on 120 m and Aghir: Set of 8 points of 100m each.

Protective structures were built by DGSAM at Houmet Essouk 300 m of Palmivelle 200m rocking stop.

To the north of the town of Zarzis, three coastal sites were protected by a rock embankment, on a total line of about 632.

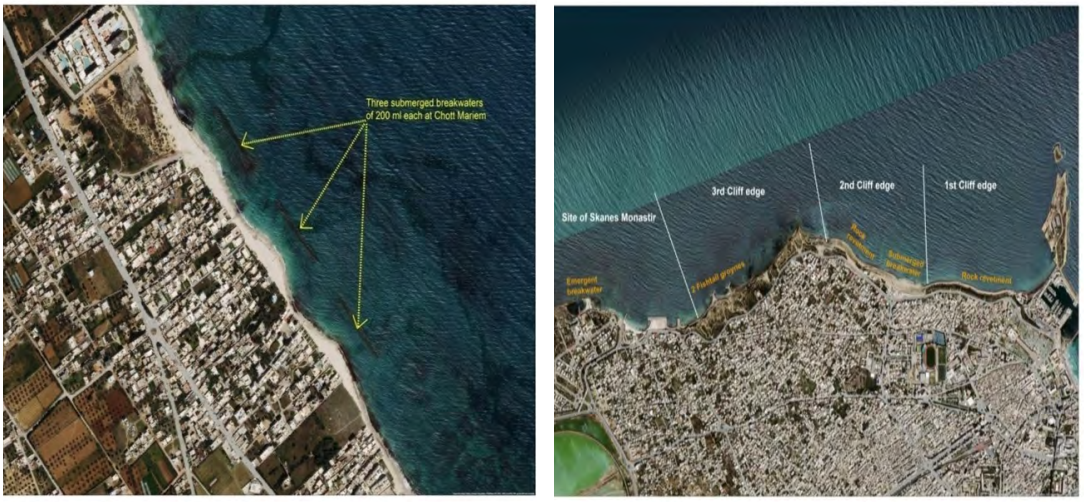

Figure 7. Protection works on the El Mamounia section in Kélibia, 2017

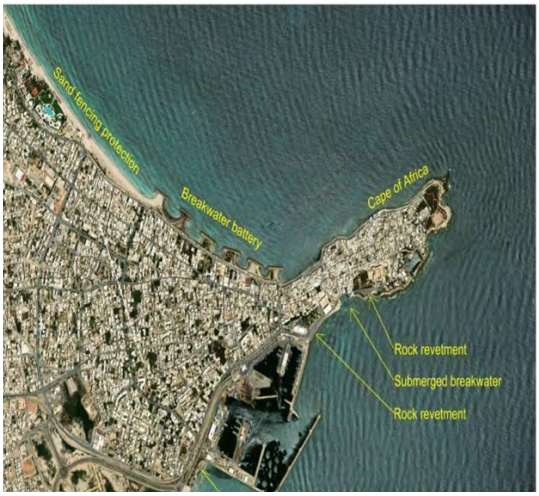

Figure 8. Protections realized in Mahdia

Jerba (Aghir) protected by Spikes

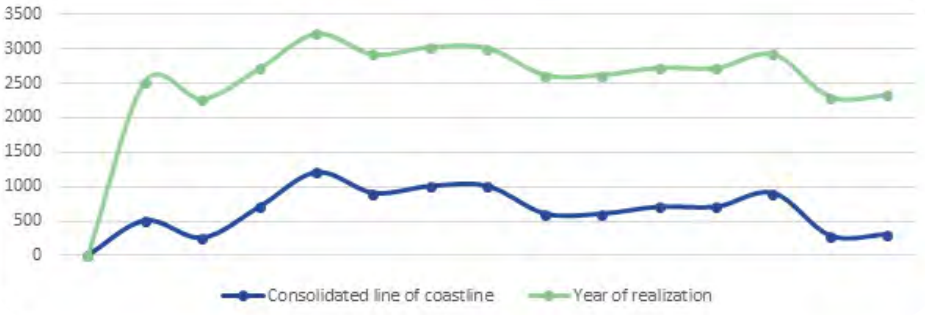

Figure 9. Assessment of the Tunisian achievements in the field of stabilization of the top beach by ganivelle

