

Pollution and Anthropogenic Pressures Affecting Ecosystems in Tourism Areas

Lebanon scale





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

Pollution and anthropogenic pressures affecting ecosystems in tourism areas Lebanon scale



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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 on a national scale” Co-funded by ENI CBC Med Program (Grant Agreement A_B.4.4_0075).

This document constitutes the **Deliverable 3.1.4.72** (Pollution and anthropogenic pressures affecting ecosystems in tourism areas – Lebanon scale) of the **Activity 3.1.4** (Threats and Enabling Factors at National: 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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I. Introduction

None can deny that Lebanon's environment is at stake. This is obvious through several striking features everywhere in the country. In fact, they represent a distorted image of the breathtaking attractiveness and landscape of Lebanon. The environmental degradation in Lebanon consists of several aspects such as the fact of covering the terrestrial and marine environments with the atmospheric zone. However, reasons remain unknown and ambiguous.

The environmental problems have been witnessing an increasing interest since Lebanon's geopolitical situation became unstable. Hence, most of the environmental degradation includes water pollution, air pollution, marine pollution, inadequate solid waste management and uncontrolled use of synthetic agrochemicals (WHO, 2010). Added to pollution, Lebanon has also suffered from the hazardous impact of anthropogenic problems mainly generated by the irresponsible human activities, such as the uncontrolled construction of inconvenient urban planning, excavation, marine backfilling, quarrying, *etc.* Therefore, in response to this environmental degradation, Lebanon allocated much more importance to the significant growth in environmental governance and related policies and institutions since the 1990s.

Nevertheless, the problem is still exacerbating despite all the measures taken by the government. The reason behind this unfavorable situation is mainly related to the unproductivity of institutional organization and management. Added to that, the ineffectiveness in delegating responsibilities and missions to different institutional parties involved in the projects. Furthermore, the problem is further deepened because of the natural conditions, like climate change, the country's geographical situation, and the limited surface area and natural resources.

Pollution is considered as one of the most prominent aspects of environmental degradation along the Lebanese coast, which results in severe repercussions on human health and affects the quality and quantity of both the tremendous biodiversity and the entire ecosystem. This is strikingly obvious in the coastal zone because the Lebanese shoreline is extending along the entire alignment of the country, occupied by more than 70% of the population with significant activities (*e.g.*, urban, touristic, construction, industrial, *etc.*).

After 2000, the Lebanese coastal stripe has become commonplace for wastewater discharge and solid wastes dumping. Thus, thousands of cubic meters are daily discharged into the sea, as well as thousands of tons of solid wastes are disposed of on the shoreline. As a result, hardly could a year pass without a disastrous environmental incident (*e.g.*, microbial outbreak, spoiled fish, *etc.*) caused by seawater pollution (Shaban, 2008).

In Lebanon, the anarchic urban sprawl (*e.g.*, construction on sand or on rocky shelves, sand extraction, *etc.*) along with the related destructive activities have been exacerbated lately. This is also the case for the other aspects of human activities in the sea (*e.g.*,

shipping, sand dredging, *etc.*). In addition, the largest parts of coastal properties (with illegal private ownership) have been seized by the most dominant people in the country. Therefore, these properties have become out of any environmental control or any appropriate governance.

This report is going to discuss deeply the existing problems on the littoral environment, including both the marine pollution and the anthropogenic influencers leading ultimately to environmental worries and concerns on the coastal ecosystems. Thus, different aspects of these concerns (*i.e.*, pollution and anthropogenic) will be categorized. This will include the geographic distribution of major pollution sources and the footprints of human activities along the coastal zone. Consequently, this current document is going to emphasize on diagnosing the impact of these worries on the marine environment, considering the temporal and spatial dimensions.

II. Marine Pollution

Waste disposal, including liquid and solid wastes, are directly and indirectly released into the sea along the Lebanese shoreline, resulting in the creation of several pollution zones along the coastline. The sources of pollution encompass a variety of aspects, dimensions, and mainly decaying mechanisms.

Since the early 70s, studies and research projects have been carried out to assess the quality of marine waters in Lebanon (Kouyoumjian, 1970; Harakeh, 1978; Kayal, 1981). However, most of these studies emphasized the short coastal stretches and time limitation intervals. Moreover, the number of studies and projects has been increasing along with the growing rates of pollution, as well as the exacerbation of coastal zone crisis and degradation.

There are several factors affecting pollution in Lebanon, especially in densely populated regions like the coastal stripe, where effective environmental measures and appropriate legislations are lacking or not enforced.

II.1. Natural factors

The natural factors cover the geographic setting of the entire coastal zone of Lebanon where the adjacent mountain chains are sloping seaward. Along this zone, which is occupied by more than 70% of Lebanon's population and it is as well characterized by high population density (> 700 person/km²), all waste waters (*e.g.*, sewage, gray water, *etc.*) are dumped into the neighboring streams and rivers, which in its carry these wastes to dump them into the sea. When large quantities of eroded soil and rocks are carried by water streams and delivered into the sea. Consequently, they form estuaries with huge plums extending several kilometers long into the sea (tens of kilometers).

