Coastal Protection Measures in Tourism Areas

Lebanon scale

ENI CBCMED
Cooperating across borders in the Mediterranean

Project funded by the EUROPEAN UNION

REGIONE AUTÒNOMA DE SARDIGNA
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Co-Evolve4BG

Analysis of Threats and Enabling Factors for Sustainable Tourism at Pilot Scale

Coastal Protection Measures in Tourism Areas

Lebanon scale

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OVERVIEW

The present document was produced within 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 on a national scale" Co-funded by ENI CBC Med Program (Grant Agreement A_B.4.4_0075).

This document consists of the **Deliverable 3.1.4.78** (Coastal Protection Measures in Tourism Areas – Lebanon scale) of the **Activity 3.1.4** (Threats and Enabling Factors at National Scale: Overview) under the **Output 3.1** (Integrated analysis of Threats and Enabling Factors for sustainable tourism at MED scale) of the project.

REVIEW

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ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
AE-CID	The Spanish Agency for International Cooperation
AEWA	Agreement on the Conservation of African-Eurasian Migratory Water Birds
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNRS-L	Lebanese National Council for Scientific Research
EIA	Environmental Impact Assessment
EPC	Environment Protection Committee
GAC	Government Appointed Committee
IBA	Important Bird Area
ICZM	Integrated Coastal Zone Management
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoI	Ministry of the Interior
MoPH	Ministry of Public Health
MoPWT	Ministry of Public Works and Transport
MPA	Marine Protected Area
NCMS	National Center for Marine Sciences
NGO	Non-governmental Organization
OAPN	Autonomous Office for National Parks of Spain
PINR	Palm Islands Nature Reserve
RSC	Remote Sensing Center
SPAMI	Specially Protected Area of Mediterranean Importance
SPA/RAC	Specially Protected Areas Regional Activity Centre
TCNR	Tyre Coast Nature Reserve

I. Introduction

This report represents the coastal protection measures in touristic areas-Lebanon. This deliverable is going to provide an analysis of coastal protection plans and their implementation at the Lebanese National scale. First, it will present an overview of the coastal defense measures, and then it will provide an analysis of the recently adopted monitoring approaches along the coastal Lebanese areas. Besides, it will demonstrate the strengths and weaknesses of coastal planning management. It will also provide an analysis of the management and development of the Lebanon touristic area.

The Lebanese coastal plain is almost a narrow ribbon that ranges between 0.5 and 7 km wide. It extends 240 km from Aarida in the north to Ras Al Naqoura in the south covering 16% (180,000 ha) of the total Lebanese territory. The Lebanese coastal zone is the richest in terms of natural resources, but it is the most vulnerable zone of the country. Over 80% of the coastline (within a stretch of 500 m) is dominated by a variety of economic activities (*e.g.,* urban, industrial, and agricultural areas), while bare areas represent less than 20% of the total coastal zone. In addition, this zone is characterized by its high population density if compared to the overall Lebanon population density. Almost 70% of the total population lives in the coastal zones and that host 33% of all built-up areas (CDR, 2005).

Lebanon is well known along the Mediterranean coast as an attractive destination for diverse international tourists coming from different corners of the world. The Lebanese coast encompasses several residential areas, as well as industries, businesses, tourism, and other activities as well. Thereby, causing environmental pressures and degradation of coastal lands and resources. In fact, Lebanon coastal area lands are highly solicited thanks to their coastal setting and their proximity from the major Lebanese cities, including Beirut the capital, as well as their attractive touristic aspects. Yet, most public maritime domain has been privatized over the past four decades mainly by anarchic massive touristic entities, which does not actually facilitate attaining the coast sustainable tourism development (UNEP – ERML, 2012; CAMP, 2017).

Lebanese touristic traditional trends have had a destructive impact on the environment, in addition to the coastal waters that host a wide variety of ecosystems, such as coralligenous habitat, vermetid reefs and other aspects of unique ecosystems (Bariche, 2010), including habitats associated with endangered fauna and flora, having unique ecological and landscape value. Therefore, the presence of Marine Protected Areas (MPAs) and coastal zone management in Lebanon is highly vital, considering various aspects.

II. Materials and methods

The information and data used in this study to identify the coastal protection measures in the Lebanese tourism areas are mainly based on recently published reports, studies and observations concerning the Lebanese coastal protected areas. Besides, protection measures are going to be studied through the current research in terms of their legal and legislative aspects.

There are also a considerable number of reports and strategies adopted from ministries and international organizations.

This report will clearly illustrate the available coastal protection measures and the related plans designed or implemented along the Lebanese coastline, whether adopted by the Lebanese government and/or the private sector. Thus, all information on coastal monitoring programs will be compiled and illustrated later. This might be of a high assistance in the implementations of coastal protection plans by national institutes and local NGOs. Moreover, the report will provide a thorough description of the Marine Protected Areas (MPAs) located along the Lebanese coast, as well as their role in the protection of coastal biodiversity and habitats. It will as well identify the governmental policies, or the legislation related to coastal protection and MPAs in Lebanon. In addition, the report is going to tackle the relevant international conventions or agreements on coastal protection planning. Yet, a gap analysis will be performed regarding coastal management issues and measures which will be highly recommended to ensure the coastal area sustainability and the sustainable tourism plans implementation.

As a supplementary tool for the report, thematic maps showing MPAs along the Lebanese coastline will be drawn to facilitate the geographic setting understanding of the MPAs and the related protection areas.

III. Coastal protection planning and management in touristic areas

Lebanon is characterized by a relatively narrow coastal strip that is parallel to the Mediterranean Sea and it occupies several rocky beaches, sandy shores, rocky cliffs, bays, and islands (Figure 1). These marine habitats support a diversity of marine life, with a variety of thousands and thousands of different species types, and new ones under continuous research for discovery (MOE/UNDP/ECODIT, 2011).

Although the Lebanese coast is known for its natural beauty and high attraction to tourists, it is yet suffering from several calamities, such as urbanization, infrastructure destruction, recreational activities, as well as waste discharge and other emerging pollutants. In addition, the illegal buildings founded on coastal resorts as well as the violation of the maritime public laws all have led to coastal areas privatization, beach erosion, and both land and ecosystem degradation.