The graph shows the variation of the installation of Ganivelles all along the Tunisian coasts from the years 2000 to 2019. The location of these all along 1200m and more began in the 2000s in El Mahdia on a 1000m stretch of coastline during the years 2005 and 2012 near the Korba esplanade on a wide coastline that reaches 1200 m and has Bni Khiar on 900 m coastline. ATabarka in 2013 between hotel Mehari and Abu Nawess on 250m of the coastline, in Mahdia city of length 1150m on an extended 600 m coastline in addition to Chebba , Gabes and Jerba on lengths as follows: 700 m, 900 m and 280 m.

In 2019 their creation all along the 500 m coastline and made a tabarka and Hammamet on 1000 m of the coasts and Sebkha Dime and has Zarzis on successively 700 m and 300 m each its coastline to decrease the wind action and due to coastal defense.

III.2. The impact on Tunisian tourism

The Tunisian coast is home to more than 95% of the accommodation capacity and tourism activities in Tunisia, which provides more than 400,000 direct jobs, mostly under seasonal contract according to official data, and 286,200 indirect jobs. Tourism is the key sector of the Tunisian economy that has been heavily affected in recent years by political crises and terrorist threats.

Figure 10. Location of seaside resorts in Tunisia

The Municipality of Sousse and the regional services of the Coastal Protection and Development Agency (Apal), accompanied by the maritime guard and the municipal police, April 7, 2022 to the execution of the decisions of demolition of establishments and « anarchic» tourist spaces built on the coastal domain maritime public of Sousse. (The presse 2022)

III.3. Effects of Storms on Spanish Coasts

Marine boundaries are defined as the subdivisions of marine regions and sub-regions that constitute the spatial perimeter on which each marine strategy will be developed.

They are developed to :

- Increase legal certainty for coastal rights holders.
- Facilitate the adaptation of beaches to climate change.
- Ensure transparency and information to citizens about their properties and other rights, so that no citizen can ever again acquire a house or other property on the coast and find out later that it does not belong to them because they are LMPD.
- Establish effective coastal protection, allowing all agents acting on the coast to clearly know which goods are in the maritime public domain-to avoid inappropriate uses or occupations that could affect an area as sensitive as the shoreline.

In April 2022, the specific force of the storms that generated waves up to 11 meters within the Strait of Gibraltar, requires urgent action to repair the damage caused by it. The Ministry has taken as a precaution measures to repair the damage caused by the sea breeze and the storms that have affected the southern coasts and actions of an estimated amount of more than 12.3 million euros are planned along the Andalusian coast of the communes of Ceuta, Melilla, Murcia and Valencia. In this context, the Minister of the Environment (MITECO), signed a resolution proclaiming the urgency of the work necessary to repair the damage caused by the lunar storm. From March to early April, the distribution of interventions in the states of Almeria, Granada, Malaga, Valencia, Alicante, Cadiz, Murcia, etc.

Strong winds and waves have caused, among other things, erosion and loss of sand on beaches, estuaries and boulevards, leading to situations that can endanger the use and enjoyment of the beach, even in less violent storms. The impact on the dune system is also significant, with the disappearance of the 200-metre dune of the beach

of Tavernes (Valencia) and the impact on the beach of Cabo Pino (Malaga). The adoption of new structures to more effectively and efficiently strengthen the shoreline, which is a government priority. The Directorate General of the Sea Coast will impact on a case-by-case basis extreme episodes such as these depending on the specific dynamics of each coastal zone and whether natural regeneration is spontaneous and predictable. (MITECO)

In Spain, the conservation of biodiversity has played a key role in the tourism sector highlighted by the Sites of Community Importance, which are the areas of the entire national territory or maritime waters under national sovereignty or jurisdiction, including the exclusive economic zone and continental shelf, approved as such, which contribute significantly to the maintenance or, as appropriate, to the restoration of the favourable conservation status of the natural habitat types and habitats of species of Community interest listed, respectively, in Annexes I and II to Law 42/2007, in their natural range.