II.2. Anthropogenic factors

These factors are the most significant influencers in terms of pollution, specifically in the marine environment. They imply many aspects including the lack of formal controls and the unethical behavior of some citizens. Both factors, along with the absence of appropriate solutions for waste management in the country, reflect clearly the detrimental environmental features of the Lebanon coastal strip, such as landfills, sewers, oil residues, *etc.*

II.3. Institutional factors

Since its establishment in 1992, the Ministry of Environment (MoE) in Lebanon has made efforts to find effective solutions to waste disposal. Yet no measure or solution proved to be effective due to the jurisdiction conflict between different institutions. The problem lies in the lack of coordination between the governmental authorities, especially

because waste disposal (liquid and solid) is under the jurisdiction of different ministries and authorities. Until quite recently, no successful solution has been adopted to properly dispose of thousands of tons of daily solid waste, notably those belonging to the coastal cities, including Beirut the capital.

Moreover, the environmental legislations elaborated by the MoE have never been implemented or enforced since they are still not yet adopted by other institutions on the national scale. On the other hand, many plans and programs have been established by the MoE supported mostly by foreign international agencies, such as UNDP, UNESCO, WB, *etc.*

From a touristic point of view, a comprehensive field survey has been carried out by the National Center for Marine Sciences - National Council for Scientific Research in Lebanon (CNRS-L, 2018). This survey relied on 26 stations fixed along the Lebanese coast in order to monitor the beaches' suitability for swimming along the coastal strip between Al-Arida and An-Naqoura (~225 km). The results of this survey showed that there are 15, 4 and 6 sites which proved to be acceptable, slightly acceptable, and unacceptable respectively for swimming, as shown in (Figure 1). However, these results reflect neither the microbiological nor the physicochemical characteristics of the whole coastline, but they reflect specific areas where littoral sand beaches exist.



Figure 1. Classified sites for swimming along the Lebanese coast (CNRS-L, 2018).

II.4. Types of Marine Pollution along the Lebanese Coast

Unfortunately, the Lebanese coast has gone through all types of marine pollution, including the physicochemical and biological types, as well as tremendous oily sludge and random oil spills. Thereby, leaving a highly detrimental impact on the environment. In general, the Lebanese coast is severely polluted with liquid and solid wastes, the pollutants on the other hand are located either directly on the shoreline or in some areas offshore.

Apart from their types and proportions, the liquid and solid wastes are usually detected along the coastline. In fact, they have different features, and they don't follow a common pattern of waste release (disposal) into the sea; this has been spotted in different coastal areas.

There are different types of pollution (*i.e.*, the geographic locations where pollutants are generated) that threaten and affect the Lebanese coast, and this is often reflected on the mechanism and flux of pollutants' transport and volume. The largest number of these sources is continuous and steady, while other sources are intermittent, or they appear occasionally in the sea waters. The main sources of pollution along the Lebanese coast are emitted from the following:

- Terrestrial environment (in-land), including the adjacent urban areas which can reach several tens of kilometers away from the coast such as
- Liquid pollutants (*e.g.*, sewers) which flow along sewer pipes, open channels, or along the streams and rivers.
- Solid wastes transported by vehicles to the coast and dumped in coastal landfills.
- Turbid water flows along rivers and streams after rainy periods.

1. Sources located directly to the contact between the inner land and the coast, represented by:

- Sewage outfalls and gray water from the urbanized areas and touristic resorts directly located on/near the coast.
- Oily water from the refineries and factories which are spreading on the coastal strip.
- Warm water from electric power plants.
- Solid wastes (*e.g.*, garbage, chemicals, medical, *etc.*) which are dumped in the beach and others in landfills.

2. Human activities exerted directly on the marine zone (in seawater) including:

- Oil spills released from ships and oil tankers.
- Unspecified sources of pollution, such as chemicals and toxic materials which are mentioned frequently in the press media, or by witnesses.

Studies conducted on marine pollution in Lebanon focused either on limited coastal stretches or investigated specific seawater properties, such as nutrients, chemistry, bacteriology, *etc.* (Khalaf, 2003; Nakhle, 2004), and some other studies focused on the seawater mechanisms, such as temperature variations, currents, *etc.* (Kabara *et al.* 2001).

The development of remote sensing techniques, which have the advantage of observing large area with both less time-consuming and lower cost enabled better periodical monitoring of seawater and coastal strip as well. In this respect, a comprehensive study has been conducted for the entire coast of Lebanon using remote sensing techniques, more specifically Aster and Landsat 7 ETM⁺ (Shaban, 2008). These images, which have spatial resolution of 15 and 30 m, respectively, have the potential to apply thermal and spectral discrimination. This in its turn helped in detecting all sources of marine pollution along the Lebanese coast as well as calculating their dimensional aspects and patterns (Table 1).

Table 1. Major marine pollution types and their sources along the coastal strip of Lebanon (Shaban, 2008).

