CLIMATE CHANGE VULNERABILITY AND ADAPTATION

COASTAL ZONES

Lebanon's Second National Communication
Ministry of Environment/UNDP

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1. VULNERABILITY AND ADAPTATION OF COASTAL ZONES

1.1. VULNERABILITY ASSESSMENT

1.1.1. Background

The Lebanese coastline extends about 230 kilometers in length from the northwest border at Aarida to the southwest border at Naqoura (CDR, 2005). For the purposes of this assessment, the coastal zone area is considered to encompass the seaward limit (the external part of the territorial sea) and the landward limit of the coastal administrative units (Figure 1-1). The coastal zone, comprised between the Mount Lebanon chain and the Mediterranean Sea, is characterized by being very narrow, except in the north and the south of the country. In a 500m-wide corridor along the coastline, coastal zones represent eight percent of the total Lebanese surface area which is approximately 840 km^2 of the Lebanese territories. The mean annual temperature on the coastal zone varies between 13.5 and 27°C with an average annual rainfall of 600 mm (CDR, 2005; Nasrallah, 2007).

The coastline is excessively cut and is marked with a series of promontories such as Ras Beirut, sandy beaches - around 20 in Chekka, Batroun, Jbeil, Maameltein, Ramlet el Bayda, Jnah, Damour, Tyre, etc., cliffs such as the cliff of Ras el Chaqaa and of Bayada at Naqoura, rocky capes such as Ras Es-Saadiyat, Nabi-Younes, Sarafand, and bays as present in Jounieh, at the Pigeon Rock in Beirut and in Naqoura. The coastline is well-known for housing natural habitats for endangered fauna and flora (CDR, 2005, MoE, 2005). Table 1-1 compares the land use distribution of the coastal zone within a corridor of 500m, showing the dominance of economic activities over 80% of the coastline, while the natural areas represent less than one-fifths of the total coastal makeup.

Table 1-1 Land use along the coast

TYPE OF LAND USE	WITHIN A STRETCH OF 500M (%)
Urban areas	40
Agricultural areas	41
Natural areas[11]	19
Total	100

Source: CDR, 2005

Coastal and marine fauna and flora are considered of the Mediterranean type with a sub-tropical tendency. The habitats recorded along the coastal stretch included rocky, sandy, silty, coastal, neritic and oceanic habitats. Marine flora mostly consists of benthic algae - microphytes and macrophytes. Sandy/ soft bottom habitats are characterized by a soft bottom and are relatively poor in biodiversity and productivity (ECODIT/IAURIF, 1997).

The coastal zone has a very high population density; it was estimated at around 594 inhabitants per km^2 in 2000 which is relatively high compared to the overall population density of Lebanon of 307 inhabitants per km^2. In fact, 55 percent of the total population lives in the coastal zones that host 33 percent of all built-up areas (Figure 1-1) (Abu-Jawdeh et al., 1999; CDR 2005).

1 Beaches, dunes, etc

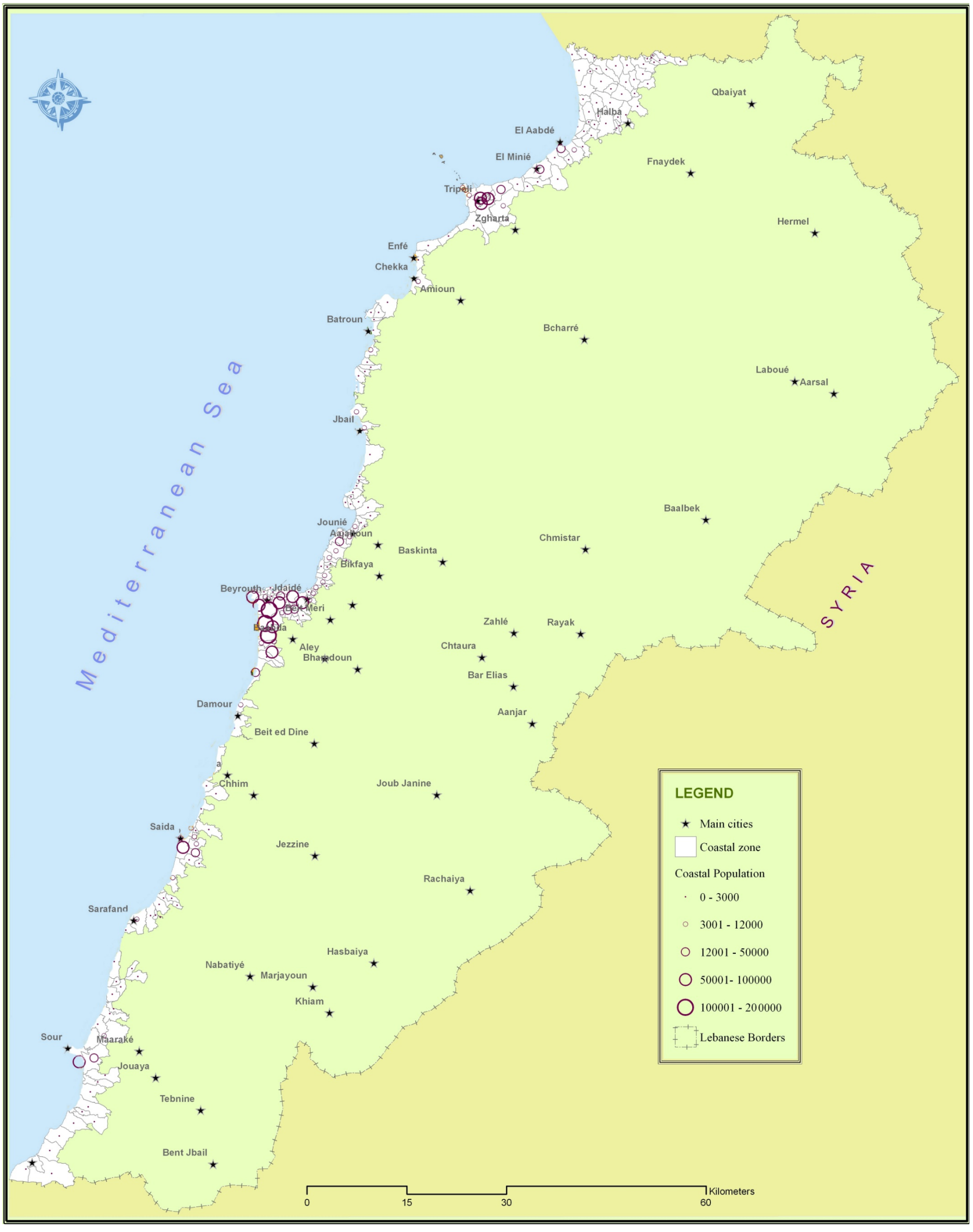

Figure 1-1 Distribution of the coastal population along the shoreline

The three major cities of Lebanon, Beirut, Tripoli and Saida, are located along the coast. Hence, Lebanon's economic activity is concentrated on the coastal zone and contributes to more than 74 percent of Lebanon's GDP through commercial and financial activities, large industrial zones, important agricultural lands as well as fishing and tourism (MoE, 2005; Abu-Jawdeh et al., 1999). Figure 1-2 shows the types of urban development along the coastline.

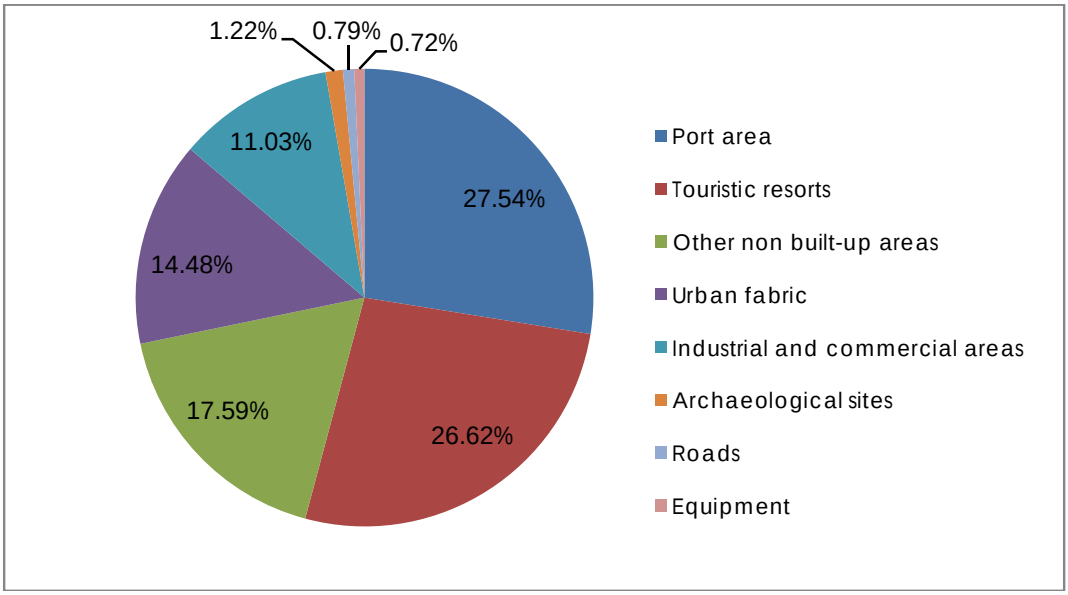

Figure 1-2 Distribution of urban development structures along the coastline as a percentage of total coastal length[2]

Source: Lichaa-El Khoury & Bakhos, (2003)

The majority of industrial, commercial and financial activities as well as the largest cities are situated in the coastal zone due to the wide range of services provided by coastal ecosystems. Figure 1-3 shows the land use/ land cover classes through the distribution of the urban development structures along the coastline. The importance, the influence and the impacts of different economic activities on the coast are further explained below.

