CLIMATE CHANGE VULNERABILITY AND ADAPTATION

HUMAN SETTLEMENTS AND INFRASTRUCTURE

Lebanon's Second National Communication
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1. VULNERABILITY AND ADAPTATION OF HUMAN SETTLEMENTS AND INFRASTRUCTURE

1.1. VULNERABILITY ASSESSMENT

1.1.1. Background

Human Settlements

Lebanon's resident population is estimated to be around 4.29 million people[1] for the year 2004 (CDR, 2005). Lebanon is classified as a highly urbanized country with more than 85 percent of its residents living in urban areas, while sustainable urbanization remains a key national development challenge (UN, 2008a).

The population in Lebanon is unevenly distributed among regions where one third of the population resides in the Greater Beirut Area (GBA), and only 12.5 percent of the population resides in the governorate of Bekaa, which is the largest administrative region by surface area (Figure 1-1). The country has one of the highest population densities in the world ranking 11th with 391 persons/km^2, higher than Japan's population density (336 persons/km^2) (MoE, 2005). The population density in the city of Beirut is 21,938 persons/km^2, the highest density among all governorates (MoE, 2005; CAS, 2004).

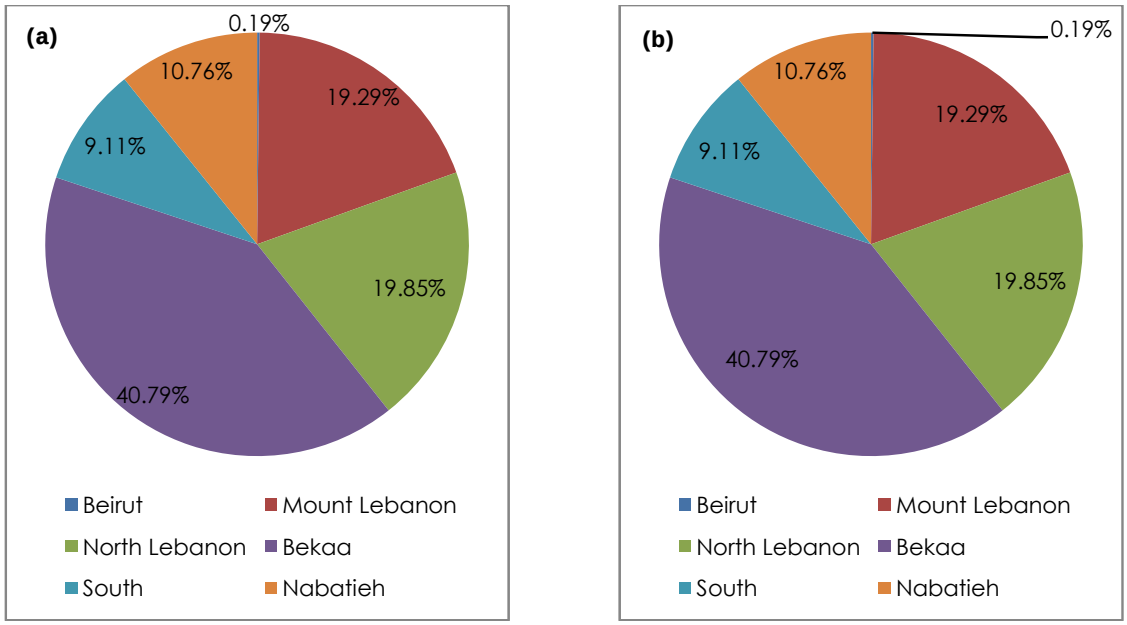

Figure 1-1 (a) Share of the total area by governorate (MoE, 2001) (b) Percent distribution of individuals per governorate (CAS, 2004)

Wastewater Infrastructure

Lebanon generates an annual average of 250 million m^3 of domestic wastewater (0.68 million m^3 per day) (UoB et al., 2004). Most towns and villages lack public wastewater drainage and infrastructure. The mostly commonly used wastewater disposal methods at the household level are traditional concrete-lined sanitary pits and unlined boreholes that are dug into the bedrock. The second method poses a high risk of groundwater aquifer contamination with wastewater through seepage (LDK-ECO,

1 This estimate was obtained through applying an annual growth rate of 1 percent to the population record of 1997 of 4 million (CDR, 2005).