The Lebanese coast is also characterized by its valuable habitats, such as, vermetid platforms that are the most affected areas by irresponsible touristic activities. These natural platforms have an ecological importance. In fact, in addition to their highly varied biodiversity, they act also as wave barriers that protect the coast from erosion and storm surges. Other habitats including sandy and rocky beaches as well as cliffs and dunes are becoming more and more vulnerable due to the recent phenomenon threatening the ecosystems diversity that is triggered mainly by land appropriation and coastal sand extraction for the purpose of construction (UNEP – ERML, 2012).

Therefore, coastal protection planning, and management have become crucial to ensure further effective habitat sustainability especially in Lebanon touristic areas.

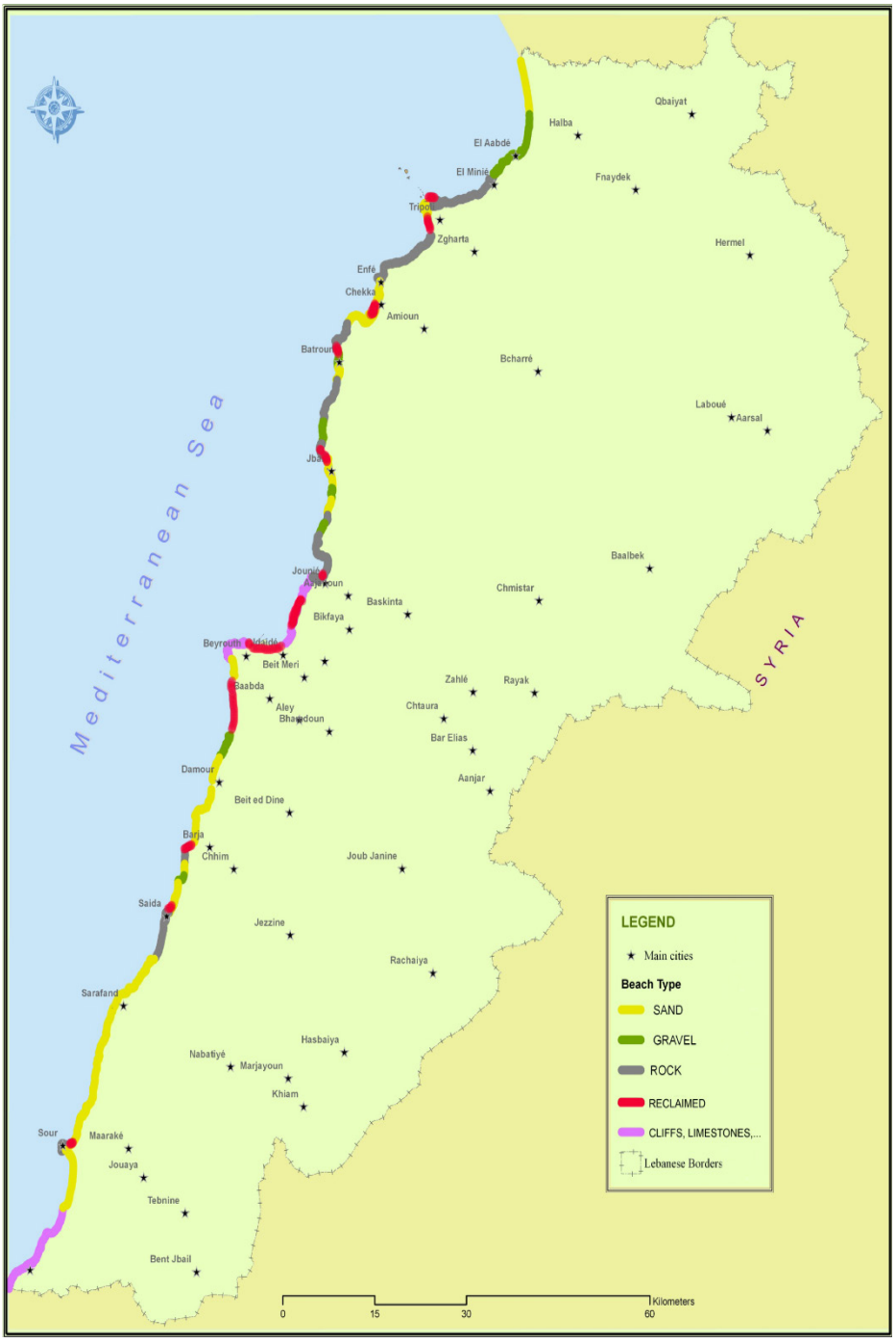

Figure 1. Types of beaches along the Lebanese shoreline (MoE & UNDP, 2011).

III.1. Review of coastal protection plans in Lebanon

III.1.1. Coastal protection plans and programs

The Lebanese government is aware of the coastal zone sustainability importance especially, in over exploited and vulnerable areas. Therefore, the Ministry of Environment (MoE) has implemented several planning projects targeting coastal protection in Lebanon in collaboration with national and international entities (Table 1; MoE, 2017).

Table 1. Coastal protection planning projects implemented by the MoE.

Project Name	Starting date	Status
Market Policy and Legislative Development for Mainstreaming the Sustainable Management of Marine and Coastal Ecosystems in Lebanon	November 2013	Ongoing
Supporting the Management of Important Marine Habitats and Species in Lebanon	January 2012	Ongoing
Mainstreaming Conservation of Migratory Soaring Birds into Key Productive Sectors along the Rift Valley/Red Sea Flyway	June 2008	Ongoing
Conservation of Wetlands and Coastal Zones in the Mediterranean	March 2002	Accomplished
Coastal Area Management Program	September 2001	Accomplished

The MoE aims to achieve a healthier, more productive, and wider diverse marine environment and ecosystem in collaboration with several national and international entities such as the International Union for Conservation of Nature (IUCN). For instance, the IUCN and the MoE have worked together to build a MPAs Strategy with the support of other partners such as the Regional Activity Centre for Specially Protected Areas (SPA/RAC), the Spanish Agency for International Cooperation (AE - CID), the Autonomous Office for National Parks of Spain (OAPN) and the MAVA Foundation. This strategy aims to create a network of MPAs that contributes to revive Sea and marine environment safety in Lebanon. The proposed MPAs network is previewed to become part of an integrated coastal zone management perspective both at national and Mediterranean scales (El Shaer *et al.*, 2012).