These CIS are more appropriate in terms of number and area for the conservation of the bird species listed in Annex IV to Law 42/2007, of 13 December, on natural heritage and biodiversity.

According to the World Tourism Organization, ecotourism is growing. Thanks to the diversity of its landscapes, the richness of its biodiversity and its cultural richness, the Mediterranean is one of the regions most conducive to its development. Several ecotourism projects have been developed, including the MEET project (2013-2015) which aimed to develop an ecotourism model for Protected Areas (PAs) in the Mediterranean, based on the European Charter on Sustainable Tourism, to promote a better seasonal distribution of tourist flows (MedPan).

III.4. The effect of the defense operations on the Italian coasts

The Italian coast seems to have declined by a total of 1534 km (23%) during the period between 1960 and 2012. This can be quantified to 92 square kilometers, but decreased by a total of 1306 km (19%). 57km². Coastal decline and loss of sea level are particularly pronounced and widespread in estuaries. The entire beach is very remote, losing territory and its value both from an environmental and economic point of view. Coastal erosion also often compromises the safety of homes, roads and railways, especially in the event of a storm. Despite numerous coastal protection and restoration measures, beaches continue to lose surface (artificial uplifts between 1997 and 2011 were mostly more than 20 million cubic metres from the seabed (MATTM – Sogesid; 2017).

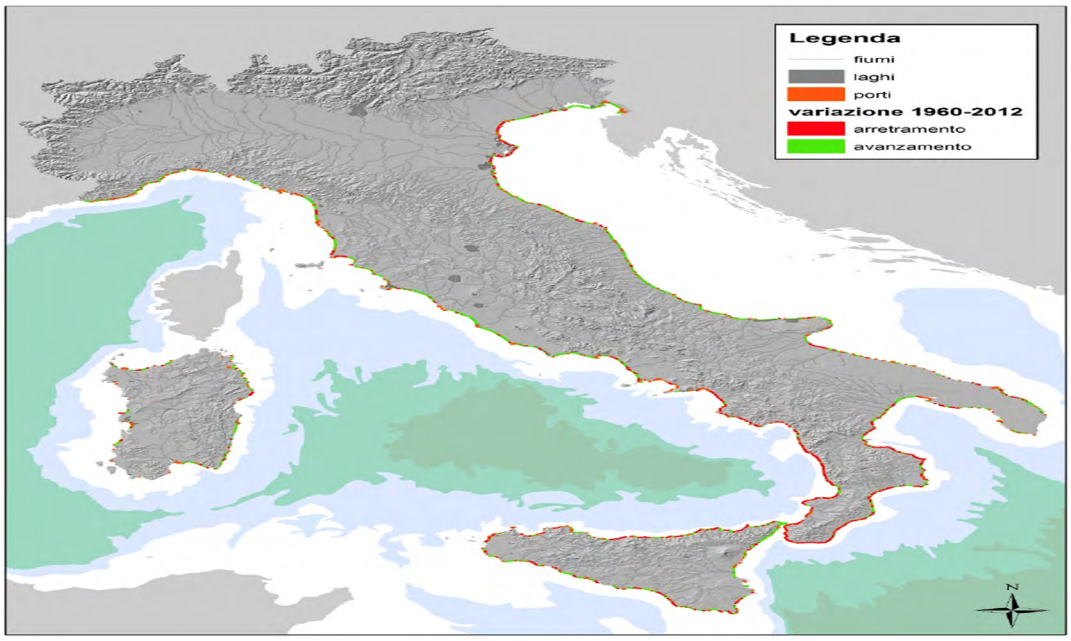

Figure 11. Variation of the coastline from 1960 to 2012 (MATTM – Sogesid, 2017)

III.5. The Measures of protection of the coast Greek

Greece has the longest coastline in Europe and the 10th longest in the world of (16,000 km) of which 5% is located in areas of unique ecological value. It is divided equally between the continental regions and the 3,000 islands. (Hellenic Ministry of Environment and Energy). Rich nature and an ideal Mediterranean climate and more than 70% of the rocky coastline (EU, 2009) are just some of the factors that attract millions of tourists each year. In particular, coastal and marine tourism is the most common in Greece. It includes all tourism activities within coastal areas and at sea as well according to national statistics seems to attract the majority of tourists by providing significant support to the national economy (Hellenic Statistical Authority, 2019). But coastal areas today are threatened by a variety of threats such as human activity and climate change.