2006; UoB et al., 2004). Less than 68 percent of dwellings have access to public sewage networks. Beirut has the highest rate of connection the public sewage network while Nabatieh has the lowest rate (Table 1-1) (CAS, 2004).

Table 1-1 Percentage of housing connected to the sewage network

GOVERNORATE	PERCENTAGE
Beirut	99.1
Mount Lebanon	74.9
North Lebanon	61.1
South Lebanon	65.7
Nabatieh	17.9
Bekaa	45.7
Average	**67.4**

Source: CAS, 2004

Since 2000, CDR has started the planning and installation of more than 30 wastewater treatment plants in the different Lebanese regions. Wastewater treatment plants are now at various stages of execution: under construction/ under preparation/ secure funding. These are expected to solve the untreated wastewater problem and to improve the quality of surface water, sea water and groundwater (CDR, 2009).

The Ghadir wastewater treatment plant, located south of Beirut, remains the only fully operational wastewater treatment plant in Lebanon since 1997. It covers the southern region of Beirut and its suburbs serving an estimated population of 784,000. It provides preliminary and primary treatment after which the effluent is piped offshore and released into the Mediterranean Sea (LDK-ECO, 2006; UoB et al., 2004).

Solid Waste Infrastructure

As per the estimates provided for the GHG inventory, Lebanon annually generates an estimated average of 1.56 million tonnes of municipal solid waste (Ref: GHG inventory section). A daily average of 0.75 to 1.1 kg per capita is generated in urban areas, while the daily average in rural areas stands at 0.5 to 0.7 kg per capita. The annual growth in MSW generation is estimated at 6.5 percent (METAP, 2004).

Municipal solid waste management practices vary in the different regions in Lebanon. Illegal dumping and open burning of MSW are common where most towns or cities operate open dumps within their jurisdictions. Table 1-2 below shows the different management systems of MSW by region. Proper MSW management systems are operational in the GBA, in Zahle and to some extent in Tripoli (MoE, 2005).

In the GBA, the MSW management services of street sweeping, collection, sorting, treatment and disposal are contracted out to the private sector. The GBA generates 12 percent of the total MSW stream in Lebanon, of which only 15 percent are composted and five percent are recycled (LDK-ECO, 2006). The remaining MSW of GBA is disposed of by landfilling in the Bsalim landfill, for bulky waste, or in the Naameh landfill, for inert material. The landfilling of 80 percent of the MSW generated in the GBA is dramatically reducing the projected lifetime of the sanitary landfill in Naameh. The Zahle and Tripoli municipalities also benefit from relatively advanced solid waste management systems (MoE, 2005; LDK-ECO, 2006).

Outside the GBA, the MSW management is the responsibility of municipalities that collect waste and transport them to open dumps where they are burnt in open air as a means of disposal. The illegal

dumping and uncontrolled burning of MSW endangers flora and fauna and their habitats, deteriorates local air quality and creates a nuisance thereby decreasing the quality of life in neighboring areas (NEAP, 2005). Recycling rates of MSW are generally low. In 2004, 77 percent of the total MSW generated in Lebanon was landfilled, and only 7.67 percent was recycled (CAS, 2007).

Table 1-2 Summary of MSW management systems in Lebanon by region

GOVERNORATES	MSW MANAGEMENT SYSTEM
North Lebanon	Open dumping and burning, except in five municipalities of Greater Tripoli
Akkar	Open dumping and burning
Mount Lebanon	Covered under the Greater Beirut Area contract except for: the entire District of Jbeil and parts of Aley, Kesrouan, Baabda and Metn
Beirut	Entirely covered under the GBA contract
South Lebanon	Open dumping and burning
Nabatieh	Open dumping and burning
Baalbek-Hermel	Open dumping and burning
Bekaa	Open dumping and burning except for 15 municipalities in the District (Caza) of Zahle which dispose of their MSW in the Zahle landfill

Source: MoE, 2005

Transport Infrastructure

The transport systems in Lebanon include land transport (mainly road transport), marine transport (sea ports of Beirut, Tripoli, Sidon and Tyre) and air transport subsystems (Beirut Rafic Hariri International Airport).