III.1.2. Monitoring Programs

It is worth mentioning that the most comprehensive monitoring program in Lebanon has been conducted by the National Centre for Marine Sciences (NCMS) - National Council for Scientific Research in Lebanon (CNRS-L) along the Lebanese coastal zone since 1972. NCMS's main goal is to study the marine environmental status and to evaluate its alteration level. Bathing water quality control has been carried out by

monthly extracting samples from around 36 coastal stations. Thus, NCMS Lebanese coastal monitoring approach can be highly effective in the development of the pollution and marine litter national monitoring plan. In fact, focusing on the analyzed parameters annual monitoring, the NCMS managed to spread this updated map that reveals and clearly highlights the monitored sites bacteriological status all along the shore. Thereby, offering the chance not only to the Lebanese citizens but also to tourists to refer to this annual map for more awareness of the surrounding status (Figure 2).

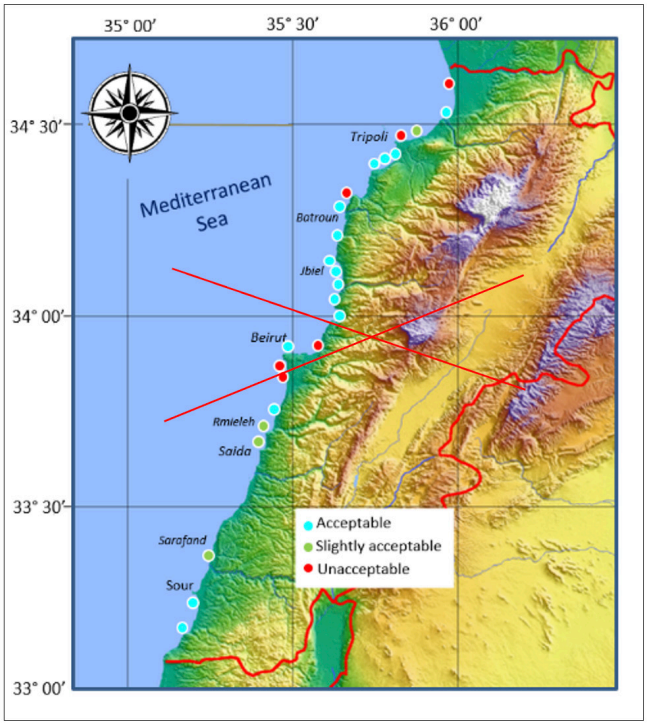

Figure 2. Classified sites for swimming along the Lebanese coast (CNRS-L, 2021).

III.1.3. Coastal zone management

The maritime region, including the Lebanon coastal zone is mandated by several actors including mainly the following:

- The ministries of Environment, Public Works and Transport, Energy and Water, Public Health, Tourism, Agriculture, Industry, Interior and Municipalities, and Culture,
- Lebanese Army (Ministry of Defense),
- Municipalities, Districts and Governorates,
- Council for Development and Reconstruction,
- Ports Authorities.

Even though there is a problem of responsibilities overlapping between all these actors, a certain level of coordination remains crucial in order to protect the coastlines and the existing activities. In fact, these actors depend mainly on their scientific and academic entities to build the appropriate and effective plans and management policies. Therefore, they have (for example) incorporated with the CNRS-L through the Remote Sensing Centre (RSC) and NCMS. They resorted to the latter strategy in order to be able to monitor processes and upgrade information, as well as cooperate with several development projects on environmental monitoring. Besides, such a strategy has offered the opportunity to acquire further data within various sectors, and to draw various useful thematic maps (*e.g.,* land cover/use, environment, integrated coastal zone management, natural hazards, natural resources, *etc.*; CNRS-L, 2021).

The same has been done through the collaboration with Bahaman University which has been involved in coastal zone management, specifically to improve Lebanon's northern coast. It has been also effective in implementing several projects on the Integrated Coastal Zone Management (ICZM) as being a key tool to develop a structural strategy in cooperation with local stakeholders to improve the Lebanese coast management (University of Balamand, 2019).

III.2. Legal and administrative framework for coastal areas

III.2.1. Legislations on the national level

There are much legislation related to the conservation and protection of both the marine and coastal habitats, as well as Lebanon biodiversity. Below is the list of these legislations (MOE/UNDP/ECODIT, 2011).

- Law no. 444/02 (Environment Act) is the most vital framework for the Lebanese environmental legislation. It emphasizes environmental monitoring to prevent pollution. It specifies as well the protection, conservation and management of nature and biodiversity, all under Chapter VIII.
- Law no. 690 dated 26/8/2005 organizes and defines MoE mandates. It states that MoE is responsible for the establishment, protection, and management of protected areas.
- Law no. 214 dated amendments to Law no. 247 dated 7/8/2000 by the Ministry of Public Works and Transport (MoPWT) is mandated to control the legislation and rules implementation in transport and marine public properties.
- Law no. 708/98 declared the Tyre Coast Nature Reserve on November 5, 1998.
- Law no. 121/92 declared the Palm Islands Nature Reserve on March 9, 1992.
- Law no. 508/04 (hunting law) aims to regulate and control specific bird species hunting.

- The law issued as decision no. 2775 dated 1929, refers to the control of marine and coastal fishing and their amendments.
- Decree no. 31 dated 18/1/1955, defines the Ministry of Agriculture (MoA) mandate. In fact, it states that the MoA is responsible for legislations implemented in relation with fisheries and fishing activities.
- Decree no. 22 dated 22/1/1981 (Organization of the Army) states that the Marine Forces in the Army are responsible for coast defense. Therefore, the Ministry of Defense/ Lebanese Army oversees patrolling the sea and keeping its activities in order.
- Decree no. 8213 dated back to 24/5/2012, it relates to the Strategic Environmental Assessment of the Proposed Policies, Plans and Programs in the Public Sector (SEA Decree). This decree is relevant to the national monitoring programme, as it requires that the environmental management plans must be involved into the environmental monitoring plans.
- Decree no. 8633 dated back to 7/8/2012. It relates to the Environmental Impact Assessment (EIA Decree) Fundamentals. According to this decree, all major development, infrastructure, and industrial projects are subject to EIA or Initial Environmental Examination (IEE) studies including their biodiversity effects.
- Ministerial Order no. 216 dated 08/04/1993 pertaining to standards for bathing water quality.
- Ministerial Order no. 1/52 dated 12/09/1996 pertaining to standards for reducing air, water and soil pollution.
- Decree no. 17614 of MoPWT dated 1964 pertaining to the exploitation of the public maritime domain.
- Decree no. 4810 of MoPWT dated 1966 pertaining to regulating the occupation of the maritime public domain.
- Ministerial decision no. 69/2004 dated 2/7/2004: “Establishment of a permanent inter-ministerial committee to implement the agreement ACCOBAMS “.
- Ministerial decision no. 524 of the General Secretary of Ministers Council dated 10/5/2005: “Designation of the NCMS – CNRS/L as the focal point of the ACCOBAMS agreement”.
- Ministerial decision no. 1154, pertaining to the general conditions for the protection of marine mammals (whales, dolphins, and seals).
- Ministerial decision of MoA no. 125/1 dated 23/9/1999 banning the fishing of marine turtles, monk seals and whales as well as selling, use or trade of any derivatives from the mentioned species.