Agriculture

Despite the fact that the Lebanese coastal zone is narrow, agricultural zones are not absent in this area. The largest agricultural areas are located in Akkar, Abou Ali valley in the north, Damour and the southern plain, e.g. in Qasmiyeh and Ras el Ain (CDR, 2005)(Figure 1-3). Cultivations in the coastal zone include subtropical crops (bananas, oranges, avocado, etc.) that are concentrated in the south along with wheat and a variety of irrigated crops and vegetables that are however mostly grown in the northern coastal plain of Akkar (Lichaa-El khoury & Bakhos, 2003). Agriculture on the coast is considered as one of the activities offering environmental opportunities for green areas and has the additional benefit of reducing CO_2 enrichment of the atmosphere (Abdul el Samad, 2001).

2 The non-built-up artificial area category has been devised to include mineral extraction sites, dumpsites, landfills, urban extension and/or construction sites, as well as vacant urban areas. Equipment category include schools, universities, cultural and religious buildings (Lichaa-El Khoury & Bakhos, 2003).

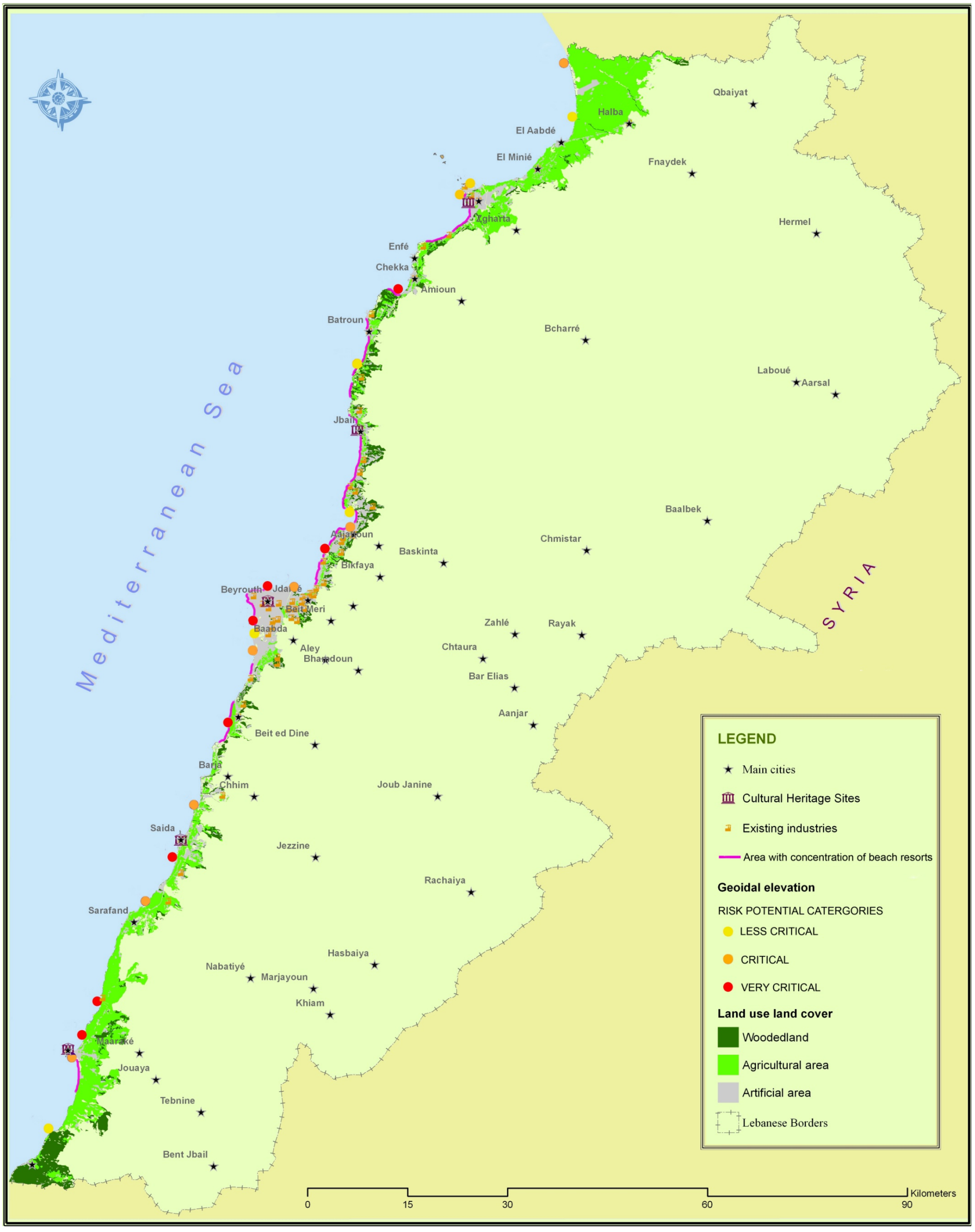

Figure 1-3 Land use along the Lebanese coastal zone

Shipping and Fishing

Lebanon has four main commercial ports in Beirut, Tripoli, Sidon (Saida), and Tyre, and a number of small ports along the coastline which are primarily used for fishing and leisure purposes. The Port of Beirut, one of the largest ports on the Eastern Mediterranean coastline, occupies a total area of 1.2 km^2 and has four basins, 16 quays and a newly built container terminal. The traffic at the Port of Beirut has reached around 5 million tonnes per year; while in Tripoli it is around 0.7 million tonnes per year (CDR, 2005).

Fishing ports are traditional as the fishing sector in Lebanon is largely artisanal. The Lebanese fishing fleet is composed of 2,662 vessels operating along the coast from 44 fishing ports and landing sites. The marine fishing sector employs 6,500 persons who annually capture, on average, 3,646 tonnes of fish (in 2000) and 200 tonnes of mollusks and crustaceans (in 1997) (Majdalani, 2005; WRI, 2007). The busiest fishing ports are in Tripoli, Beirut and Saida (Table 1-2).

Table 1-2 Distribution of vessels by ports

PORT	NUMBER OF VESSELS	PERCENTAGE
Tripoli	957	36.0
Beirut	715	26.9
Saida	417	15.7
Tyre	231	8.7
Jounieh	184	6.9
Jbeil	125	4.7
Chekka	33	1.2
Grand Total	2,662	100

Source: Majdalani, 2005

Tourism

Tourism on the coast is expressed through different forms:

- Beach resorts and marinas projects for leisure and recreational activities that both occupy 8.5% of the coastline (Assaf, 2009).
- Archaeological monuments such as in Tripoli, Jbeil, Saida and Tyre.
- Natural landscape such as Ras Chaqaa, Enfeh, Pigeon Rock and Ras Naqoura.
- Natural reserves such as Tyre Coastal Nature Reserve and Palm Islands Nature Reserve.
    - Tyre beach is the only remaining stretch of sandy beach located to the south of the southern city of Tyre. It owes its specificity to the presence of artesian springs with high flows at Ras el Ain and for the breeding sites of Mediterranean Sea turtles (ECODIT-IAURIF, 1997).
    - The Palm Islands Nature Reserve is of important natural heritage. It attracts nesting, migrating and wintering bird populations of global concern. The number of bird species that were recorded at the tiny Palm Islands Nature Reserve makes 40 percent of the total national avifauna (MoE & UNDP, 2004).

Industry

The main industrial activity is located in the vicinity of the coastal cities of Beirut, Tripoli, Chekka, Selaata, Sibline and Zouk. In fact, 65 percent of industries are situated on the coastline for a better supply of raw materials through the extensive coastal road network and faster export of products

through the ports (CDR, 2005). Large industrial or commercial units occupy about 24 km of the coast which is equal to 10 percent of its total length (Assaf, 2009).

1.1.2. Methodology

1.1.2.1. Scope of assessment

Unit of Study

This study examines the current and future vulnerability of urban, industrial, commercial, touristic and agricultural agglomerations along the Lebanese coast and the shoreline to sea level rise (SLR) and sea surface temperature (SST). It assesses the likely impacts of SLR and SST rise on coastal and marine biodiversity, on coastal populations and on the different types of coastal activities.

Spatial Frame

The study area includes all the coastal administrative units which extend from the northwest border in Aarida to the southwest border in Naqoura with a length of 230 km, and includes the Palm Islands in the north opposite to Tripoli. Along this stretch, certain segments could be highly vulnerable to climatic factors such as the low-lying areas, areas under anthropogenic pressures and areas that experience saltwater intrusion.