Pollution type	Major sources	Description
Sediments and turbid water	Sediments and eroded materials from land	Sediments derived along rivers and streams from long distances due to human activities (mainly excavation)
	Sediment along the shoreline	Transported sediments along the coast due to erosion and different instability processes
	Fragmented, eroded sand and lost sediments	Almost refereed to those debris resulted from rocks trees because of torrential rainfall.
Coastal landfills	Solid wastes	Costal landfills that accumulate different solid wastes from area away from the coast
	Coastal embankments	Sediments and rocks that used to bury the littoral in order to increase the land area for different purposes
Wastewater effluents	Sewage outfalls	Wastewater derived from urban settlements through pipes to the sea
	Sewage seeping	Wastewater with no uniform flow, but seeps through porous rocks and alluvia deposits
	Gray water along streams	Wastewater released from urban areas at a distance from the coast along streams and
Chemical and medical products (Solid and liquid)	Chemicals from factories	Factories producing industrial or chemical products and generating different residues
	Medical materials from hospitals	Medical residues from hospitals dumped into the coast
Oil residues	Oil spills	Intermittent slicks emerging mainly from ships and tankers, as well as from marine accidents
	Oil from refineries	Oil liquids and slugs from oil refineries at the coast
	Oil from power plants	Oil leakage from generators and pipes of coastal power plants
	Maintenance and workshops operations	A miscellany of oily liquids resulting from maintenance implements in workshops at the coast
	Oil from ships	Oil leakage from ships
Thermal water	Coastal power plants	Hot, polluted water from the generators of the coastal power plants

The main polluted sites identified via satellites were investigated by implementing field surveys on these sites to ensure the reliability of detected areas results, as well as to study the in-situ characteristics for each site (*e.g.*, dimensions, flow mechanism, dumping manner, *etc.*).

The results of the study, which was carried in 2008, were reviewed and updated by the recent available data and information, and therefore the major permanent sources of pollution were considered and plotted on a map covering the entire Lebanon (Figure 2).

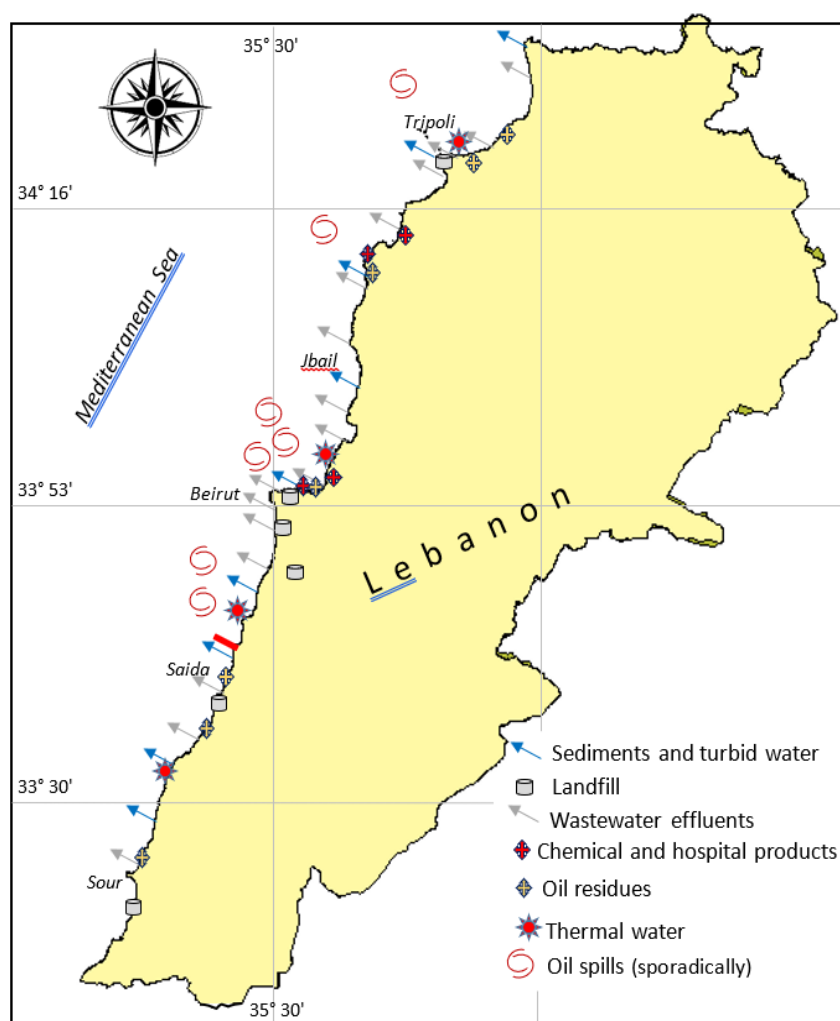


Figure 2. Major marine polluted areas (hotspots) along the coast of Lebanon (Shaban, 2008).

There are several polluted areas along the Lebanese coast, which may exist in small stretches (Figure 3). However, tremendous pollution sources exist with small dimensions (*i.e.*, extension into the sea) or occur only within limited time periods. These sources are widespread along the coast. Nevertheless, the elaborated study by Shaban showed that there are 47 major pollution localities (hotspots) where the largest number are related to continuous pollution discharges (*e.g.*, sediments along estuaries & sewers), whether permanently or temporarily (Shaban, 2008). Thus, most pollution sources are perceived to be deriving from soil.



Figure 3. Example showing different pollution sources along the Lebanese coast.

The recognized marine hotspots are found as the following: 19%, 13%, 36 %, 8.5 %, 15% and 8.5 % (4) and corresponding to sediments, turbid water, landfills, wastewater effluents, chemical and medical products, oil residues and thermal water as well. In addition, there are several oil spills which exist sporadically as they can be always clearly observed via satellite images.