III.6. The works of protection of the coasts Greek

A number of defences are considered to maintain the stability of coastal sandstones against marine phenomena by dividing them into two categories (National Research Council, 2007);

- **Hard measurements :** Civil engineering work aimed at the resistance of tides, and swells e.g. transverse and parallel to coastal breakwaters, embankments, etc.

- **Flexible measures :** artificial beach reconstitution, sea energy exploitation, sand bypass systems (dunes), submerged breakwaters, etc.

In Greece, there are a large number of Mediterranean habitats included in the Natura 2000 reference document, ranging from the high seas, tidal areas and sea dunes to bushes and grasslands of all kinds and mountain coniferous forests. The Greek network of Natura 2000 sites includes 241 Sites of Community Interest (SCI) and 202 Special Protection Areas (SPAs).

Governments and local authorities have begun to act against the negative variations that threaten coastal ecosystems. Because of human activities and the side effects of climate change such as the serving effect and the rise in temperature or the aggressive winter causing flooding and SLR, coastal areas suffer from massive degradation.

Strategies to adapt to sea-level rise can be based primarily on retreat, evacuation and protection. The withdrawal refers to adapting to changes and maintaining any entropic activity in coastal areas so that these activities are not significantly affected by this phenomenon. (Hellenic Ministry of Environment and Energy, 2016).

To this end, several actions are implemented :

- Development of protective zones between the shoreline and the residential area.
- Erosion is a serious threat that requires the authority to control the development of habitats and trade in coastal areas.
- Move new construction and infrastructure in coastal areas to higher areas if necessary.

Figure 12. Transversal breakwaters.
Source: intersailclub.com.

Figure 13. Parallel breakwaters.
Source: Discovering Happisburg

III.7. Coastal protection planning and management in touristic Lebanese areas

A linear extension is showed all along the Lebanese coastline of 22.13% mainly due to the establishment of several installations during the last four decades (Faour and Abi Rizk, 2008)

An environmental monitoring programme for coastal water quality is being implemented to study environmental conditions along the Lebanese coast and assess the extent of its changes. Measurements of physico-chemical, bacteriological and biological parameters are taken every month at 25 sites, reflecting the geomorphological and ecological variations of the Lebanese coastal zone. Each year, a map showing the different sites and their updated environmental status is published (NCMS-National Center for Marine Sciences/ CNRS-Lebanon).