Temporal Frame

Vulnerability of the coastal zones to climate change-induced effects shall be examined throughout the whole year and during the periods of extreme storms. Periodic measurements of wind speed at sea and wave height in Tripoli and Beirut show that wind speed reaches maximum levels in the months of January, April and September, while waves reach record highs during the peak winter months of January and February (Table 1-3).

Table 1-3 Months characterized by the most intense wind and wave conditions

	BEIRUT GOLF, SOUTH OF BEIRUT	EL-BEDDAWI, NORTH OF TRIPOLI
Months of Maximum Wind Speed	January, April	January, September
Months of Maximum Wave Height	January, February	January, February

Source: Kabbara, 2005

1.1.2.2. Climate factors

Sea level rise is the climate change-related factor that is most important to predict natural shoreline erosion, coastal flooding and to estimate the risk of salinization of groundwater wells. Sea level rise increases coastal flooding from rainstorms and can cause shoreline erosion if it was combined with wind-driven waves.

Sea surface temperature (SST) is a climate change-related factor that may be used to predict the intensity and the frequency of storms. A rise in SST, influenced by global warming, is most likely linked to an increase in storms.

1.1.2.3. Methods of Assessment

This assessment study was conducted based on:

- Developing two baseline socio-economic scenarios that show and characterize the current and the future variation in the demographic, socio-economic and technological driving forces in the country.

- Developing a climate change scenario to indicate how climatic and climate-related factors could probably change.
- Identifying vulnerable hotspots to climate change based on their social and biophysical exposure, sensitivity and their adaptive capacity to climate change. This identification was based on maps, professional judgment and literature review.
- Setting out indicators to study the sensitivity, adaptive capacity and vulnerability of vulnerable hotspots under socio-economic and climate change scenarios.
- Determining the likely climate change impacts through a literature review and further analysis.

1.1.2.4. Data Sources and Gaps

In this chapter the main data sources used in the analysis are reports generated by the:

- Council for Development and Reconstruction (CDR)
- Ministry of Environment (MoE):
- the draft National Environmental Action Plan (NEAP) report (2005)
- State of the Environment Report (SOER, 2001)
- Other sources include: ECODIT/IAURIF, World Resources Institute, Plan Bleu, Food and Agriculture Organization (FAO), the Economic Accounts Mission of the Presidency of the Council of Ministers and the International Monetary Fund for national accounts data, and the UN Population Division's World Population Prospects for population growth data

In this chapter the major data gaps were the:

- The disparity in figures between the different government publications regarding coastline length and width, coastal population and density, etc.
- The lack of accurate data on current (and projected) sea level rise, fish catch and a recent scan of coastal storms (sea storms, tempests, floods, etc.) during climatic extremes.

1.1.2.5. Assumptions and limitations

The analysis of future vulnerability takes into account the current vulnerability, and assumes that the policies and strategies currently in place will be on the course of implementation by 2030. The analysis does not however account for internal and external security shocks which would severely impact growth, the population's livelihoods and vulnerability, hence intensifying any natural shocks from the projected climatic changes.

Assumptions made in the formulation of the socio-economic scenarios were based on an examination of national statistics on GDP growth trends from national accounts (EAM-PCM, 2005; EAM-PCM, 2006; EAM-PCM. 2007) and IMF's World Economic Outlook, and population growth prospects as projected by the UN Population Division.

1.1.3. Scenarios

1.1.3.1. Socio-economic Scenarios

The coastal zone in Lebanon harbors three-quarters of the total national economic activity and houses over half of the total population (MoE, 2005; Abu-Jawdeh *et al.*, 1999; CDR 2005). The existing social and developmental pressures on the coast are increasing with the increasing growth in the economy due to the relatively better access to and quality of physical and institutional infrastructure in the coastal areas. In this section, the policies and strategies decreed by the Lebanese government for coastal development are presented even if they have not been implemented to date, along with two

baseline socio-economic scenarios which examine possible future changes in the main economic sectors presented in the background section regardless of any changes in the climate system and its associated factors.

Policies and Strategies

In order to preserve, valorize and increase the sustainable use of the important Lebanese assets in coastal areas, CDR has defined in its NPMPLT report (CDR, 2005) a series of complementary regulations and operational measures. Although not executed, these plans can improve the quality of life in coastal cities. The NPMPLT recommends the following actions for the coastline.

- Manage and maintain sandy beaches as they are a very rare resource in Lebanon which belongs to the maritime public domain.
- Classify and protect exceptional sites as historical heritage and remarkable natural sites[3] as natural heritage.
- Underline the high ecological value of certain parts of the Lebanese seashore and manage them in a better way.
- Preserve and develop the seashore promenades and cornices.
- Preserve the picturesque ports of Jbeil, Tripoli and Tyre for their important touristic value.
- Allow public access to the seashore and the use of the maritime public domain through adopting several legislative steps against illegal constructions.

The CDR has included in the NPMPLT an action plan for land use which defines various steps for the mitigation of urbanization pressures. Those actions that guarantee a sustainable use of the coastal zone are briefly described below:

- Protect and conserve the sensitive coastal and current or potential hotspots on the coastal zone from construction, illegal exploitation and misuse.
- Decree the administrative, juridical and operational delineation of the Lebanese coastal zone as proposed by the CDR.
- Establish the National Agency for Coastal Zone Management by the CDR, MoE, MoA, MoPW&T and DGUP.
- Restrict land reclamation to strategic projects of public utility through the preparation and enforcement of legislation by the MoPW&T and enforcing the implementation of strategic environmental assessments (SEAs) and environmental impact assessments (EIAs).
- Completely halt sand extraction from riverbeds, dunes and beaches.
- Restrict seafront dumps and rehabilitate the existing dumpsites.
- Reconvert urban fallow areas for the preservation of the natural coastal areas.
- Reduce intensive agricultural practices and monoculture in the coastal areas.

Socio Economic Scenarios

The CDR defined, in the NPMPLT report, different challenges that Lebanon is facing today and might face in the future. Based on the NPMPLT's assumptions on growth trends and socio-economic changes, the authors of this report proposed two scenarios that appear in the column on the left hand side. Scenario A is a low to modest growth scenario and Scenario B represents a relatively high growth scenario. According to the challenges, policies and strategies and growth assumptions, interpretations

3 See Appendix B

of the repercussions of Scenario A and Scenario B on the development of the coastal zone until 2030 are outlined in the right hand side column.

Scenario A ▪ Growing integration of international trade, Lebanese production of exchangeable products would not be significantly developed ▪ Less balanced economic development ▪ GDP grows at an annual average rate of 4.2%[4] ▪ Low population growth: Population will grow, however at a decreasing rate – average of 0.35%[5] between 2010 and 2030 ▪ Total urbanized area will slightly increase ▪ The migration balance[6], between 2001 and 2030 will be around (- 27,000) persons yearly ▪ Same standard of living	Under this scenario, tourism, food production industries and commerce activities will probably be the main economic activities. Therefore, shipping activities over the four main commercial ports will increase. Fishing activity will slightly increase as a result of the low population growth and less balanced economic growth. Any increase in tourism activity will threaten the coastal zone's major assets as well as the remaining agricultural lands in Akkar plain, Damour, and south Lebanon. The CDR has recommended several measures in the NPMPLT (mentioned above) that will reduce the pressure on coastal zones due to the planned management, preservation and valorization of coastal assets. Population density along the coastal zone is expected to remain stable or might face a slight decrease due to low population growth, increased emigration and the planned development of inland cities which is expected to relieve the pressure on the coast. Salt water intrusion due to excessive use of groundwater along the coast will remain a problem or could probably decrease as coastal population density slightly declines and as agricultural areas recede to be replaced by tourism infrastructure.
Scenario B ▪ Growing integration of international trade, local production could better resist the competition induced by imported products ▪ Balanced economic development	Despite the CDR vision concerning the development of inland cities in the Bekaa and the South, population density and thus concentration of settlements will increase at a high rate along the coast as a result of the high

4 This is an average of the actual GDP growth rate, at constant 1990 prices, between 2000 and 2004 (IMF, 2009).

5 This an average of the population growth rate in a **low fertility scenario** as projected in the World Population Prospects: The 2008 Revision (UN, 2009).

6 The migration balance is the difference between the number of persons having entered the territory and the number of persons having left the territory in the course of the year. This concept is independent of nationality (Insee, 2010).

▪ Considerable GDP growth - GDP is assumed to grow at an annual average rate of 8.6% between 2010 and 2030[7] ▪ High population growth - Population will grow at a modest increasing rate with an average of 0.96%[8] between 2010 and 2030 ▪ Total urbanized area will increase with population, growth of 284 km^2 in urbanized areas ▪ The migration balance, between 2001 and 2030, will be around (-6,000) persons per year. ▪ Better standards of living ~ 2.4 times higher.	population growth. The total income from fishing will probably increase as a result of the reorganization of the agriculture sector and the investment in the fishing sector. The contribution of coastal activities (industry, agriculture, tourism…) to GDP is expected to significantly increase due to an increase in Lebanon's production that will boost its competitiveness. The demand on water resources for agricultural irrigation as well as for domestic use might increase. Water will be mainly extracted from new private wells; under such conditions, the risk of seawater intrusion and aquifer salinization will highly increase despite plans (under the NPMPLT) to reduce monoculture and intensive agriculture which could potentially reduce groundwater withdrawal for irrigation therefore sea water intrusion into coastal aquifers.