- Ministerial decision of MoA no. 1/385, dated 26/1/1997, stating that fishing activities are prohibited in all estuaries. The protected areas involved extend over 500 m on each side of the estuary, 500 m inside the river and two kilometers seawards, as well as human activities are banned except for scientific purposes and coast guards.
- Ministerial decision of MoA no. 202/1 dated 14/4/1997 for organizing underwater spearfishing.
- Ministerial decision of MoA no. 93/1 dated 14/3/2008 regulating the scuba-diving industry including permitting procedures and safety measures and scuba-diving fishing.
- Ministerial decision of MoA no. 346/1 dated 15/7/2010 regulating and identifying fishing types and equipment and banning the use of small mesh sizes and trawling nets and fishing.
- Ministerial decision of MoA no. 676/1 dated 27/7/2011 to forbid the fishing, transportation, selling and consumption of some types of fish.
- Ministerial decision of MoA no. 8/1 dated 4/1/2012 organizing and defining some fishing gears and materials.
- Ministerial decision of MoA no. 1160/1 dated 25/11/2014 for the general conditions of shark fishing.
- MoA decisions banning dynamite fishing.

III.2.2. Regional and international conventions

Lebanon has agreed on and has as well ratified several conventions and treaties related to the coastal environment and natural habitats and biodiversity protection. The multilateral environmental agreements ratified by the Lebanese government are represented in Table 2.

Table 2. Multilateral environmental agreements ratified by the government of Lebanon (MOE/UNDP, 2011).

Year	Convention, Treaty or Protocol	Details
1954	International Convention for the Prevention of Pollution of the Sea by Oil (London)	Adhesion; Law No. 68/66 16/11/1966
1963	Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and in Underwater (Moscow)	Ratification; Law No. 59/64 30/12/1964
1969	International Convention on Civil Liability for Oil Pollution Damage- (Brussels)	Ratification; Law No. 28/73 12/10/1973
1969	International Convention relating to Intervention on the High Seas in cases of Oil Pollution Casualties (Brussels)	Ratification; Decree No. 9226 12/10/1974
1971	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and the Ocean floor and in the Subsoil-(London-Moscow-Washington)	Ratification; Decree No. 9133 07/10/1974
1971	Convention on Wetlands of International Importance especially as Waterfowl Habitat-RAMSAR (Iran)	Adhesion; Law No. 23 01/03/1999
1972	UNESCO Convention on the Protection of Cultural & Natural Heritage (Paris)	Adhesion; Law No. 19 30/10/1990
1973	International Convention for the Prevention of Pollution from Ships (London)	Adhesion; Law No. 13 28/05/1983
1975	Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES (Washington)	Law No. 233 – 22/10/2012
1976	Protocol for the Prevention and Elimination of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft (Barcelona)	Signature 16/02/1976; Accession – Decree Law No. 126 30/06/1977
1976	Convention for the Protection of the Mediterranean Sea against Pollution-Barcelona	Signature: 16/02/1976; Accession – Decree Law No. 126 30/06/1977
1976	Protocol Concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency (Barcelona)	Signature: 16/02/1976; Accession – Decree Law No. 126 30/06/1977
1979	Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention)	State party on the 01/06/2019
1980	Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources (Athens)	Adhesion; Law No. 292 22/02/1994
1982	Convention of the Sea, Mont –Diego Bay (Jamaica)	Adhesion; Law No. 295 22/02/1994

1982	Protocol Concerning Mediterranean Specially Protected Areas (Geneva)	Adhesion; Law No. 292 22/02/1994
1992	Convention on Biological Diversity (Rio de Janeiro)	Ratification; Law No. 360 11/08/1994
2002	Agreement on the Conservation of African-Eurasian Migratory Water Birds, AEWA (the Netherlands)	Adhesion; Law No. 412 13/06/2002
2004	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea, and contiguous Atlantic Area, ACCOBAMS (Barcelona)	Adhesion; Law No. 571 05/02/2004
2008	Protocol on Integrated Coastal Zone Management in the Mediterranean (Barcelona)	Ratification; Decree No. 639 18/09/2014
2010	Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization under the Convention on Biological Diversity (Japan)	Law No. 3 03/02/2017

III.3. Marine Protected Areas in Lebanon

MPAs management strategies have proved to be the most highly effective and multidisciplinary tools that aim to protect the marine environment, especially in the Mediterranean Region. Indeed, they have helped sustain biodiversity in areas where vulnerable ecosystems are at stake. Hence, they have become considered as one of the most valuable assets in coastal ecosystems protection, with a special emphasis on the sustainable use of fisheries resources as well as maintaining the prohibition of fishing activities during breeding or nursery seasons to allow the restoration and the preservation of important susceptible resources. The presence of MPAs along the coast can also stimulate fishing management in that protected area, and subsequently enhance the protection of susceptible marine organisms. Moreover, MPAs provide an opportunity for local, regional, and national conservation targeted groups, beneficiaries and communities to be involved in conservation activities within the marine environment, as well as, to provide the local community with a vast range of ecosystem services and education.

The MoE in 2012 has proposed 9 coastal marine sites as MPAs (Naqoura; Sidon Rocks; Rawshe Cliffs and Caves; Beirut Port Outer Platform; Byblos; Madfoun Rocky Area; Batroun Phoenician Wall; Ras El Chekaa Cliffs and Enfeh) (MoE-IUCN, 2012) based on scientific assessments (Bariche, 2008) and on field surveys. In fact, the MoE and IUCN are collaborating tightly in order to build a protection strategy and to create MPAs network, as well as an associated monitoring program to evaluate the applied management approaches effectiveness. So far, Lebanon has implemented three MPAs, these are: Palm Islands Nature Reserve (PINR), Tyre Coast Nature Reserve (TCNR) and recently Al-Abbasyeh Coast Nature Reserve (Figure 3).