The Lebanese road network consisted of 22,000 km of roads in 2001 out of which only 6,380 km (about 30 percent) were classified[2] as paved roads while the remaining 70 percent (about 15,400 km) were un-classified roads which are governed by municipalities (MoE, 2005). The road network suffers from inadequate maintenance, low traffic capacity leading to slow traffic flows and congestion, and poor road safety conditions. The conditions of the Lebanese road network are shown in Figure 1-2 which displays the results of the visual inventory study carried out by the Ministry of Public Works and Transport (MoPW&T) in coordination with the Council for Development and Reconstruction (CDR) (MoE, 2005).

2 Classified roads are subdivided into the following four categories: international, primary, secondary and local roads. Classified roads fall under the authority of the MoPW&T.

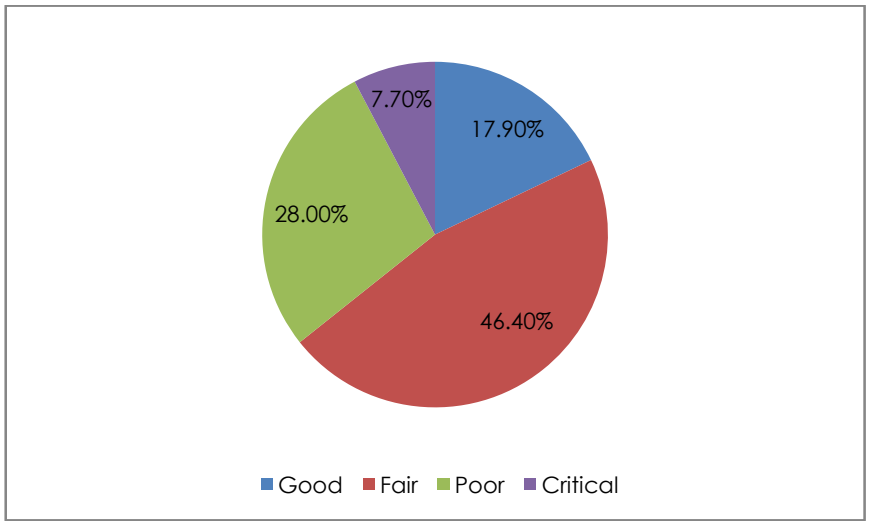

Figure 1-2 Lebanese road conditions

Source: MoE, 2005

The land transport fleet in Lebanon consists of more than one million registered vehicles. The lack of an efficient, reliable and wide public transport system has necessitated a reliance and eventual dependence on the personal car as the main means of transport within the country. The rate of car ownership of 3 persons for every car is amongst the highest in the world (UN, 2002). The total number of vehicles in 2003 was estimated at around 1,081,477 vehicles. In fact, 52.5 percent of Lebanese households own at least one car, while 47.5 percent do not possess personal cars (MoE, 2005; CAS, 2004).

Beirut-Rafic Hariri International Airport (B-RHIA) is the main passenger and goods airport in Lebanon. It consists of two runways, one extending two kilometers into the sea, related taxiways and aircraft stands. Levels of traffic through B-RHIA were around 3.2 million passengers and 60,000 tonnes of cargo in 2004 (CDR, 2006).

Beirut Port is the main port in Lebanon. Traffic through the port largely consists of goods, while it receives moderate passenger flows reaching 50,000 passengers in 2004. In addition to the four main commercial ports of Beirut, Tripoli, Sidon (Saida) and Tyre (Sour), there are a number of small ports along the Lebanese coastline primarily used for fishing and leisure purposes, such as Jounieh and Batroun (CDR, 2006).

1.1.2. Methodology

1.1.2.1. Scope of Assessment

Unit of Study

This study considers four categories of infrastructure: human settlements, wastewater, solid waste and transportation. The assessment examines the vulnerability of settlements and public infrastructure to likely changes in climatic and climate-related factors and establishes the categories of infrastructure most at risk. It then examines the likely impacts from climatic changes on the studied human settlements and infrastructure.