1.1.3.2. Climatic Scenarios

Sea Level Rise

Values for the 20th century global sea level rise based on tide gauges records published during the 1990s, are in the range 1 to 2 mm/year (Church et al., 2001). The largest contribution of SLR arises from thermal expansion due to warming of the oceans that have mainly occurred since the 1950s.

In the Mediterranean Sea after the mid-1990s, altimetric measurements suggest a rapid rising of sea level in the Eastern Mediterranean Basin in the order of 20 mm/yr (Cazenave et al., 2001). Studies using altimetry data of the Topex/Poseidon satellite available since early 1993 show a continuous sea level rise in the order of 5-10 mm/yr, as shows in Figure 1-4, along the Lebanese coast. Sea level change results from two main causes: volume change due to density changes of sea water in response to temperature and salinity variations, and mass change due to water exchange with the atmosphere and land through precipitation, evaporation and river runoff. If it were to continue in the future, the 5-10 mm/yr rise in the sea level along Lebanon's coast will be 12-25 cm by 2030 and 22-45 cm by 2050.

According to Margat (2004), the predicted sea level rise in the Mediterranean, with a wide margin of uncertainty, is in the order of 45-50 cm between 2004 and 2050.

7 An assumption, whereby the annual average GDP growth rate would grow by double the IMF-projected average annual growth rate of 4.3%, for the period between 2010 and 2014 (IMF, 2009).

8 This an average of the population growth rate in a **high fertility scenario** as projected in the World Population Prospects: The 2008 Revision (UN, 2009).

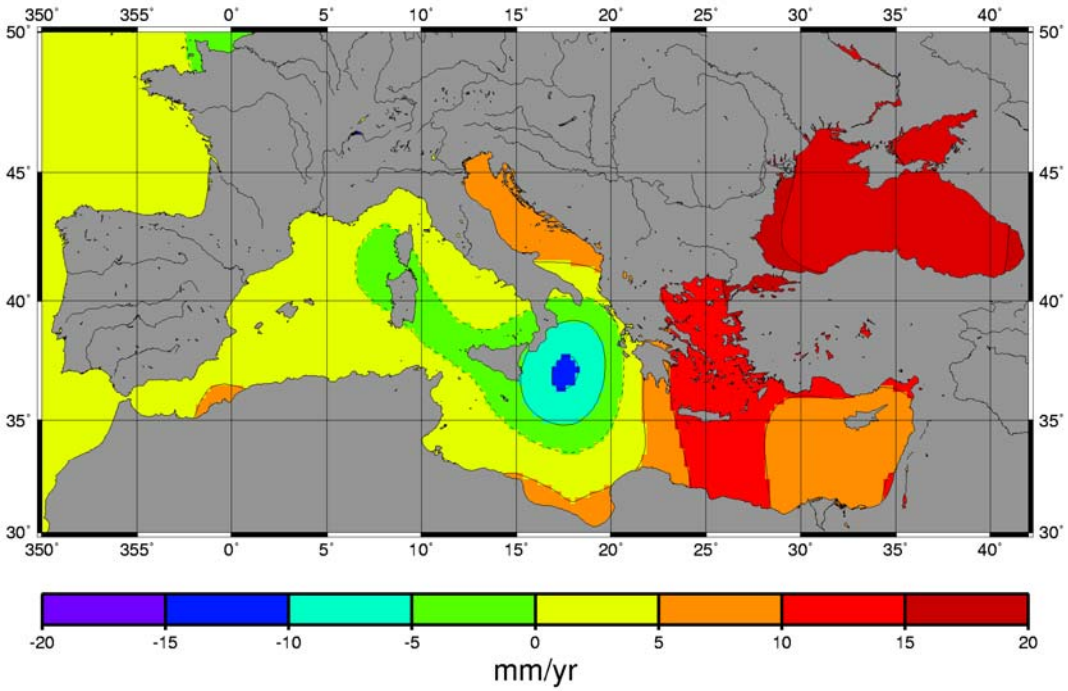

Figure 1-4 Mediterranean Sea level changes as observed during the period between 1993 and 1999

Source: Tourre et al., 2008

Sea Surface Temperature

The observed sea level rise is well correlated with sea surface warming in the period between 1993 and 1999 (Cazenave et al., 2001). Regional temperature increases have been reported in the Mediterranean Sea, where sea surface temperatures (SSTs) across the Mediterranean as a whole, have been rising about twice as much as those of the global oceans.

Mediterranean Sea surface temperatures (SST) are expected to gradually rise due to climate change. Satellite SST data indicate that over the last 11 years a general warming has occurred over the Levantine Basin, across both inter-annual and seasonal intervals (Rhoads et al., 2009). A rise in SST induces a likely increase in the frequency and intensity of storms and hurricanes (Jäger et al., 2008).

1.1.4. Vulnerability Assessment

1.1.4.1. Sensitivity to Climatic Factors

The coastline is sensitive to erosion due to natural factors such as strong storms, and different local, anthropogenic factors which act as pressures on coastal ecosystems. Sensitivity of the coastal zone to climate change-induced phenomena, such as sea level rise, increase in sea storms frequency and intensity, and rise in sea surface temperatures, is higher in low-lying coastal areas which are more exposed to tides and have lower natural defense structures. Resorts and touristic complexes, located mainly on the northern shores, afflict the coastal biodiversity and increase pressure on coastal resources, while the existence of polluting industries along the coast has increased the marine, water and air pollution levels in the coastal zone. Moreover, the improper management of agricultural activities, rural migration to coastal cities and urban sprawl is leading to the disappearance of the coastal agricultural lands which will lead to a reduction in water infiltration in the soil and therefore

pose a greater risk of flooding of the lower coastal plains in the events of heavy rainfall (UoB, undated; CDR, 2005; LDK-ECO, 2006). The natural factors and anthropogenic pressures that prevail in some coastal areas in Lebanon might result in an increased sensitivity of coastal areas and structures to climate change and its associated impacts.

1.1.4.2. Adaptive Capacity

The adaptive capacity of coastal communities is influenced by the concentration of activities and the mix of livelihood resources[9] on the coast. This influence would be negative when public or private structures, such as buildings, roads, and beach resorts, are poorly planned and do not account for possible natural risks and hazards in their design. In the case of climate change, which is a relatively new concern yet to be mainstreamed within the public and private sectors' decision-making frameworks, adaptation in the urban stretches of the coast may be autonomous and linked with financial and technical capacity for adaptation. An example of such autonomous adaptation is the retreat of beach installations in seaside resorts. The adaptive capacity of coastal communities is low when coastal habitats and ecosystems, such as wetlands, which act as natural defense structures or natural capital, are destroyed.

1.1.4.3. Vulnerability Assessment Results

In this assessment, 26 coastal hotspots[10] and sensitive areas were identified to be threatened as a result of the combined effects of concentrated residential, industrial, touristic and infrastructure activities. In fact, housing and infrastructure development as well as recreation are the major anthropogenic pressures with which the Lebanese coast is confronted (Abu-Jawdeh *et al.*, 1999). The sensitivity of coastal ecosystems and adaptive capacity of coastal communities are undermined by the threats afflicting the coastal region, and which are summarized below.

- Urban sprawl and privatization of the coastline

The high demand for coastal lands as a result of their economic attractiveness coupled with poor enforcement of legislation, especially during the civil war period, has led to uncontrolled and illegal development along the coastline. Moreover, the coast is littered with illegal occupation of recreational projects, breakwaters and marinas (land reclamation projects) that prevent public access to the seafront. All these changes are major causes of coastal hydrodynamic modifications, coast degradation, soil erosion and loss of biodiversity (CDR, 2005; MoE, 2005).

- Solid waste disposal

Inefficient solid waste management and illegal dumping practices have transformed the seafront of many coastal locations into dumpsites. Prime examples are the dumpsites at the coastal fronts of Saida, Tyre, Tripoli and Bourj Hammoud in Beirut. Generated solid waste is dumped along the coast or reaches the sea through rivers and streams. Some beaches are littered with garbage aggravating marine pollution. Uncontrolled dumpsites are sources of heavy metals and other priority pollutants that leach into marine waters (MoE, 2005).

- Marine pollution

9 Livelihood resources or assets as outlined in the Sustainable Livelihoods Framework are formed of the human, natural, social, physical and financial capital. The degree of resilience or adaptive capacity of a certain group depends on the mix of 'capital' that is accessible to the group.

10 See Appendix A

Raw sewage generated from residential and industrial areas is directly discharged to the sea or nearby rivers. There are approximately 53 outfalls along the coast, 16 of which are located in the Greater Beirut Area between Dbayeh and Ghadir. Lebanon annually generates an estimated 249 Mm^3 of wastewater (UoB, 2004; MoE, 2001).