Urgently a management plan should be developed for each nature reserve. This will really help in reaching better management including natural resources and biodiversity. It will be as well a guide for visitors and for various activities (*e.g.,* scientific research, education, awareness, recreational, *etc*.) involving stakeholders and local communities, and it should be endorsed by the MoE contribution. Recently, initiatives have been taken by the MoE in order to endorse the nature reservation and new management plans through the Council of Ministers decree.

III.3.1. Palm Islands Nature Reserve (PINR)

The PINR is a unique and integrated natural marine system created under law No 121 on March 9, 1992. The law states that any committee established through MoE decision for a period of three years and including seven volunteers, under any circumstances, is compiled to undertake effectively the activities related to protection, prevention, as well as the mobilization of scientific studies and expertise to ensure nature ecological restoration and reservation.

The PINR is 5.5 km far from the coast of Tripoli, and it consists of three flat rocky (pavement) islands: Sanani (0.04 km^2), Ramkine (0.016 km^2) and Palms (0.2 km^2). Its area (including 500 m of sea around the islands) is nearly 5 km^2 (Figure 3).

PINR is public and currently managed by the non-governmental Environment Protection Committee (EPC) (208/ad, 1986) under the supervision of MoE and the Ministry of Interior (MoI). In addition to the Government Appointed Committee (GAC - Decree # 121) under the tutelage of the MoE, the three islands are open to visitors only in the period from July to September.

Rangers are always present during the visitation season (July-September) to protect, survey and control visitors and poachers (MoE, 2000).

The islands represent a remarkable destination for sea-crossing migratory birds, and the only seabird breeding sites in Lebanon. PINR is designated as an Important Bird Area (IBA) by Birdlife International in 1994. The islands also include a habitat of plants that is no longer found on the Eastern Mediterranean littoral, including threatened and endemic species, as well as important sites for threatened marine turtles and globally endangered bird species. This reserve is considered as an important area for marine diversity and habitats. PINR was classified as a Ramsar Wetland of Special International Importance in 2001, and a Specially Protected Area of Mediterranean Importance (SPAMI) in 2012. The islands are also widely renowned for their cultural heritage.

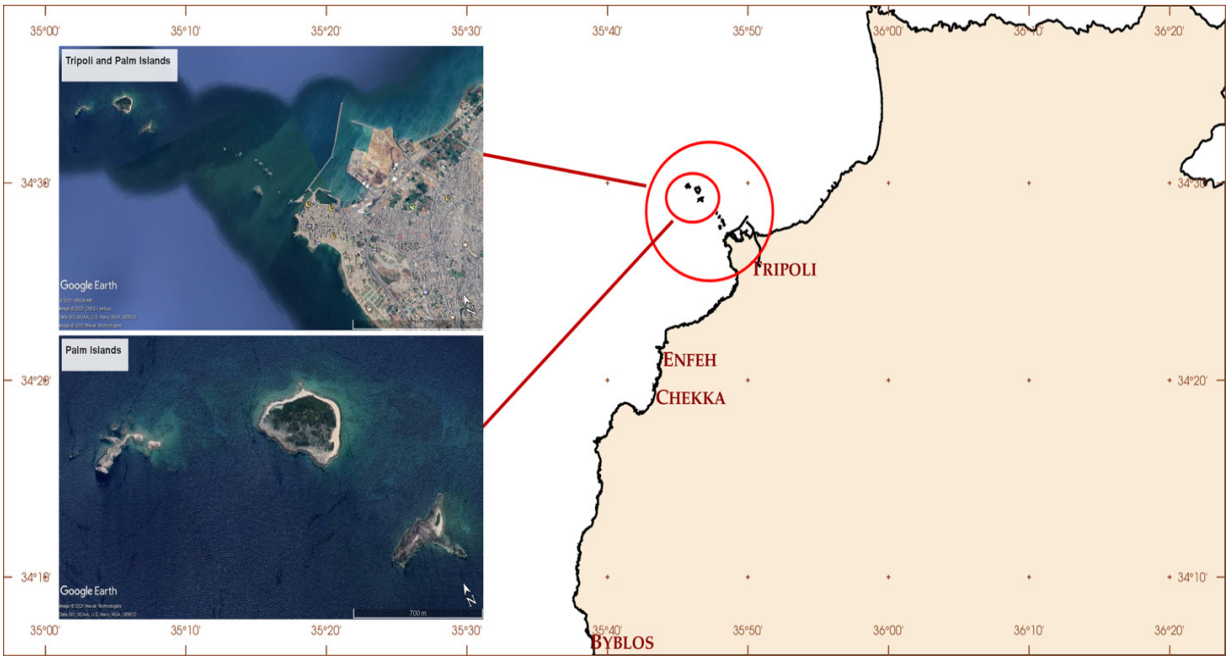

Figure 3. Location of the PINR, North Lebanon.

III.3.2. Tyre Coast Nature Reserve (TCNR)

The TCNR was established by Law no. 708 dating back to November 5, 1998. The law states that any committee established through MoE decision for a period of five years and including five volunteers are required to fully undertake the site management. TCNR has been recognized as a SPAMI (since 2013), a Ramsar site (1999), and an IBA-to-be. It includes 4 diverse ecosystems: sand dunes, wetlands, agricultural, and marine ecosystems.

Currently, two EU-funded projects under the ENI CBC MED have been already executed in these reserves: COMMON (Coastal Management and Monitoring Network for tackling marine litter in the Mediterranean Sea), and Med4EBM (Mediterranean Forum for Applied Ecosystem-Based Management).

The TCNR extends on an area of about 3.8 km² and a marine surface area of about 113 km² divided into four zones: a marine zone, a touristic zone, an archeological zone surrounded by agricultural activities, and a conservation zone that includes the Phoenician Springs of Ras El Ain (4). It is an important nesting site for globally endangered Mediterranean Loggerhead and Green Sea turtles, a site containing a wide diversity of ecosystems; marine, agricultural, wetlands, and sand dunes, which encompass the Mediterranean characteristics. The TCNR is also located on major bird migratory routes where internationally important bird species have been identified. It has also been designated as a Ramsar site (No. 980) since 16/04/1999 and a SPAMI (Specially Protected Area of Mediterranean Importance) since 2013. Many management plans have been already set by the MoE after the consultation of experts and NGOs from various organizations aiming at achieving this reserve protection and conservation (Peillen *et al.*, 2012).