The characteristics of the areas, where liquid pollutants are discharged, and solid wastes are dumped, are significant in terms of the pollutant's mechanism spread. These include a variety of factors such as water depth, shoreline type (*e.g.*, sandy, rocky, meandered, *etc.*), extent of the continental shelf and sea currents, *etc.* The pollutant areal extent in the marine environment does not indicate the degree of pollution impact whereas, the type of pollutant is more important in assessing it a real environmental threat. For example, the terrestrial sediments discharged from rivers into the sea are larger in terms of dimensions (*i.e.*, several square kilometers into the sea), but with less pollution impact if compared to the oily water and oil spills. These are much more noxious to the marine environment, but with less aerial extent into the sea (Shaban, 2008).

II.5. Marine Pollution impact on the Ecosystem

It is undeniable that Lebanon's environmental problem is tightly related to pollution in general, and particularly to marine pollution. Moreover, the tremendous pollution sources spreading along the coast are sometimes a geographical overlap of different sources of pollution (*i.e.*, more than one source in the same site). In fact, the impact of marine pollution is very harmful not only to the ecosystem but also to its environmental components.

The identified types of pollution along the Lebanese coastal strip have displayed different levels of impact on the ecosystem. **Table 2** summarizes the major impacts of marine pollution on the ecosystem, and they can be discussed as follows:

Table 2. Types, characteristics, and impact of marine pollution along the Lebanese coast.

Type of marine pollution	localities	Geographic extent	Impact on ecosystem	Dynamic of existence
Sediments transport	Several (5-15 estuaries), along watercourses	Several tens (up to 40 km) of kilometers length and few (up to 20 km) kilometers width	Slight to moderate	Temporarily
Coastal landfills	5 major landfills	200-400 m diameter	Noxious	Static
Wastewater effluents	Several (5-15 estuaries),	Small to large channels (50-500 m)	Noxious	Permanent and temporarily
Chemical & hospital products	Local spots	Chaotic (undefined)	Extremely Noxious	Sporadic in defined localities
Oil residues	Tremendous and chaotic	Irregular strips up several kilometers' length	Extremely noxious	Temporarily
Thermal water	4 localities	Elongated plumes up to few kilometers (1-2 km)	Noxious	Permanent

II.5.1. Impact of transported sediments

Even though the transported sediments from the terrestrial environment along with estuaries into the sea are often characterized by large geographical extent, yet they slightly impact the marine ecosystem, and encompass opposite (negative or positive) effects. For example, there are many organisms that have adapted to fine sediments and high sedimentation rates by making use of estuaries as habitat. there fine-sediment beds are important for burrowing tube-making invertebrates, and other burrowing

species (Minshall, 1984). Besides, the diversity and uniqueness of species, is declining with a steady increasing rate of both sediments and organic matter (Junoy and Vieitez 1990). In Lebanon, no studies have been conducted to research transported sediments impact on the marine ecosystem. However, the general understanding is that the transported sediments are almost noxious for coral reefs, notably those located at a shallow depth in the near-shore sites.

II.5.2. Impact of coastal landfills

There are several lumps of garbage (small landfills) along the Lebanon coastal strip, specifically there are six major ones, with a large volume of solid wastes located exactly (except En-Nahmeh landfill) on the shoreline (Figure 2). All these landfills have reached their maximum capacity and they often witness load failure where large parts of waste fall into the sea.

The decayed toxic materials from solid wastes, which are mostly in liquid state, slowly seep into the marine water, leading ultimately to an intensive marine pollution that in its turn affects the surrounding ecosystems (Table 2). In addition, the burning of coastal landfills represents a striking aspect of air pollution where smoke affects humans, vegetation, *etc.*, located nearby these localities (Figure 4).

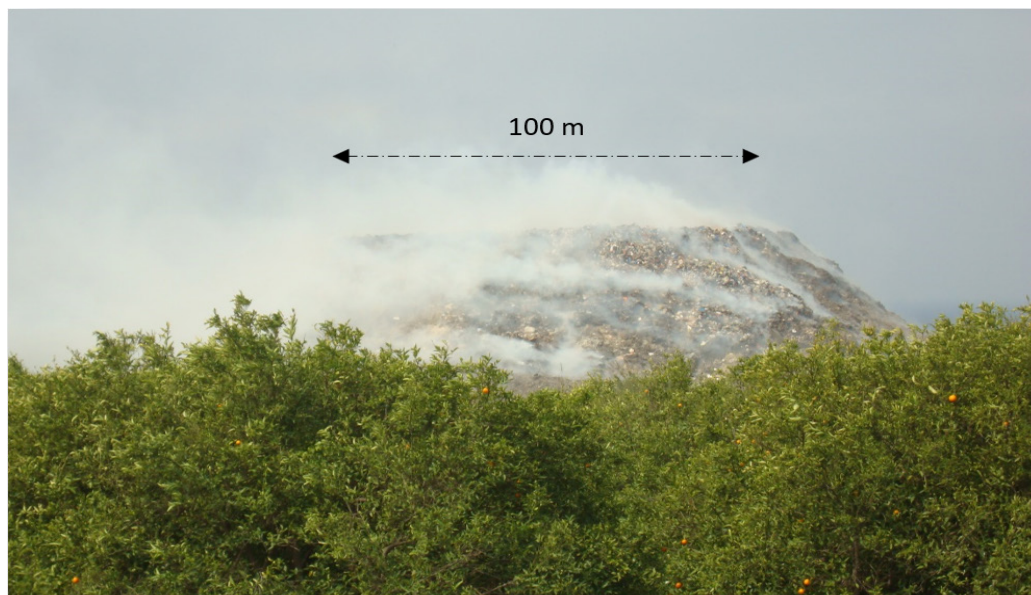


Figure 4. Landfill burning south to Sour City, a daily view along the coast.