Many of the Lebanese industries are located along the coastline (65 percent of industries) and discharge their untreated effluents directly into the sea. As a result, sea water is contaminated with industrial effluents, and domestic wastewater which have increased marine water pollution levels (LDK-ECO, 2006).

- Beach quarrying and sand extraction

Historical sand dredging operations and their aftermath are one of the main problems facing the Lebanese coast. Natural sand dunes have been exploited with an estimate of 1.5 Mm^3 of sand being annually extracted for construction. This has contributed to destabilizing the coastline, while leading to coastal erosion and coastal hydrodynamic modifications (MoE, 2001; MoE, 2005).

- Salt water intrusion

Legal and illegal drilling of groundwater wells across the coastal zone and the excessive, uncontrolled withdrawal of groundwater have led to the lowering of the water table in coastal aquifers. This has ultimately increased the mix between fresh and salt water which raised saline and chloride levels in coastal wells. Seawater intrusion is a direct consequence of water mismanagement and poses a serious threat to the quality of fresh water in coastal areas. It is understood that the salinity levels in wells across Greater Beirut is at least five-fold the accepted scientific threshold for public use (MoE, 2005; Saadeh 2008).

- Coastal setbacks

Coastal setbacks are poorly enforced in Lebanon which has led over the years to maritime violations along the coast. These violations date back to the civil war period and remain unresolved. Their existence bans public access to beaches which are a public domain and of public interest (Doumani, 2009).

Vulnerability of coastal zones to climate change has been defined as "the degree of incapability to cope with the consequences of climate change and accelerated sea-level rise" (Bijlsma *et al.* 1996).

The absence of proper land use planning, high population density along the Lebanese coast, large contribution of coastal economic activities to the national GDP, weak regard of the environment as well as the lack of legislation, weak enforcement capacity and existence of unresolved threats that undermine the natural coastal environment increase the vulnerability of the different coastal units along the Lebanese coast to climatic factors.

The vulnerability to climate change of some coastal hotspots selected below is higher as the exposure to coastal hazards and sensitivity to climatic and climate-related factors such as sea level rise, storm surges, coastal inundation and flooding, and increased rainfall intensity are compounded with a low adaptive capacity (Table 1-4). The vulnerability of the coastal hotspots increases whenever their geoidal elevation is below 2.5 meters[11]; these areas, defined as low-lying areas in the First National Communication (1999), may experience significant changes. The coastal hotspots are discussed hereafter.

11 See Appendix C

Marginalized urban settlements

The Lebanese coastal zone is densely populated where coastal slums exist around major cities such as the coastal slums between Khaldeh and Ouzaï in the southern suburbs of Beirut. Such urban settlements that lack sewage networks and public services are vulnerable to changes in climatic factors due to haphazard urbanization with poor infrastructure and poverty conditions.

Small and medium coastal enterprises

Small beach resorts spread along the coastline[12] as well as small fishing harbors are potentially vulnerable to coastal flooding and inundation due to projected sea level rise combined with likely extreme storm events. Moreover sea level rise threatens the infrastructure on which coastal tourism depends and implies changes in water levels in harbors, with possible implications on the shipping and fishing industries that would require investment in infrastructure improvements and protection against more frequent (or more severe) storms and sea level rise.

Natural Areas: Sandy beaches, gravel beaches and coastal habitats

Beaches are extremely vulnerable to shoreline erosion or the permanent loss of sand and gravel. Severe erosion is a result of high water level and wind-driven waves that can result in storm surges. Sandy beaches cover a length of 49 km and represent 20 percent of the shoreline. Figure 1-5 shows the different type of beaches along the Lebanese coast. In a study on shore erosion between 1963 and 2003, it was noted that sandy beaches were the most eroded with a 45.2 percent of coastal erosion while gravel beaches are less eroded with 24 percent of coastal erosion (Abi Rizk, 2005).

The sandy/soft bottom habitats are particularly vulnerable to environmental degradation due to past sand and gravel dredging practices. Habitats are under stress as a result of gradual deposition of dust from coastal factories such as Chekka factory. Rocky habitats that are closer to the shores, are also vulnerable to pollution from domestic industrial sources; hence the need for protection (ECODIT/IAURIF, 1997). Furthermore, the presence of the five large-scale dumps, namely Normandy, Bourj Hammoud, Tripoli, Tyre and Saida on the coast exacerbates coastal degradation and causes significant pollution of marine waters. Existing pressures on natural areas are bound to decrease the resilience of habitats to potential threats that are projected to be induced by climate change.

Low-lying areas on the coast are more likely to be vulnerable to climate-related changes in sea conditions, namely sea level rise, sea storms, coastal flooding and sea surface temperatures. Table 1-4 presents an assessment of vulnerability of the three systems presented above through an analysis of the potential sensitivity to climate-related factors (see Section on Climate Factors).

Coastal agricultural plains

Agricultural plains in Akkar, Damour, Saida and Tyre are vulnerable to coastal flooding and inundation due to sea level rise combined with extreme storms events. Furthermore, these areas' productivity is threatened by irrigation water that is sourced from groundwater wells given the sea water intrusion into coastal aquifers mainly due to the excessive pumping of groundwater from coastal aquifers for the supply of potable water to the rapidly growing coastal urban areas.

The vulnerability of coastal zones to climate change under both socio-economic scenarios will be moderate to very high depending on the coastal hotspot under consideration (Table 1-4). The vulnerability of the coastal zone to climatic changes under Scenario B would be high due to the high

12 In Tripoli, Chekka, Amchit, Jbeil, Jounieh, Damour, Jiyeh, Saida and Tyre

population growth, low emigration and high urbanization rate that would place a higher pressure on the coast and its resources where major urban and economic poles are located. On the other hand, GDP growth and the balanced economic development could help the population and development authorities implement a variety of measures to increase the coping and adaptive capacity of coastal zones. These measures might be implemented in the case of a high level of environmental and social concern and value. The vulnerability of coastal zones to climate change in both scenarios could be low to moderate if steps to initiate investment in adaptation and internalize future risks from climatic variability are taken.

Table 1-4 Vulnerability of coastal units

	SYSTEM	SENSITIVITY TO CLIMATE CHANGE	ADAPTIVE CAPACITY		VULNERABILITY
LOW LYING AREAS	Marginalized urban settlements	High due to the proximity of developments to the shoreline, high population density and to the existing state of seawater intrusion into coastal aquifers	Scenario A	Moderate	High
			Scenario B	Low	Very high
	Small and medium coastal enterprises	High due to the proximity of installations to the shore	Scenario A	Low	Very high
			Scenario B	High	Moderate
	Natural areas: Sandy beaches, gravel beaches and coastal habitats	Moderate due to the fragmentation of and pressure on natural areas by manmade structures and low altitude. The pressures may be counteracted by resilience and natural adaptation	Scenario A	Moderate	Moderate
			Scenario B	Low	High
	Coastal agricultural plains	High due to expected increase in sea surface temperature and a likely accompanying increase in storms and coastal inundation	Scenario A	Moderate	High
			Scenario B	High	Moderate