III.3.3. Al-Abbasyeh Coast Nature Reserve

As an extension to the TCNR, Al-Abbasyeh Coast Nature Reserve has a sandy beach that is characterized by friable sand with some pebbles (Figure 4). It extends over 3,300 m and has a width of 15 to 60 m (4). It is still virgin and undeveloped, except for a few local urban sites. In fact, the beach is densely inhabited by Palestinian refugees. Thereby, shrinking the size of agricultural fields. The Abbasyeh sandy coast and diverse ecosystem represent the most appropriate shelters for numerous ecological elements, natural resources, and a wide biodiversity. It is also home to a wide variety of animal and plant species. In addition to its friable sand, movable dunes that offer a favorable environment for the presence of dense shrubs, hosting a variety of birds, insects and reptiles, the Abbasyeh coast is considered as one of the most important sea turtle nesting sites, namely for the Loggerhead sea turtle *Caretta caretta*) (SPA/RAC-UNEP/MAP, 2020).

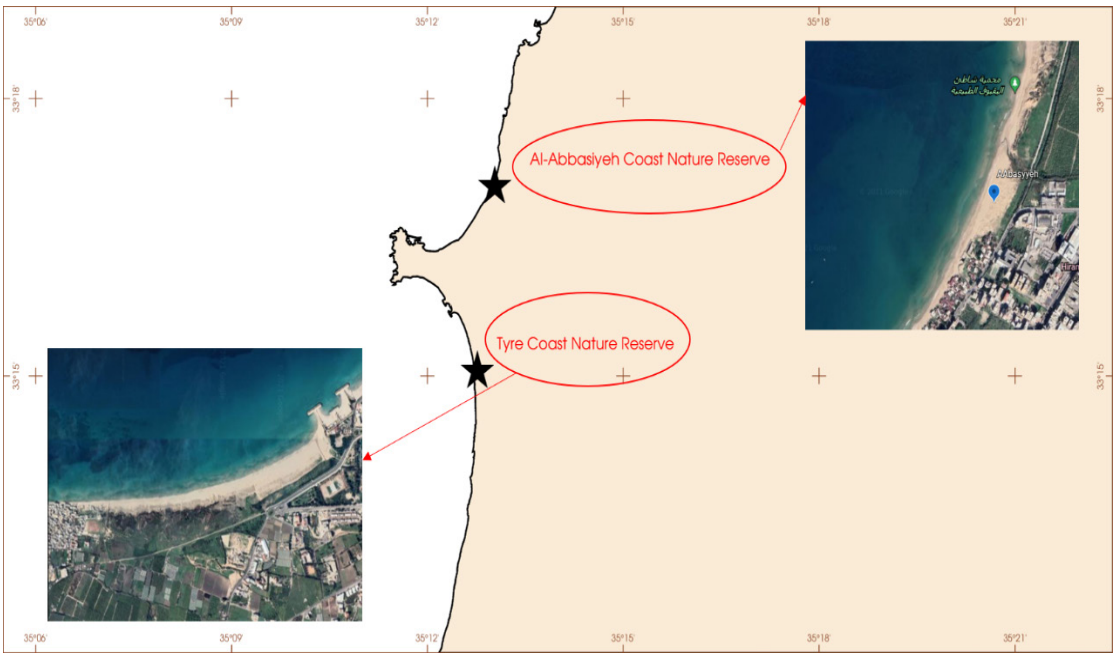

Figure 4. Location of the TCNR and Al-Abbasyeh Coast Nature Reserve, South Lebanon.

III.4. Coastal defense problems and adaptation measures

The Lebanese coastal area is widely dominated by small economic industries, urban sprawl and agricultural activities. It consists of several resorts and touristic compounds. These in their turn have increased the pressure on coastal resources and affected coastal biodiversity (terrestrial and marine). The exacerbated marine and air pollution in the coastal zone due to the lack of effective management as well as to the chaotic random disposal of industrial, domestic and agricultural discharges, have all led to further detrimental and devastating effects on the coastal area (MOE/UNDP, 2011).

The natural factors together with the anthropogenic pressures along the Lebanon coastal zone might result in further threats of coastal destruction and more devastating climate change impacts. Indeed, the damage of both the coastal habitats and ecosystems (acting as coastal defense structures) resulted in decreasing the adaptive capacity of coastal communities.

Climate change has dramatically influenced the region due to the steady increase of global warming, that has led to dramatic changes in sea-surface temperature (SST), as well as sea level rise that has become strikingly obvious. Moreover, the increased SST can be linked to the dramatic increase in storms frequency and intensity. On the other hand, sea level remarkable rise has contributed to increasing rainstorms, coastal flooding and has as well caused shoreline erosion accompanied with wind-driven waves, and saltwater intrusion.

III.4.1. Sea level rise

The largest impact of sea level rise has been always generated from thermal expansion due to oceans warming that have mainly been occurring since the 1950s. The global sea level had risen from 1 to 2 mm/year during the 20th century according to tide gauges records published during the 1990s.

Studies using altimetry data of the Topex/Poseidon satellite images which have been available since early 1993, showed a continuous sea level rise of 5-10 mm/year along the Lebanese coast (MOE/UNDP, 2011).

III.4.2. Sea Surface Temperature (SST)

Regional local temperature increases have lately been highly obvious in the whole region of the Mediterranean Sea, where SSTs across the Mediterranean as a whole, have been rising by almost twice as much as those of the global oceans (MOE/UNDP, 2011).

The SST in Lebanon has gradually risen because of climate change. *In situ* data indicated that over the past two decades, a spring warming of 0.09 °C/yr has occurred in Lebanese waters (Ouba, 2015; Figure 5).

A rise in SST induces a likely increase in the frequency and intensity of sea storms and hurricanes.

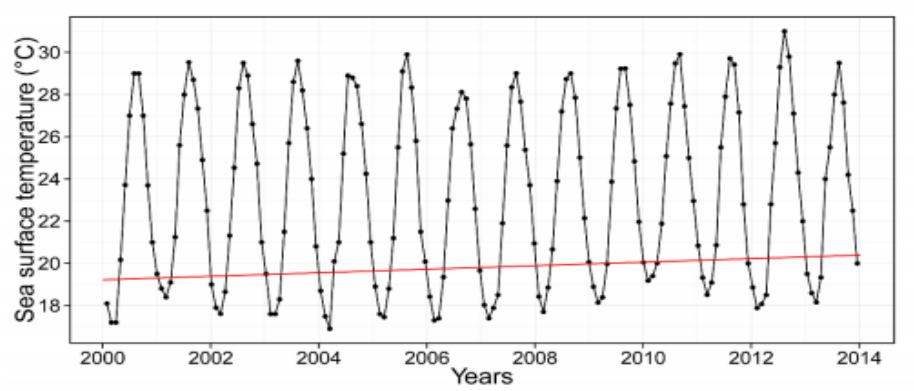

Figure 5. Temporal evolution of the sea surface temperature at Batroun (2000-2013), the red line represents the general trend of sea surface temperature evolution in Spring (Ouba, 2015).