II.5.3. Wastewater effluents Impact

Municipal wastewater pollutants together with sewage discharges represent one of the greatest threats to the marine ecosystem. Thus, Lebanon's poor infrastructure has led to untreated (or partially treated) wastewater from urban areas discharging directly into the sea. This may bring about a huge public health risk, as well as serious geo-environmental problems that affect the coastal marine ecosystems (Geara *et al.*, 2010).

Most of the municipal wastewater pollution requires the presence of bacteria and other microorganisms that use oxygen to metabolize the sewage they accompany. While breaking down the sewage in the seawater, these microorganisms can cause hypoxic (oxygen-depleted) dead zones, which lack oxygen that fishes and other native organisms need to survive.

Shellfish infected with sewage-related bacteria sicken people around the world. In marine environments, human gut bacteria (*Escherichia coli*) can infect corals and cause coral bleaching disease. When corals lose their natural bacteria and algae, they die and as a result they generate areas where the whole coral ecosystem, from bacteria to fish populations, usually decay and expire (Blaettler, 2018).

The Sewage threat is so obvious and clear along the Lebanese coast, where 17 major sewage outfalls exist (Figure 2 and Table 2). In addition, the total reported volume of raw sewage generated in Lebanon was about 165 Mm³/year (130 and 35 Mm³/year of domestic and industrial wastewater; respectively). Less than 50 Mm³/year of this volume is treated or infiltrates into substratum, and the rest (about 110 Mm³/year) is dumped into the marine environment (Karam *et al.* 2013).

II.5.4. Chemical and hospital wastes impact

Generally, chemical and hospital medical (including industrial) wastes are discarded or dumped either in storage facilities or usually along the coastal zone. Besides, they can be thrown away in the abandoned mines and valleys which are often connected to the coast channels. Thereby, resulting in extremely damaging pollution impact on the marine ecosystem. These suspicious and toxic wastes leak into the groundwater, killing cattle and causing cancer among the inhabitants.

These marine pollution categories are considered as sporadic since they are suspiciously dumped at different time periods, almost in diverse localities near the coast. Thus, they are usually found as lumps at relatively small localities (Table 2).

II.5.5. Oil residues and spills impact

There are some areas where oil residues that are coming from industrial sites and refineries are permanently dumped along the coast (Figure 2), while many oil spills take place temporarily either along the shoreline or at a range offshore (Figure 5). In fact, oil components are highly toxic and detrimental. Consequently, they lead to serious

implications on human health, biodiversity, fisheries, and tourism as well. These in their turns induce further hazardous implications on both Lebanon economy and inhabitant's survival and livelihood (UN-GA, 2009).

The most striking marine pollution in Lebanon occurred during 2006 war, when the Jyeh Power Plant was struck due to a huge oil spill on the Lebanese coast with about 3,100 km² of surface area (Shaban *et al.* 2009). As a result, it affected remarkably both the coastal and marine ecosystems, such as the vermetid terraces, coralline and reef communities in Cheikh Zennad, Al Mina seashore, the Palm Islands, Batroun marine zone, Jbeil to Amshit, and Rocks of Wata Slim. In addition, a significant impact on the seabed was detected, especially on the seagrass meadows at Aarida, Amshit, Jbeil and Beirut Airport wave breaker (MOE/UNDP/ECODIT, 2011; IUCN, 2006).