Spatial Frame

The study area spans the whole country. It focuses on:

- Coastal areas that are vulnerable to sea inundation and harbor major infrastructure and investments,
- Mountainous areas that are vulnerable to landslides, rockslides and mudslides, and
- Urban agglomerations that are prone to flooding or are sensitive to extreme climatic events.

Temporal Frame

Climatic impacts on the infrastructure and human settlements could be felt throughout the year especially during the winter season which brings a high risk of floods and inundation due to the intensity of rainfall and storm surges, and extreme cold events. Otherwise, an increased frequency and intensity of sand storms and hot summer days, during the spring and summer seasons, are expected to generate impacts that are worthy of further investigation.

1.1.2.2. Climate factors

Climatic factors of relevance to the assessment of vulnerability of the infrastructure and settlements to climate change include:

Precipitation: Increased rainfall intensity threatens to inflict damage on houses, roads, irrigation systems and other construction due to flooding, mudslides and rockslides, especially in mountainous areas, areas with poor infrastructure, and areas with natural risk such as fault zones. This will increase the risk of isolation of human settlements especially if it was accompanied with broken telecommunications and traffic connections.

Temperature: Higher temperatures and extended heat waves can result in a more rapid degradation of asphalt and materials of roads, bridges and buildings.

Sea-level rise: It is important to assess the vulnerability of human settlements and infrastructure vis-à-vis the risk of coastal inundation from a possible rise in sea level and increase in storm surges. The concentrated presence of vital infrastructure (airport, ports and highways) and large urban settlements on the coast necessitates the study of this indirect climatic factor.

Frequency and intensity of storms: Study of this factor allows the examination of risk to coastal infrastructures as well as on the airport operations and ports.

1.1.2.3. Methods of Assessment

This assessment was conducted based on:

- Developing two baseline socio-economic scenarios that show and characterize the current and the possible 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 possibly change.
- Identifying vulnerable hotspots to climate change based on their social and biophysical exposure, their 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)
- Central Administration for Statistics (CAS) reports:
  - Living conditions of households, (2004)
  - Statistical Yearbook, (2007)
- Other sources include: United Nations Human Settlements Program, United Nations Development Program, United Nations (Johannesburg Summit), Plan Bleu, Mediterranean Environmental Technical Assistance Program (METAP) and Arab Forum for Environment and Development (AFED).

In this chapter the major data limitation and gaps were:

- The contradiction in figures between the different government publications such as the population, urban density, ways of solid waste dumping, solid waste and wastewater generation rate, etc. Usually when governmental data was available they were given priority over scientific studies. In cases where contradictions still existed, experts' judgments were considered in order to select the value to be used in the analysis.
- The lack of important data and values such as the population density in river catchments and vulnerable zones, as well as distribution of slums and squatter settlements all across the country.

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 to implementation by 2030. However, the analysis does not 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 (2009), and population growth prospects as projected by the UN Population Division (2009).

1.1.3. Scenarios

1.1.3.1. Socio-economic Scenarios

The war that Lebanon witnessed over 15 years between 1975 and 1990, the state of poor to non-existent law enforcement in that period, and the rapid boom in reconstruction during the 1990s have led to the near-disappearance of the coastal land in certain areas, the deterioration of physical and environmental conditions in and around urban settlements, the recession of agricultural lands, the destruction of natural and archaeological sites and an urban sprawl that proceeded without adequate provision of roads and service infrastructures (UN, 2008a).

In 1976, in order to meet the needs resulting from the devastating war, the High Relief Commission was established by a ministerial decision (No. 35, issued on the 17th of December) as the only official body approved for relief work in Lebanon. HRC's role is relief work in the various sectors as it focuses its efforts on the recovery phase after any kind of disaster.

Human Settlements

Assessing the future vulnerability of human settlements to climate change needs to account for the envisaged plans for urban development under the National Physical Master Plan for the Lebanese Territories (NPMPLT) which might or might not circumvent or assist in the adaptation to the probable impacts from climate change. In this assessment, it is assumed that the decreed NPMPLT and future changes to occur to urban development under its umbrella are part of the future baseline scenario without climate change.