III.4.3. Coastal erosion

Coastal erosion is a common natural phenomenon that usually occurs due to the increasing extreme weather events recurrence. Thereby, leading to sea level rise and severe coastal alteration in circulation patterns. Aerial Diachronic photographs processing as well as Lebanese coastline satellite images taken between 1962 and 2003, and together with the topographic maps' analysis made in 1963, all these revealed that changes that have occurred in the coastline could be determined throughout the Lebanese seashore statue. While (Abou Dagher *et al.*, 2012) comparing the 1962 North Lebanon aerial photographs to satellite images acquired between 1970, 1994 and 2007, the changes in the shoreline were easily detected and determined.

Figure 6 shows the major Types and surface materials of the shoreline along the Lebanon coastal zone, which occupies:

- Marine terraces and sandy beaches (31 km = 13.7 %)
- Rock derbies, gravel, and alluviums (33 km = 14.6 %)
- Massive and rocky (61 km, 27.1 %)
- Littoral sand and sand dunes (45 km = 20%)
- Cliffy, massive carbonate (29 km = 12.8 %)
- Alluvial deposits mixed with sand and clayey soil (26 km= 11.5 %).

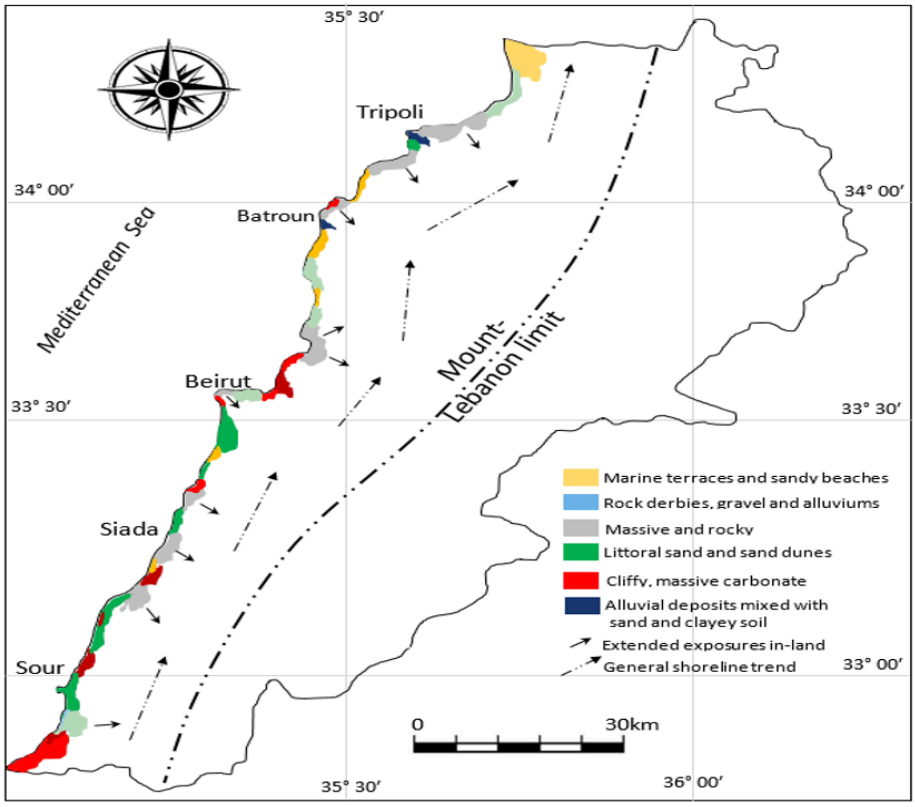

Figure 6. Types & surface materials of shoreline along Lebanon coastal zone.

The Lebanese coastline shows a linear extension of 22.13% mainly due to the establishment of several installations during the last four decades. Table 3 shows a comparison between the different coastal components between 1962 and 2003 (Faour and Abi Rizk, 2008).

Table 3. Morpho-sedimentary type between 1962 and 2003 (Faour and Abi Rizk, 2008).

Morpho-sedimentary type	Linear in 1962 (km)	% in 1962	Linear in 2003 (km)	% in 2003
Artificial coast	36.03	12.91	147.01	41.03
Rocky coast	111.09	39.85	110.44	30.82
Sandy beach	108.28	38.8	81.9	22.86
Pebble beach	23.52	8.42	18.99	5.3

For example, the beaches along Lebanon's northern coast have lost about 931,000 m^2 of sand and pebbles between 1962 and 2007 due to erosion (Table 4).

Table 4. Modification of the Lebanon Northern Coastline (100 km in length) (Faour and Abi Rizk, 2008).

Compared to 1962	1970	1994	2007
Erosion	211,000 m^2	90,800 m^2	931,000 m^2
Accretion	7,000 m^2	13,000 m^2	30,000 m^2
Sea filling	98,000 m^2	1,091,000 m^2	1,759,000 m^2

In addition to climate-induced problems, the natural coastal defenses and stability can also be threatened by the combined effects of residential, industrial, touristic and infrastructures activities. Most 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 submarine springs disappearance.

Many measures should be taken and implemented in order to avoid coastal defenses damage along the Lebanon coastline. An overarching adaptation and management options to relieve pressures on the coastal zones should be adopted in the integrated coastal zone management, and more specifically the technical and engineering measures.

Declining coastal conditions adversely impact tourism revenues and decrease tourist fluxes, especially in areas where loss of semi-natural and natural land, as well as destruction and fragmentation of coastal habitats occur, together with the increase in beach erosion frequent recurrence. Whereas, in areas where eroded beaches have been restored, tourist visits and revenues have clearly increased (Simboura *et al.*, 2019).

Moreover, wherever coastal adaptation and management measures are being effectively implemented, tourism has been promoted and the whole sector scored better improvement.

Below, some measures adopted from the Adaptation Action Plan in the Coastal Zones Sector (MOE/UNDP, 2011).