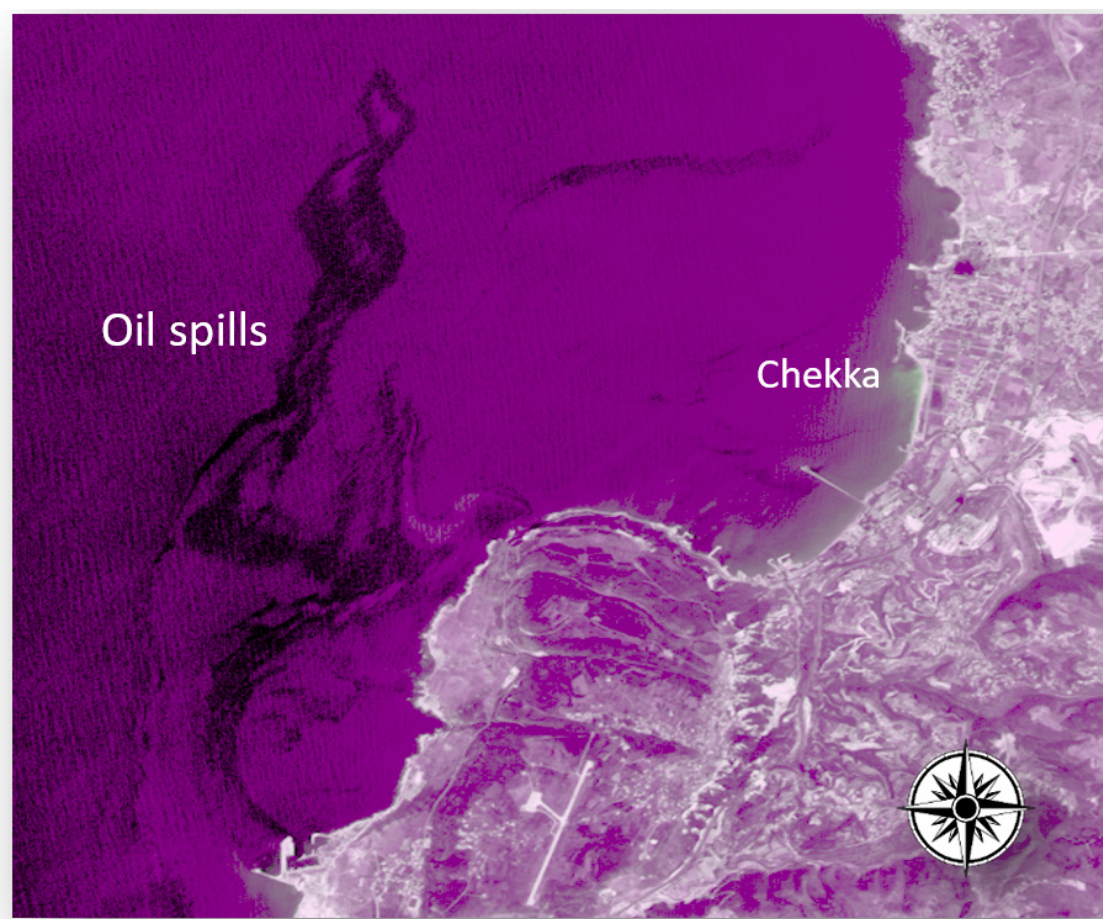


Figure 5. Aster satellite image showing a temporary oil spill (in black).

II.5.6. Thermal pollution impact on the marine environment

There are four power plants along the Lebanon coastal strip that generate and provide the whole coastal zone with electricity. Then, the released wastewater is immediately dumped into the sea causing pollution hotspots, called “Thermal pollution”. Warm marine waters from the power plants extend as plumes into the sea and cover a few kilometers offshore areas (Figure 6). The shapes and dimensions of thermal plumes along the shoreline were identified by the thermal Infrared Survey (TIR) (CNRS-L, 1999).

The thermal pollution triggers a variety of sub-lethal effects upon aquatic organisms. Studies indicate that organism reactions include increases in metabolic rate and digestion, growth rate, swimming speed and disease. moreover, increased water temperatures can change the pattern of spawning, reproduction, and fish migration (Shiomoto and Olson, 1978).

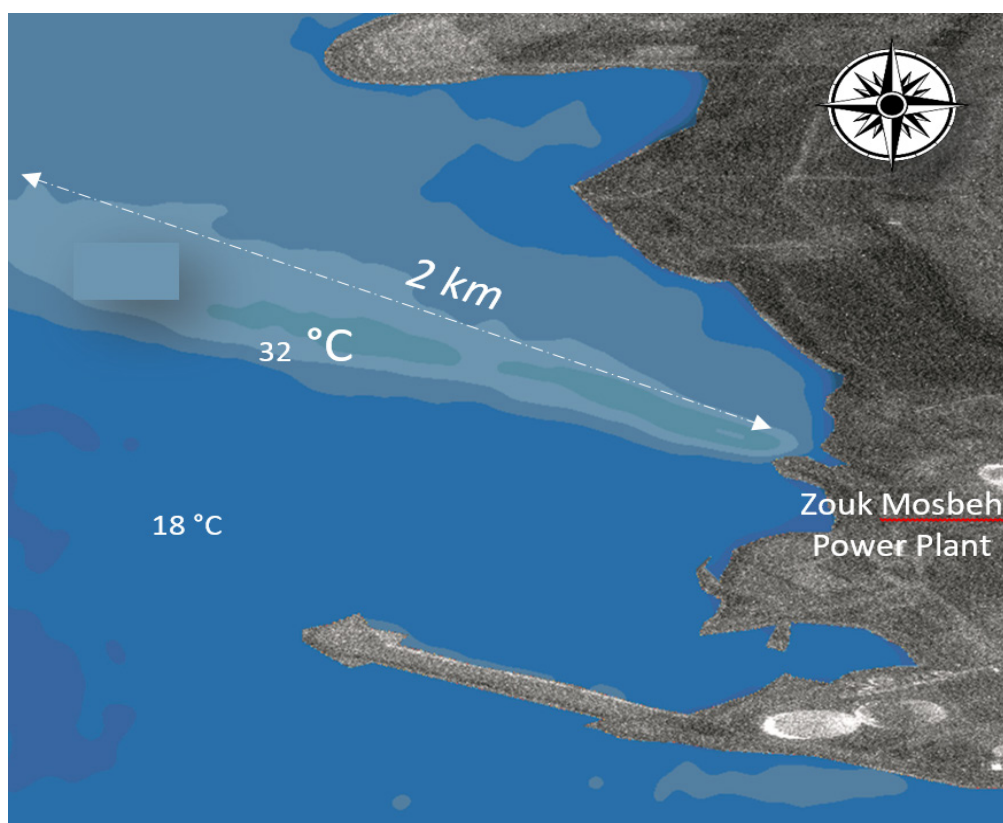


Figure 6. Thermal Infrared images showing the extent of thermal plume.