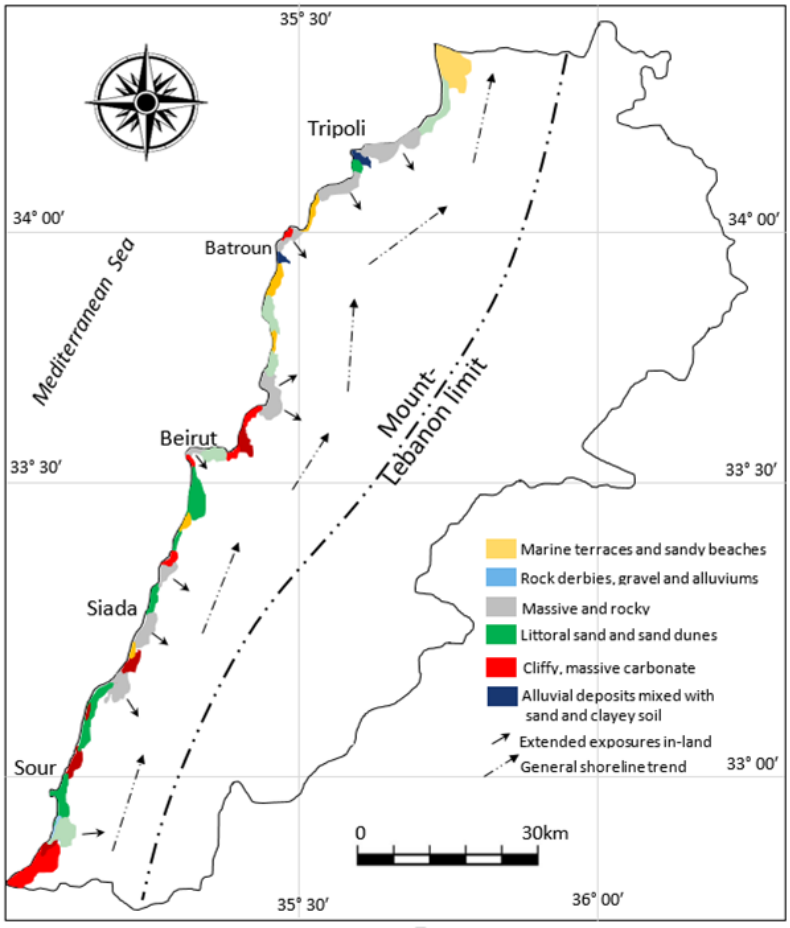

Figure 14. Types (& surface materials) of shoreline along the coastal zone of Lebanon.

The natural coastal defenses and stability can also be threatened by the combined effects of residential, industrial, touristic and infrastructures activities.

The majority of these problems are :

- Urban sprawl and privatization of the coastline
- Solid waste disposal and wastewater effluents
- Marine pollution by industrial and oils residues
- Beach quarrying and sand dredging.
- Salt water intrusion and disappear of submarine springs

III.8. Technical Protection measures

Defense works based on applied approaches and technical tools along the Lebanese coast have similar functions by following different techniques. They are collected at the individual level, while others are set at the local government level or ministries concerned (mainly MoPWT). The (Table1) shows that there are 95 designated conservation sites on the Lebanese coast identified by satellite imagery (Ikonos, 1 m spatial resolution). On the other hand, these measurements have varied dimensions along the coast, ranging from less than 100 m to more than 1 km.

Table 1. The technical protection measures along the coastal zone of Lebanon.

Technical measures	Number of identified measures	Major defense purpose	Restored Beaches (Ha)	Effectiveness
Retaining walls	19	Reducing waves energy, Erosion, Protecting urban settlement, surface materials collapse and drifts.	No Data	Very effective
Concrete fences	12	Coastal floods and then protecting shoreline	2526.00	Effective
Rock Groin	18	Stabilizing shorelines with soft materials, especially from coastal floods, drifts and collapses	1405.45	Very effective
Embankments	19			
Dolosse	9			
Harbours (including other protection tools)	15	Reduce waves energy and then protect shores from erosion	No Data	Slightly effective
Stabilization Planting	3	Stabilize shore and coastal plains with argillaceous and loamy soil	938.5	Moderately effective

IV.
Regional Defenses in Different Countries

IV. Regional Defenses in Different Countries

We note that the total number of monitoring measures installed on the coasts and the area of the beaches restored after the implementation of these measures varies according to the regions of each country , in the north of Tunisia eight measures are created and contribute to the restoration of 12 beaches so in central Tunisia there are about 20 beaches are preserved after the implantation of 26 defences and in the south 18 protective works have contributed to the maintenance of 16 beaches all along the coastline. In Spain 43 protection measures are already installed in the Catalonian coasts. Thus approximately 112 other defences are placed all along the coasts of Valencia , Balearic Islands , Region of Murica and Andalucia and amenes to the development of 2,338.3 beaches and therefore the tourist development of hotels in this country . However in Italy, Greece and Lebanon those measures were not applied .