The recently-decreed NPMPLT, which was prepared by the CDR, has recommended different approaches to reduce the risk from natural hazards. The timeline of the NPMPLT extends to the year 2030. One of the major approaches envisioned is to ensure a distinguished urban development respecting the characteristics of each region. This approach could be realized through the following points (CDR, 2005):

- Determining the preferential uses of different parts of the territory that would be divided into three categories: urban regions mixed with rural regions, agricultural domain of national interest and natural sites of national interest.
- Promoting urban quality through building around 400,000 new dwellings and destroying 50,000 old ones as well as constructing hundreds of kilometers of new roads, streets, avenues, boulevards and expressways. The substantial improvement of urban quality will also include the protection and conservation of built-up heritage and the development of mountain cornices to build viewpoints over admirable landscapes.
- Organizing urban development in large agglomerations through the elaboration of local land use plans in urban areas.
- Introducing measures for limiting scattered construction, controlling linear developments along roads and providing inter-urban connections.

The CDR also developed different measures to implement the NPMPLT for urban planning. In summary, these measures consist of the following:

- Launching legislative and legal reforms that define the principles of land use.
- Launching a series of strategic urban planning operations.
- Elaboration of several local urban plans with precedence to the zones threatened by urban linear expansion and agricultural lands jeopardized by haphazard encroachment of urban structures.
- Creation of an urban development agency with the duty to carry out missions for the Government and municipalities in different fields. The activity of this agency would first be aimed at the management of extension zones of the agglomerations (CDR, 2005).

Wastewater Infrastructure

Different ministries and public institutions are involved in the management of the wastewater sector namely the Ministry of Energy and Water (MoEW), Council for Development and Reconstruction (CDR), Regional Water Establishments (RWEs) and municipalities (LDK-ECO, 2006; UoB et al., 2004).

The ultimate objective of the CDR is to attain a total coverage of the entire territory, whether by sewage systems or by individual solutions. The priorities are directed towards the regions where wastewater threatens groundwater resources and to urban zones where vulnerability of water resources is high. Wastewater treatment services provision is viewed as a top priority action undertaken to preserve public health through the protection of water resources. The efforts are also concentrated on the rehabilitation of existing sewage networks where necessary and the construction of new collectors and transmission pipelines (CDR, 2005).

Solid Waste Infrastructure

Several public institutions are involved in MSW management namely, the Ministry of Environment (MoE), Ministry of Interior and Municipalities (MoIM) and the Council of Development and Reconstruction (CDR). MoE is responsible for establishing and monitoring standards and for developing a solid waste management strategy. MoIM has the responsibility to implement MSW management operation in the different municipalities while the role of CDR is to implement emergency solid waste management projects. The inadequate management of the sector is mainly attributed to the unclear distribution of responsibilities among the different stakeholders (MoE, 2005; LDK-ECO, 2006).

The CDR 5-year plan proposes the construction of controlled dumpsites in different districts as well as transfer stations and treatment plants where it is needed. It includes the rehabilitation of uncontrolled dump sites in the major cities as in Tripoli, Sidon, Baalbek and Tyre. CDR aims on the short term to remedy the critical situation of the large agglomerations while for the medium and long terms the CDR intends to establish and implement a complete sorting, recycling and treatment plan (CDR, 2005).

Transport Infrastructure

Different institutions are responsible for road construction and maintenance particularly the Ministry of Public Works and Transport (MoPW&T), the CDR, the municipalities and other ministries such as the Ministry of Interior and Municipalities (MoE, 2005).

The absence of a sufficient policy, regulatory and competitive framework weakens the transport sector's ability to serve growing demands for the various economic services. Growth of the transport sector has not matched demographic growth and the rapid urbanization that Lebanon witnessed in the past two decades and after the civil war (CDR, 2005).