III. Anthropogenic Pressure

Anthropogenic pressure in the coastal zone is usually attributed to pollution which is considered as the primary influential factor. However, there are other aspects of anthropogenic pressure that are interrelated with human influence and as well as the coastal and littoral ecosystems' degradation. This is highly remarkable along the Lebanese coastal zone where a miscellany of human activities from multi-sectors exists, including construction works and urban development, tourism, industry and agriculture.

III.1. Types of Anthropogenic Pressure along the Lebanese Coast

The coast of Lebanon is permissible, and the environmental legislations are often neglected/or overridden. In addition, the socioeconomic pressure in the rural areas resulted mainly in many dramatic demographic changes that are echoed clearly from the soaring rate of migration from rural areas towards the urban coastal zones.

Setting and planning the Strategic Action Plan for the Conservation of Mediterranean Marine and Coastal Biological Diversity (SAP BIO), in which 149 specific threats adversely affecting marine and coastal biodiversity have been recognized after a country-by-country analysis (UNEP/MAP/RAC-SPA, 2003). Hence, Lebanon coastal zone was found to be at risk of many coastal threat categories. Therefore, most of the anthropogenic pressure along the coastal zone of Lebanon (in addition to pollution) implies mainly the encroachment on the natural resources and their components.

III.1.1. Uncontrolled coastal development

The chaotic and uncontrolled development is a widespread human feature along the Lebanese coast that affects the touristic sector and includes both the uncontrolled or unplanned coastal urbanization (*e.g.*, housing, industries, marine backfilling, *etc.*), and illegal dwellings. This resulted ultimately into changes in land due to the use of a variety of components during construction activities. It is as well usually accompanied with increased tourism and development of touristic resorts, aquaculture activities and coastal erosion (Nader *et al.* 2012). These developments (*i.e.*, stresses) can be highlighted as follows:

- Industrial and energy establishments, which are spread exactly along the shoreline, such as Sela'ata Chemical industry site, Industrial zone in Saida city, Chekka and Seblin Cement Factories, *etc.*, as well as the four coastal power plants (Figure 2).
- Illegal constructions, and these were built on the public maritime property including sandy and rocky shorelines. Most of these constructions are being expanded regardless of the public ownership.

- Illegal harbors, which are privately-owned and were built without engineering specifications and thus they do not follow any environmental regulations. There are more than 60 illegal harbors with different dimensions that were reported along the Lebanese shoreline.
- Refugee sites, where there are 10 sites (camps) located either exactly along the coast or at less than 2 km distance. These sites lack the proper environmental control and sanitation systems, and thus affect the nearby shorelines.

III.1.2. Devastation and tapping of natural components.

Unfortunately, Lebanon's largest coastal zone has been dangerously devastated. Similarly, its natural components, which have made it a distinguished geographic region at the regional level, have also been destroyed. The natural influencing factors (*e.g.*, global change), which impacted the natural components are due to human interference. These natural components can be summarized as follows:

- Forests and green cover, which extend from the coast along to reach the foot-slopes then the mountains. Forest fires, wood logging, overgrazing and quarrying became widespread phenomena in these areas.
- Wetlands, where the three identified coastal wetlands (Palm Islands, Ras Echeke'a and Ras Al-Ain) are unstable, in particular Ras Echeke'a which has been considered as an abandoned wetland (Shaban, *et al.*, 2016).
- Submarine springs, which are located either on the coast or at a range offshore. Most of the springs have dried off over the last four decades due to groundwater over-pumping from the coastal aquifers (Shaban, 2020).
- Sandy beaches are ignored, and their morphological characteristics have been destroyed due to the absence of formal and even ethical controls.
- Sea sand is being dredged in several areas either directly from seawater, or from the sandy beaches and thousands of tons are extracted daily.
- Rocky marine shelves have become under risk due to the backfilling of rock debris, sludge and garbage, whereas these shelves are common coral habitats.
- Abandoning agricultural lands, these have been ignored lately due to many economic reasons. In fact, these lands are abused due to the overuse of fertilizers and chemicals to reach mass agricultural productivity.

III.1.3. Groundwater pumping/saltwater intrusion

Recently, Lebanon has been suffering from an increasing water scarcity problem together with a harsh imbalanced water supply and demand situation. Thus, water supply complaints have recently become a national concern, especially in the coastal

zone where more than 70% of Lebanese dwell. The increased population as well as the changing climate influenced the discharge in rivers and springs. Therefore, water supply trends have been diverted lately towards groundwater.

For example, boreholes density in Beirut the capital has increased from 500 to 1,500 wells/km² over the last four decades, and this was reflected on groundwater dimensions in the coastal aquifers. Therefore, groundwater level has declined tens and tens of meters. This hydrogeological process gave a chance for seawater to intrude into these aquifers, increasing water salinity. Thereby, adding another pressure on this sector (Badreddine, 2018).

III.1.4. Fishing in sensitive ecosystems

Fishing on fragile biotopes and habitats has become widespread in small bays, caves, at submarine springs and near archaeological and ruin sites. This illegal fishing is now widely experienced and adopted in Lebanon. In fact, fishing with small mesh size nets increasing the by-catch has become frequent as well as the use of explosives and toxic bait, together with scuba diving, spearfishing and incidental capture. All the above have led both to the phenomenon of overfishing and the lack of data and monitoring (Nader *et al.*, 2012).