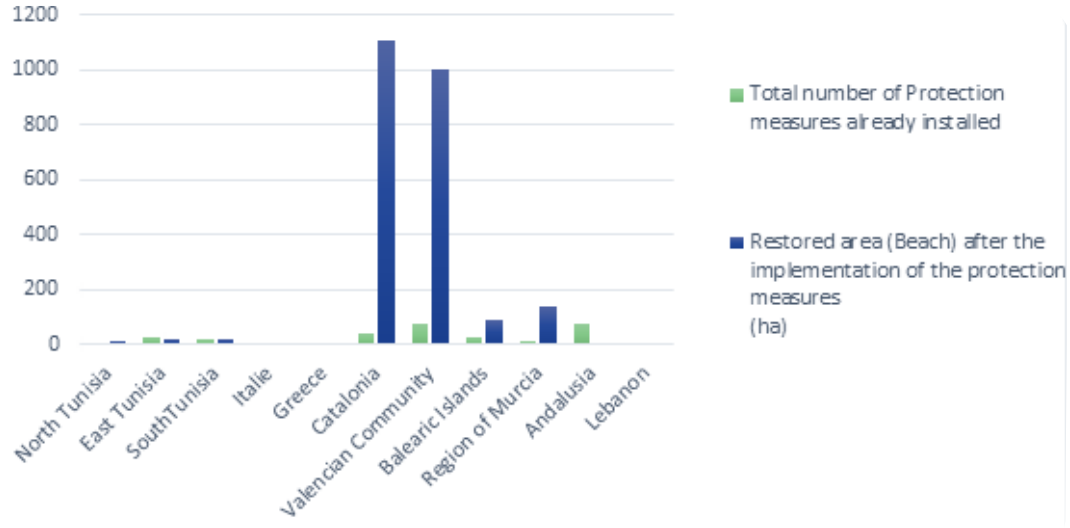

Figure 17. Total number of protected areas and beaches

The Map below shows the variability of restored Area (beach) according to the regional scale after the installation of the protection measures in each country. In the North of Tunisia, the number of places previewed from the effects of the tempests and erosion is a little reduced regarding the central and southern coasts. There are about 12 beaches and hotels maintained, by contribution to the center the protective structures have contributed a tourist development more remarkable so the restoration of 19.5 Ha of beaches within the coastal regions. In addition to the south the restoration of the beaches is done all along 16 Ha of the total area of the coasts. In the south of Spain on a scale of 1/3600000, the protected area of the beaches is zero and climbing up within the Aguilas coasts there are about 139.9 Ha of beaches protected by defenses

tools. A little further up in the Golf of Valencia a large area of about 1003.25 Ha is taken over by the coastal protection works. For the north the squares restore all along an area of 1108.3 Ha. For the rest of countries like Italie, Greece and Lebanon there is No Data.

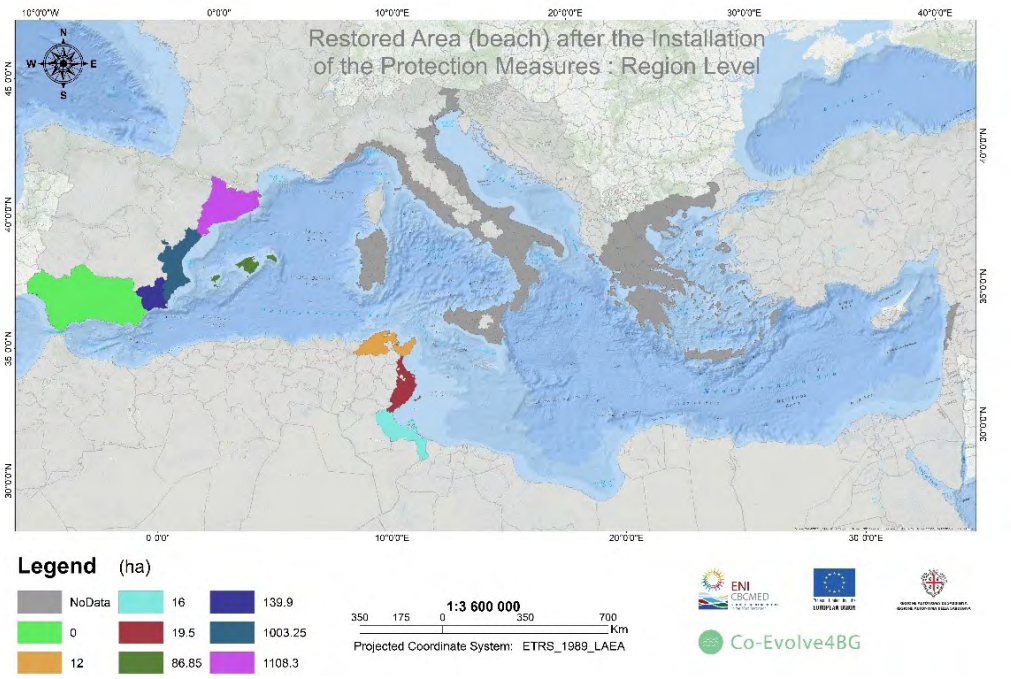

Figure 18. Restored Area (beach) after the installation of the Protection Measures: Region Level