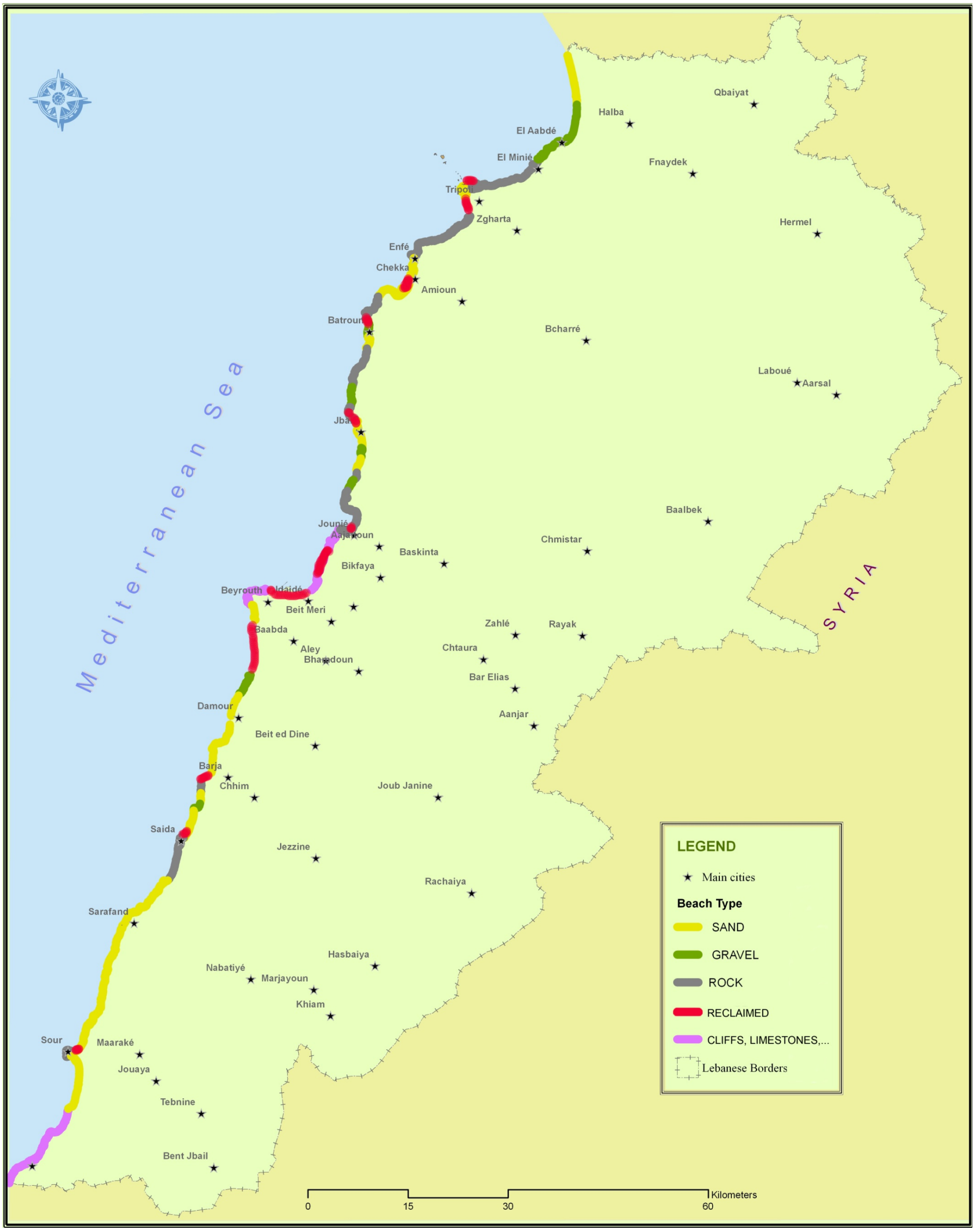

Figure 1-5 Types of beaches along the shoreline

1.1.5. Impact Assessment

Urbanization and rapid growth has lead to the development of numerous coastal urban areas along the Lebanese shoreline during the last decades. Hence, people's exposure to coastal hazards such as storms, high tides and winds has increased with the demand on coastal resources. Climate change enhances and aggravates the long-term bio-geophysical effects such as sea-level rise, shoreline erosion, sediment deficits and saltwater intrusion into coastal aquifers (Sterr et al., 2003).

1.1.5.1. Selected Impact Indicators

The following indicators (Table 1-5) were selected to assess the likely impact of climate change on the identified vulnerable systems under each of the two socio-economic scenarios.

Table 1-5 Indicators for analysis of climate change impacts on vulnerable systems in coastal zones

VULNERABLE HOTSPOTS	INDICATORS	RELEVANCE
Marginalized urban settlements	Salinity of coastal groundwater aquifers	Salinity of groundwater wells in populated zones is related to sea level rise
Small and medium coastal enterprises	Income from coastal economic activities, mainly fishing, agriculture and small tourism enterprises (coastal resorts)	Income from coastal economic activities is negatively affected by changes in sea level rise and sea storms
Natural Areas: Sandy beaches, gravel beaches and coastal habitats	Cost of beach erosion and degradation and loss of coastal habitats	Erosion is usually a natural phenomenon but it is exacerbated with sea level rise which provokes the loss of coastal habitats
Coastal agricultural plains	Growth in yield	Sea-level rise, increased storms and coastal inundation may potentially lead to decreased yields or erratic growth trends

1.1.5.2. Impacts from climatic and non-climatic factors

Less fragmented natural areas have a lower vulnerability because the nature in large undisturbed areas can recover faster than that in smaller areas (Micallef, 2009). The potential impacts of climate change on coastal zone particularly on the vulnerable hotspots are described below.

Coastal flooding and inundation

Coastal plains and shores that suffer from erosion and experience periodic inundation during high sea level conditions (e.g. storms) are the most vulnerable under such conditions. Any increase in the mean sea level, or in the frequency and intensity of episodic events affecting that level, would worsen the present situation. Coastal inundation degrades coastal ecosystem services, limits coastal use and damages infrastructures, which would lead to negative effects particularly in heavily populated areas and agricultural plains (Georgas, 2003, Micallef, 2009).

Sea water intrusion

One of the most serious impacts of sea level rise in Lebanon would be the salinization of coastal aquifers as they are one of the major components of Lebanon's water resources. Groundwater aquifers are utilized as a main source of drinking, service and irrigation water.

The sea water intrusion impact of sea level rise can be exacerbated by increased groundwater withdrawal due to upconing[13] and urbanization. In Lebanese coastal regions, the uncontrolled exploitation of groundwater resources intended for domestic, industrial and agricultural purposes, imbalances the dynamic equilibrium between sea water and the flowing groundwater (El Chami, 2005). The combination of the two occurrences, ground water exploitation and sea level rise compounds the repercussions of sea water intrusion.

Salt water intrusion poses a serious threat to the quality of freshwater, particularly that in some locations seawater has actually intruded several kilometers inland into coastal aquifers. The coastal area of Choueifat-Rmeileh region is one of many districts in Lebanon that are threatened by the penetration of seawater into the aquifers (El Moujabber and Bou Samra, 2002; El Moujabber et al., 2004).

Coastal erosion

An increase in the frequency and intensity of episodic weather events, a sea level rise or an alteration of coastal circulation patterns due to climate change could exacerbate natural coastal erosion. Coastal erosion could lead to a loss of beaches especially in locations where sandy beach stretches are narrow and buildings are close to the shoreline (El-Raey, 2009). Illegal construction that has exceeded the coastline setbacks can contribute to erosion by altering the movement of sediment along the coast; as they block the process of natural migration of sand. As mentioned above according to the study by Abi Rizk (2005), the percentage of coastal erosion between 1963 and 2003 for the rocky, sandy and pebbles beaches are respectively estimated at around 8.2 percent, 45.2 percent and 24.0 percent. Some changes in sediment deposit may be amplified by climate change such as loss of sediments in storm events.

Impact on coastal and marine economic activities

Sea level rise and extreme climatic events would afflict coastal and marine economic activities. Losses in tourism, agriculture, fisheries, transportation and other essential services are expected to occur due to climate change. The main repercussions will be on the fishing sector as marine species might be affected by temperature and have thermal intolerance. Coastal communities relying on ecosystem services, especially those relying on the fishing industry for livelihoods will bear the impacts of increases in sea water temperature as the marine fish catch might decrease and marine biodiversity might change or decline. However, other species might become more abundant such as Sardina, and other thermophilic species due to an increase in water temperature (MoE & UNDP, 1999). Climate change will have adverse impacts on coastal agriculture due to coastal flooding and salt water intrusion into groundwater aquifers. Beaches might lose their attractiveness for a longer period during the summer with the predominance of jellyfish and algal blooms[14] in coastal waters; potentially affecting beach

13 Upconing is a phenomenon where literally a cone of salt water forms beneath the point of buffer layer of fresh water, hence increasing the risk of salt water intrusion.

14 The wide presence of jellyfish and algal bloom will be caused by the combination of higher water temperatures, overfishing and human wastes.

tourism negatively (FAO, 2009). On the other hand, the length of summer season, due to global warming might be profitable for businesses that cater to beach and summer tourism.

1.1.5.3. Summary of Impact Assessment Results

The following steps were used in assessing the likely impacts of future climatic changes on coastal systems:

- Physical and economic indicators that would measure changes in the vulnerable coastal systems were chosen.
- Changes in the indicators under each of the two socio-economic scenarios were examined.
- Changes in the indicators under the climatic scenario were examined.
- The overall change in the indicators was assessed under each of the two socio-economic scenarios and under the likely climatic change scenario, i.e. combining the results from steps 2 and 3.

In general, negative impacts on the vulnerable coastal systems were found where the vulnerability of these systems is high. Table 1-6 identifies the impact of climate change on a specific indicator for every vulnerable hotspot.

Table 1-6 Impact of climate change on specific indicators

VULNERABLE HOTSPOTS	INDICATORS	CHANGES IN INDICATORS UNDER NON-CLIMATIC (BUSINESS-AS-USUAL) SCENARIOS		CHANGE IN CLIMATIC FACTORS	CHANGE IN INDICATORS UNDER THE CLIMATE CHANGE SCENARIO	OVERALL CHANGE IN INDICATORS	
Marginalized urban settlements	Salinity of coastal groundwater aquifers	Scenario A	Slight decrease	Rising sea level increases the salinity of and groundwater through salt water intrusion	High increase	Scenario A	Moderate increase
		Scenario B	High increase			Scenario B	High increase
Small and medium coastal enterprises	Income from coastal economic activities mainly small tourism enterprises (coastal resorts)	Scenario A	Moderate increase	Sea level rise has the potential to exacerbate the damaging effects of coastal storms by increasing the severity of flooding in coastal communities	Slight decrease	Scenario A	Slight decrease
		Scenario B	High increase			Scenario B	Moderate increase
Natural Areas: Sandy beaches, gravel beaches, and coastal habitats	Cost of beach erosion and degradation and loss of coastal habitats	Scenario A	Slight increase	Sea level rise combined with wind-driven waves cause shoreline erosion and habitats destructions	High increase	Scenario A	High increase
		Scenario B	High increase			Scenario B	Very high increase
Coastal agricultural plains	Growth in yield	Scenario A	Slight decrease	Sea-level rise, increased storms, coastal inundation and increased potential for more salt water intrusion may potentially lead to decreased yields or erratic growth trends	High decrease	Scenario A	Moderate decrease
		Scenario B	Moderate increase			Scenario B	Low decrease

1.2. ADAPTATION MEASURES

The purpose of coastal zone adaptation is to reduce the net cost of climate change impacts which are outlined in the Impact Assessment section, whether those costs apply to an economic sector, an ecosystem, or a country. The vulnerability of the coastal zones is not only determined by the degree of climate change but also by the current social, economic and environmental conditions as well as existing management practices. Adaptation strategies in coastal zones vary from abandoning the coasts to their natural evolution to adopting proactive measures to manage and react to the main impacts to be induced by climate change. Climate change is but one of many interacting stresses in Lebanon's coastal zones.