III.2. Impact of Anthropogenic Pressure on the Ecosystem

The impact of anthropogenic pressure on the coastal zone's ecosystem is a complex social-ecological process that often occurs in overpopulated areas. This is exactly the case of the Lebanon coast where both the socioeconomic sectors and its activities nearby, exert multiple and direct pressures. As mentioned in the previous sections, the irresponsible and random human activities are numerous and include many aspects, such as (but not limited to): urbanization, industrial development, aquaculture, fisheries, and water extraction. However, these activities result necessarily in negative consequences on the environment in general and particularly on the ecological systems, notably with the absence of conservation approaches and behaviors.

The existing coastal development has several aspects in influencing both the terrestrial and marine ecosystems. For the terrestrial ecosystem, it has destroyed the vegetation cover located on the arable lands that are spreading over the coastal plains. In addition, it has contributed to the abuse of many flora and fauna species on the rocky beaches and cliffs.

The existing pressures lead to changes in the environmental state, coast exposure to natural risks, contamination, loss and exhausting of natural resources, and hypoxia that threatens the sustainability of the entire ecosystem including human beings.

In addition to the major anthropogenic consequences, reported activities on Lebanon marine ecosystem by Badreddine, proved to be highly and directly detrimental on Lebanon anthropogenic ecosystem (Badreddine, 2018):

- Increased erosion generating habitat destruction.
- Loss of nurseries' ground such as *Cystoseira* forests
- Loss of cultural value such as vermetid reefs
- Increased risk of species extinction
- Enhancement of toxic algae development via the phenomenon of eutrophication
- Decrease of accessibility to the maritime public domain
- Alteration of the food chains
- Increase in invasive species
- Loss in the number of migratory birds
- Remarkable decrease in some flora species such as *Cyclamen* and *Narcissus*
- Decrease in some fauna species as Reptile species in many Lebanese coastal areas.
- Loss in the characteristics of wetlands and the loss of their unique ecosystem (Shaban, 2020).

The anthropogenic pressure impact has resulted in multi-sectors in the coastal zone of Lebanon as illustrated in Figure 7, where the impact extends to major ecological components, including natural resources and human health. Therefore, each pressure type was graphically simulated versus different aspects of impacted ecological components, which in its turn contribute to Lebanon coastal zone sustainability.

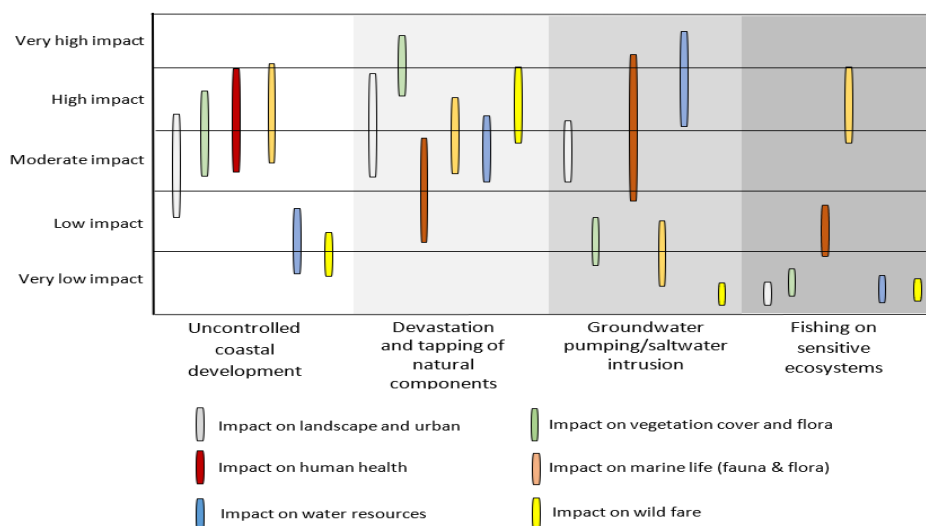


Figure 7. Impact of different anthropogenic pressure types on the major ecological components.

IV. Conclusions

Over the last years, Lebanon has remained the unique geographic region in the Middle East which was characterized by its landscape and natural resources. Thereby, creating multi-sectoral development that has contributed to the socioeconomic condition. Nevertheless, the existing geo-political conflict has led to an unfavorable situation that influenced all sectors including tourism. This resulted in anthropogenic stress on the ecosystems, which has been dramatically reflected on all the ecological components.

The Lebanon environment is really at stake, notably along the coastal zone which attracts the largest population (> 70%). Consequently, this has generated severe anthropogenic pressure on all sectors including Tourism. Both the global natural change and human footprint are severely threatening the ecosystems. Yet, the latter is more devastating.

Pollution widespread terrestrial and marine, as well as the uncontrolled man-made encroachment, are two key features describing Lebanon's environmental state. This is obvious especially through the fifty major pollution hotspots and the doubled number of minor ones, spreading along the coast. Yet, this totally conflicts with the touristic sector development.

The link between the terrestrial and the marine components has been disjointed, and the entire ecosystem is moving in a regression trend. This report discussed the pollution and anthropogenic stresses influencing the Lebanon coastal zone. It depended on literature review and studies. It was noticed that a comprehensive analysis for the ecosystem is still lacking and the exact temporal and geographic changes in ecology are still undefined. Yet, more thorough studies are recommended so as to reach sustainable tourism in the Lebanon coastal zone.

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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*. In addition, under no circumstances it could be regarded as reflecting the European Union position of the program management structures.

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