V. Comparative table of measures from all countries

V. Comparative table of measures from all countries

The following table presents a comparison of protection measures for different countries

Table 2. Country-level protection measures

Country	Total Number of safety measures	Reasons of the installation of the measures	Restored beachs and hotels for tourism development (Ha)
Tunisia	52	Protection and creation of the beach	47,5
Italy	NoData	NoData	NoData
Spain	66231	Protection and creation of the beach, city, front, buildings	NoData
Greece	66	Protection and creation of the beach, city, front, buildings, roads	2378,8
Lebanon	95	Protection and creation of the beach, city, front, buildings from coastal erosion and floodings	5676,1

VI.
Key Vulnerabilities and issues

VI. Key vulnerabilities and issues

To do that, and those are the ones that have a naval force. The ability to act and in the field.

To a greater or lesser extent, all countries have coastal risk assessment projects or programs related to erosion and flooding. Many of them have helped them diagnose these problems along the coast and thus determine which areas are currently most affected.

The challenge is to ensure human security and promote economic development without compromising ecological integrity. Although ecosystems contribute to human well-being, these services are not always quantified and therefore their benefits are not recognized at the management level. This problem is compounded by a lack of knowledge about the contribution of ecosystems to human well-being, such as the ability of salt marshes to reduce wave energy in coastal systems and their potential role as natural buffer systems. (Rochelle-Newall et al. 2005)

In Spain the dangers associated with coastal flood plains correspond to moderately probable flood scenarios (probability of 100 years and 500 years), is the foreseeable extension of the flood and the depths or heights of water, as the case may be. Return period T=100 years or T=500 years. Flood-prone areas were calculated using various wave and sea-level rise assumptions using mathematical models and the PNOA-IGN TAM (MAGRAMA)

Greek coastal areas are no strangers to the threats caused by human activities and climate change and in particular, a coastline of approximately 1,000 km in Greece is considered as vulnerable to these threats (Hellenic Ministry of Environment and Energy, 2016). Some of the biggest consequences of climate change in coastal areas are the rise of the sea level, the accelerated soil erosion, the degradation of aquatic ecosystems and the increasing frequency of extreme weather phenomena.

In the years to come, it is expected that many coastal areas in Greece will be severely affected by the rise of the sea level (SLR) (Hellenic Ministry of Environment and Energy, 2016). Many regions will be flooded, constituting a direct danger for most of the Greek citizens, since the majority of the population lives close to the sea. Apart from the economic and social impacts this will have, it will also threaten people's lives.

In 2011, Alexandrakis et al. made use of the Coastal Vulnerability Index (CVI), a method developed by Hammar-Klose and Thieler to assess coastal vulnerability, in order to discover the vulnerability of the coastal areas in the Aegean. It was estimated that approximately 90% of coasts were very vulnerable to the rise of sea level (Hellenic Ministry of Environment and Energy, 2016).

VII. Conclusion

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Marine protection systems (jetties, breakwaters, etc.) must resist the adverse effects of storms, swells and erosion to ensure adequate safety of the port facilities they protect. However, these structures are very expensive and it is important to define the criteria to determine its properties. Knowing the risks associated with the operation of a port, construction of the protective structure is essential. These risks can be clarified if the concept of probability of collapse of marine protection structures works.

The significance of the amplitude of the swell as a crucial factor in determining suitable protection measures for port facilities lies in its potential to increase the likelihood of ruin. This, in turn, can aid in the proper interpretation of results obtained from reduced model tests, as noted by (Lhermitte, P.,1957).

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