Three generic options (Figure 1-6) should be adopted as a response to sea level rise in order to protect human installations along the coast and to conserve coastal ecosystems (Parry et al., 2009). The choice of the suitable option depends on the site characteristics: pattern of relative sea level change, geomorphologic setting, sediment availability and erosions as well as social, economic and political factors. An overarching adaptation and management option to relieve pressures on the coastal zones can be the adoption of integrated coastal zone management (ICZM) which is discussed towards the end of this section.

1.2.1. Planned retreat adaptation measures

They consist of pulling back human activities from the coast through land use planning and development control. As a result, the impacts of sea level rise are allowed to occur with minimum impacts on human installations. Under this option, the following actions could be adopted:

- Including in land use plans a sufficiently wide buffer zone where no development near the shoreline is allowed. The construction should be restricted on a minimum width of 100 meters of the shore band (Ozhan, 2002). Requiring coastal development setbacks from beaches allow in an effective way shoreline migration. The shoreline migration will occur without narrowing the beach width or exposing structures to the risk of damages
- Creating a network of coastal marine reserves through the rehabilitation and preservation of more than 30 remarkable sites[15] (sandy beaches, a certain number of rocks and cliffs, fresh water springs, bays, etc.) along the coastal front. This measure will strengthen the ability of coastal habitats and species to adapt on their own.

1.2.2. Accommodation adaptation measures

Accommodation adaptation measures are reactive measures that consist of minimizing human impacts by adjusting human use of the coastal zone to the hazard through the following actions:

- Reducing or moving sources of occasional pollution (urban and industrial pollution) and diffuse pollution (agriculture) to restore environmental balance, natural resilience and adaptability.
- Introducing effective Early Warning Systems along the coast for coastal hazards such as storm surges and coastal inundations.

1.2.3. Protection adaptation measures

Protection adaptation measures are proactive measures that consist of developing a defense strategy to control sea level rise through soft or hard engineering.

15 See Appendix B

- Hard engineering techniques refer to the coastal structures such as sea walls, dykes, and embankments in order to protect the coast from more frequent high water and sea storms. However, a major downside to hard defence structures is that they do not stop beach erosion as they transfer this problem to another part of the coast. Moreover, they are generally found unattractive and are known to contribute negatively to coastal water quality. They are usually adopted on active economic environments that cannot be moved as well as on highly urbanized areas to protect expensive properties or infrastructures.
- Soft engineering techniques are adopted to restore the natural dynamism of the shoreline and include beach nourishment and sand dune stabilization. Beach nourishment consists of feeding a beach periodically with material brought from elsewhere to remedy erosion and increase beach area and sand dune stabilization involves the planting of vegetation such as beachgrass that retains sand and creates natural habitats for animals and plants. (Parry et al., 2009; Ozhan, 2002).

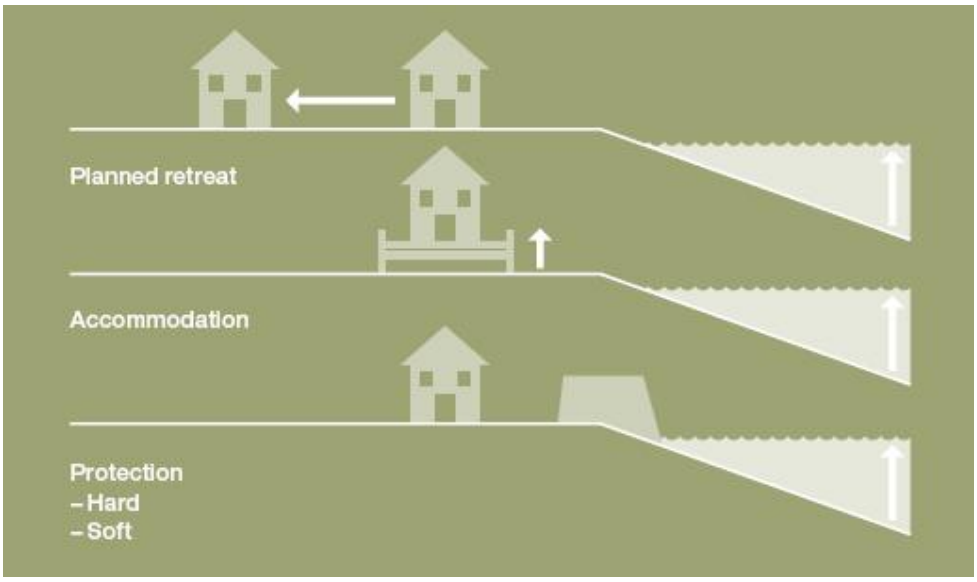

Figure 1-6 Illustration of the possible adaptation responses to sea-level rise

Source: Parry et al., 2009

1.2.4. ICZM coping with climate change

Lebanon would need to ratify and implement the Integrated Coastal Zone Management (ICZM) Protocol to adopt it as a tool of adaptation of coastal zones. Most of the suggested adaptation measures for coastal zone and the ICZM share the same general sustainable development objectives like preserving coastal zones, ensuring the preservation and integrity of coastal ecosystems and preventing and reducing the effects of natural hazards, in particular those associated with climate change (ICZM Protocol, Article 5). The objectives of ICZM play an important role in the field of adaptation and help combat the impacts of climate change. Moreover, the Protocol encourages institutional coordination (ICZM Protocol, Articles 7 and 32) and the participation of stakeholders in decision making processes (ICZM Protocol, Article 14). Hence, it will strengthen the coherence and effectiveness of the established coastal strategies, plans and programs. The Protocol also encourages its parties to develop and promote scientific and technical research on integrated coastal zone management (ICZM Protocol Articles 25 and 26), so that scientists can help assess coastal regions'

vulnerability to climate changes and guide decision-makers towards suitable solutions to land-use issues (French Ministry for Ecology, Energy, Sustainable Development and Spatial Planning, 2008; Protocol on ICZM in the Mediterranean, 2008).

Table 1-7 shows the proposed adaptation strategy and activities that correspond to some vulnerable hotspots and some potential climate change impacts along with the responsibilities of different actors, priority of the adaptation measure, an indication of the budget needed for implementation and potential sources of financing. It is worth noting that not all of the potential impacts discussed in Section 1.1.5 are assigned potential adaptation measures, due to the fact that some impacts lack feasible adaptation measures.

Table 1-7 Adaptation Action Plan for the Coastal Zones Sector

IMPACT	PROPOSED ADAPTATION STRATEGY	ACTIVITIES	RESPONSIBILITY	PRIORITY (ST/ MT/ LT)	INDICATIVE BUDGET (USD)	SOURCES OF FINANCING/ IMPLEMENTATION PARTNERS
Increase in the salinity of coastal groundwater wells	Increase the resilience of groundwater to climate change in coastal areas	- Assess feasibility of artificial groundwater recharge in major coastal areas - Strengthen the enforcement of wells' permitting and monitoring in coastal areas - Develop awareness programs to reduce water consumption in vulnerable areas - Strengthen the capacity of water and wastewater establishments to monitor groundwater abstraction - Develop a comprehensive database of groundwater wells	MoEW Water and Wastewater establishments Municipalities	ST	$ US 1 to 5 million	MoEW budget International donors
Decrease in the income from coastal economic activities, mainly fishing, agriculture and small tourism enterprises (coastal resorts) due to flooding and inundation	Increase the protective capacity of vulnerable coastal areas	- Identify/confirm vulnerable economic activities along the coast - Design soft and hard measures to protect vulnerable areas	MoPW&T MoE	LT	$ US 100,000 – 500,000 per site	MoPW&T budget Municipal budgets Private sector
	Increase resilience of small holders to be able to adapt to climate change impacts	- Improve access to information by developing a database for national indicators and establishing monitoring systems for coastal zone indicators, such as sea water temperature, sea water level, monitoring of high tidal waves and frequency and intensity of storm surges. - Introduce an effective early warning systems along the coast for coastal hazards such as storm surges and coastal inundations - Develop of financing mechanisms to support small holders	MoE CDR CNRS NCMS Academic institutions (Balamand-Institute of Environment, AUB, USJ)	MT	USD 1,000,000	UN-ESCWA International donors Academic agencies (technical assistance)
	Establish an institutional mechanism to follow up on coastal zone impacts from climate change	- Initiate dialogue between MoWT, MoE, MoA, syndicate of fishermen, municipalities... - Set up task force committee to coordinate adaptation efforts	MoWPT MoE MoA Private sector Local authorities	Short Term	USD 100,00	Private sector International donors
Increase in the cost of beach erosion and degradation and loss of coastal habitats	Increase resilience of natural/historical coastal areas to climate change impacts	- Enforce coastal land use plan defined by CDR in the NPMPLT to ensure a sufficient buffer zone - Develop a management plan for key natural/historical sites taking into consideration climate change impacts - Develop a network of coastal protected assets areas based on the 30 remarkable sites defined by CDR - Set up an institutional mechanism to protect these assets	MoPW&T CDR MoE DGA Local authorities	MT-LT	USD 100,000 per site	Government budget Municipal budgets International donors