1. Planned retreat adaptation measures: They consist of pulling back human activities from the coast through land use planning and development control which requires environmental legislations to support the implementation of this measure.
2. Accommodation adaptation measures: This needs an overall waste disposal management plan to reduce sources of intermittent pollution (urban and industrial pollution) and to diffuse pollution protective legislation (agriculture) to restore environmental balance, natural resilience, and adaptability. This ought to be reinforced mainly by adopting supportive monitoring and forecasting tools, such as Early Warning Systems along the coast to alert coastal hazards.
3. Technical Protection measures: These are proactive measures based on technical tools and approaches applied along the Lebanon coastline (Table 5). Some of these measures have almost similar functions but they follow different techniques. They are taken individually while others are taken either by the municipal authorities or by the concerned ministries (mainly the MoPWT). Table 5 shows that there are 95 localities for technical protection measures on the Lebanon shoreline as revealed by satellite images (Ikonos, 1 m spatial resolution). However, these measures have different dimensions that start from less than 100 m to more than 1 km along the shoreline.

Table 5. The technical protection measures along the coastal zone of Lebanon

Technical measures	Number of identified measures	Major defense purpose	Implementation level	Effectiveness
Retaining walls	19	Erosion, surface materials collapse and drifts	Individual & municipal	Very effective
Concrete fences	12	Coastal floods and then protecting shoreline		Effective
Rock Groin	18	Stabilizing shorelines with soft materials, especially from coastal floods, drifts, and collapses	Ministries, notably the MoPWT	Very effective
Embankments	19			
Dolosse	9			
Harbors (including other protection tools)	15	Reduce waves energy and then protect shores from erosion	Individual & municipal & Ministries	Slightly effective
Stabilization Planting	3	Stabilize shore and coastal plains with argillaceous and loamy soil	Individual	Moderately effective

IV. Analysis and recommendations for coastal protection strategies and management options

The coastal zones planning targets specifically both its future and its sustainability. Therefore, these influential and controlling factors (*e.g.,* future trends in visitor use, socio-economic and related pressures, and ecological change) should be effectively manipulated and appropriately addressed. In addition, the gaps that are already identified in previous plans should be detected and effectively approached in order to avoid their recurrence. The main constraints are balancing between coastal ecosystem conservation and socio-economic requirements of the local community. A successful management plan should go through several phases (Figure 7).

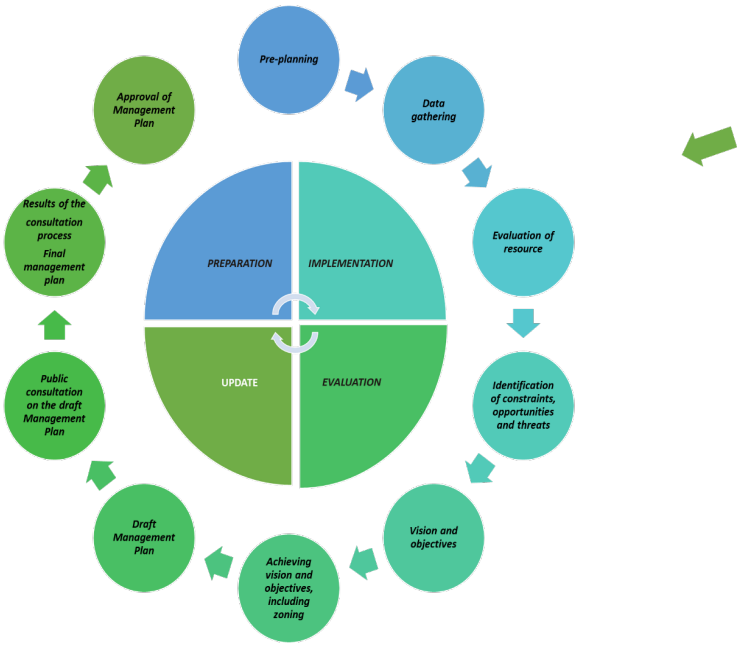

Figure 7. Phases of the management planning process (Thomas and Middleton, 2003).

To carry out protection planning, evaluation of resources ought to be primarily elaborated, and then the criteria should be defined to identify and measure the natural, cultural, and socio-economic current exacerbated factors to be avoided in the future. In addition, the features/values that make coastal areas vital for the local communities and that serve both the targeted groups and the final beneficiaries should be as well identified.

To reach an efficient management plan, both local communities and different-level stakeholders' involvement should be considered. In addition to identifying the values, the targeted protected area should be placed within its regional, national, and international context.

The following recommendations should be implemented if successful management of Lebanon coastal zone is to be achieved:

- Physical characteristics monitoring plan: it is conceived for terrestrial and seabed characteristics (*i.e.,* sediments ecological state), physicochemical and biological characteristics of water column (*e.g.,* temperature, bathing quality, *etc*.), and climate characteristics that impact the ecosystem, *etc*.
- Biodiversity monitoring plan: It includes a biodiversity analysis of the terrestrial and marine fauna and flora, including invasive marine species.
- Conservation and restoration plan: This can be achieved in the context of an integrated management approach in coordination with all concerned actors.
- Awareness and knowledge mapping: This can be fulfilled thanks to the collaboration of all stakeholders with a special focus on targeting groups and ultimate beneficiaries. In this regard, gender must be included in the list of stakeholders.
- Adoption of ecotourism: This requires establishing an integrated program for coastal tourism and its relevant ecosystems (*e.g.,* bird watching, turtle nesting events, nature/wild photography, *etc*.). This can be achieved if elaborated along with a socioeconomic development including recreational water activities, fisheries, farming, tourism, *etc*.
- Adoption of different Tourism alternatives along with ecotourism strategies such as the following that can be adopted: green tourism, soft, rural tourism and agro-tourism, community tourism, solidarity and responsible tourism.
- Patrolling, protection, and enforcing plan implementation: This can be fulfilled if the concerned ministries coordinate efficiently namely the MoI, MoT, and the municipalities.
- Early Warning System: This is an urgent alerting tool for undesirable events, such as oil spills, earthquakes, current-driven continental litter, *etc*.
- Community partnership program: a local community and multi-stakeholder integration in the protection process.
- Technical Protection program: It is a major pillar to protect the shoreline and the adjacent urban areas (including touristic sites and natural areas). This should be established within an integrated program context, incorporating different national, regional, and international entities.

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The present document has been produced with the financial assistance of the European Union under the ENI CBC Med Program. The contents of this document are the sole responsibility of the *Ministry of Public Works and Transport*, *Al Midan NGO* and *AMWAJ of the environment*, NGO. In addition, under no circumstances it could be regarded as reflecting the European Union position of the program management structures.

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