1.3. RECOMMENDATIONS FOR FURTHER WORK

In this assessment, many questions were insufficiently covered due to the lack in data or to the limited access and uncertainties. More detailed data were required for a better identification of coastal zones sensitivity and vulnerability as well as for a better understanding of climate change impacts on coastal zones. As a result, the following recommendations are suggested in order to improve the vulnerability assessment and to render it more accurate:

- Improve coordination between the different government authorities and research centers to adopt similar official figures and numbers.
- Improve access to data and information relevant to coastal zones such as sea water temperature, salinity, wave height and wind. This could be done through creating and maintaining an online portal to resources: website and data sharing.
- Ensure accurate and consistent methods of collecting and measuring data such as the sea level rise, fish catch…
- Develop and update a list of extreme events record where coastal conditions are also captured immediately after major storm events.
- Develop software using a standardized GIS methodology to map and model climate change and sea level rise data related to coastal hazards.

APPENDIX A

SENSITIVE AREA/HOTSPOT	STATUS*	RATIONALE
1. Akkar beach and dunes	B	Beach degradation and erosion
2. Akkar agricultural plain	A	Potential loss of agricultural area due to urbanisation and establishment of a free trade zone
3. Coastal stretch from the IPC refinery (Beddawi) to El-Mina port	C	Site of future wastewater plant. Possible site of future solid waste landfill on land reclaimed from the sea. Calls for re-classifying existing coastal tourism zone as an industrial zone
4. Ras en Natour & Enfeh	B	Characteristic landscape (Salinas, historic port) threatened by mass-scale tourism development
5. Ras el Chaquaa, with Chekka and Selaata industries (from Chekka to Batroun)	A	Outstanding natural beauty and biotope of rich biodiversity, threatened by industrial growth and quarries (Chekka and Selaata). De-classified stretch of coast (previously industrial) offers opportunity for sound management
6. Nahr el-Jawz valley and Msaylha fortress	A/B	Cultural, archaeological and natural landscape requiring protection. Visual impacts of illegal quarry behind Msaylha fortress.
7. Batroun marine reserve	B	Declared reserve is ill-defined with no management or conservation plan
8. Amsheet-Jbail coastal area	A	Tourism development pressures could hinder public access to the beach and spoil landscape. Rocky mountain (with garrigues) and green area could serve as urbanisation buffer zone
9. Nahr Ibrahim valley	B	Unique ecology and legendary landscape devastated by quarrying and currently still threatened by industry and urbanisation
10. Jounieh City and surrounding mountains	C	Characteristic landscape and quality of life degraded by uncontrolled urban growth
11. Nahr el-Kalb valley and river mouth	B	Geology, paleontology, biodiversity and history of this unique site are threatened by infrastructure (highway and power plants) and rampant urbanisation. Jeita spring source threatened by increased pollution
12. North Metn	C	Beaches either lost or privatised. Opportunity for planned urban development of reclaimed land. High environmental impacts of supplying required aggregates and sand
13. Beirut, with Pigeon Rock	C	Several hotspots (port, Normandy landfill) and sensitive areas
14. Airport and ELISSAR	C	Beaches either lost (if land reclamation options selected) or privatised. Delicate relocation of industries and people

SENSITIVE AREA/HOTSPOT	STATUS*	RATIONALE
15. Damour plain	B	Agricultural plain/green space threatened by tourism development pressures
16. Nahr Hammam valley	A	Pristine valley with interesting ecological habitat needing legal protection
17. Saida coastal area	C	Northern beaches threatened by urbanisation and tourism development pressures. Coastal highway project would separate old city from fishing port and Sea Castle. Environmental and socio-economic impacts of SIDON port. The Saida coastal dumpsite remains a threat to the local marine environment, surrounding human settlements and tourism infrastructure
18. Rmeileh beach	A	Sandy coast to be protected
19. Zahrani area	C	Old refinery site and industrial area requiring rehabilitation
20. Litani seashore and valley & Qasmieh plain	A	Ecological and economic importance of river warrants special protection. Sandy coast and scenic valley to be protected. Agricultural plain threatened by ribbon urbanisation along new highway
21. Mhaylib coastal area	B	Publicly-owned beach reserve, currently partially occupied by illegal housing
22. Tyre to Rashidieh camp	B	Unique historic and cultural sites. Access to the sandy beach north and south beach threatened by tourism development projects
23. Rashidieh to Ras el-Ain	A	Competing interests of conservation, agriculture and tourism require an integrated planning and management approach
24. Iskandarouna beach	A	Sandy coast to be protected
25. Ras en-Naqoura	A	Distinctive landscape and ecological importance threatened by rushed development in the event of regional peace. Opportunity to reroute inland the southern stretch of coastal expressway before expropriation and building activities take place

A – Preserved but threatened areas, requiring protection

B – Areas currently being degraded, requiring protection

C – Degraded areas, requiring rehabilitation

Source: ECODIT/IAURIF, 1997

APPENDIX B

The National Physical Master Plan for the Lebanese Territories (CDR, 2005) recommends the preservation of a group of coastal sites from all changes according to their natural configuration (coastalline characteristics, etc.). These sites and zones are:

- Coastal dunes (Akkar Plain)
- Salinas and Wetlands (Qlayaate, Enfeh)
- Seashore cornice and fishing harbour (Al-Mina)
- Beaches (Qalamoun, Kfaraabida, south and north of Jbeil, Ramlet el Baida, Jnah, Damour, Rmeileh and Jiyeh, north and south of Saida, south of Tyre)
- Archaeological sites (Jbeil and Saida)
- Fishing harbours (Batroun, Jbeil, Tyre)
- Promontories and cliffs (Ras el Chaqaa, Maameltein, north of Saida, Bayada-Naqoura)
- Bays, caps (Jounieh, Pigeon Rock-Beirut, Ras es Sadyat, Tyre, Naqoura)
- Mhayleeb Scientific Reserve, Ras el-Ain springs, and Palm Islands.

APPENDIX C

CHARACTER STATION	LONGITUDE	LATITUDE	GEOIDAL ELEVATION (M)[16]	PHYSIOGRAPHY
Near El Kabir River	34 33 32	35 59 32	2.35	level plain
Beddawi	34 31 10	35 58 45	5.73	level plain
El Mina (port)	34 27 07	35 58 45	4.34	level plain
Bahsas	34 26 38	35 49 21	4.37	level plain
Chekka	34 18 34	35 41 51	1.30	ridged hills
El Madfoun River	34 11 05	35 38 02	3.80	rolling gentle hills
Jounieh (Casino)	33 49 31	35 38 04	2.78	rolling gentle hills
Jounieh (Kaslik)	33 57 22	35 35 56	2.49	level plain
Near El Kalb River	33 54 57	33 34 56	1.5	rolling gentle hills
Beirut Port	33 54 44	35 34 51	1.8	level plain
St. Georges Bay	33 53 55	35 29 56	1.00	level plain
Al Ramleh El Baida	33 54 07	35 29 09	0.45	level plain
Beirut Airport	33 48 50	35 28 57	5.4	level plain
Beirut Airport	33 47 40	35 28 45	.42	level plain
Near Damour River	33 35 41	26 54 12	1.19	ridged hills
Electric Plant of Jiyeh	33 35 38	24 15 02	1.9	rolling gentle hills
Near Siniq river	33 35 32	21 16 43	0.11	level plain
Sarafand	33 35 28	18 03 10	2.22	rolling gentle hills
Near Kasmieh River	33 33 21	15 09 21	0.17	level plain
Al Bourghliya	33 33 18	14 55 01	1.4	level plain
Tyre Coast (south)	33 35 15	12 39 30	2.3	level plain
Mansoura	33 35 10	11 54 42	4.43	level plain

Risk potential categories geoidal elevation (m):

- Very critical < 1.5
- Critical 1.5 < x <2.5
- Less critical > 2.5

Sources: Ministry of Environment (MoE) & UNDP, 1999

16 Risk Potential Categories geoidal elevation (m): Very critical <1.5; critical 1.5< x < 2.5; Less critical >2.5.

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