In 2005, the NPMPLT adopted a plan for the transportation network. It was conceived to meet two main objectives: 1) unification of the territory by shortening the distances between cities and regions and 2) contribution to the national socio-economic development. The transportation network plan proposed by the NPMPLT consists of (CDR, 2005):

- Offering better international transport services through rehabilitation of secondary airports and improvement of the quality of the ports' services.
- Securing strong transport links and infrastructure between cities, towns and villages to reduce the travel time and distance. This objective will require a network of inter-urban connections presented in the following main steps:
    - Connect Beirut with the other major cities of Tripoli on the northern coast, Zahle in the inland region of Bekaa and Tyre on the southern coast through highways.
    - Establish new highway connections and high speed roads between main cities in the Bekaa, in North Lebanon and in South Lebanon to complete the main network.

- Maintain and improve the high speed roads towards certain localities of the Central Urban Area[3].
- Rehabilitate and maintain, on a regular basis, the connections between the different cities and localities in every district.

- Establishing an integrated transport system for the entire Central Urban Area through widening and improving major roads as well as increasing the transport capacities of other roads to resolve the critical situation of the large axes at the entrances of the GBA.

The NPMPLT report has defined different challenges that Lebanon is facing today and might face in the future. According to those challenges, two possible scenarios were proposed for the development of the human settlements and public infrastructure - wastewater, solid waste and transport) - by the year 2030. These two scenarios are detailed below.

3 Central Urban Area designates the urban entity composed of the GBA and the agglomerations of Bikfaya, Broumana, Jounieh, Aley and Damour.

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 – annual 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, Lebanon will be counting on tourism and commercial services as the major income-generating economic sectors to secure its growth in the face of integrated international trade for which it lacks competitiveness. Despite the moderate economic growth, investments will go into improving Lebanon's infrastructure in order to be capable to host international fairs, exhibitions and luxury tourism. According to the NPMPLT, Beirut Airport will be able to reach a satisfactory level of passengers per year, commercial ports will be competent with other ports in the region and new highways and roads will be established. By improving the means of transportation and as Lebanon's touristic assets are expanded over the country, population density in urban agglomerations will decrease to be slightly increased in rural areas. This assumption is validated by the low population growth and the high migration rate. Improvements in the infrastructure sector will lead to a better access to sanitation and clean water.
Scenario B ▪ Growing integration of international trade, local production could better resist the competition induced by imported products ▪ Balanced economic development ▪ 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	Under this scenario, Lebanon will be counting on its industrial and agricultural sectors to face competition induced by imported products and increase its income from exports of goods. Investments will go to re-organizing the agricultural sector and in developing medium-technology industries; thus Lebanon can acquire an important status for a number of products,

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 constant-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).

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).

grow at a modest increasing rate with an annual 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	especially high quality goods and endemic products. Improving the means of transport will allow the relocation of certain activities of the capital towards different regions. Nevertheless, the high population growth and the low migration rate will contribute in high population densities in all Lebanese regions: rural and urban areas. Access to water and sanitation will be improved due to the higher standards of living.

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

1.1.3.2. Climatic Scenarios

Precipitation

The projected changes of the simple daily intensity index (SDII)[1] indicate a decline in the rainfall intensity by the end of the century. The SDII is expected to decrease by 6 to 15 percent over three locations (Beirut, Zahle, Dahr-el-Baydar) by 2098 after an increase of six percent in Dahr-el-Baydar region by 2044.

A study by Shaban (2009) observed an increase in the number of rainfall peaks in Lebanon in the period after the 1980s. Rainfall peaks represent torrential rain events, rain intensity and their behavior. High rainfall peaks increase the risk of flooding. The annual average number of rainfall peaks in Lebanon increased from 15 to 24 peaks in the period after the 1980s. The average rate of torrential rain during these peaks was between 1 and 20 mm/day before the 1980s and 18-22 mm/day after that period. If the trend reported by Shaban (2009) is going to continue, where more rainfall peaks per year occur over the coming years, it means that the rainfall intensity will increase (Shaban, 2009).

Temperature

Hot summer days are expected to increase by 12 to 29 days in 2040 and by approximately two months by the end of the century in 2090. The maximum temperatures are also predicted to increase by 1°C around the Lebanese coast and up to 2°C in the mountainous inland. Moreover, the risk of summer drought is likely to increase in the Mediterranean area. Temperature is estimated to increase by 0.6 to 2.19°C in the period between 2010 and 2039 (Christensen et al., 2007).

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 levels 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 1-3

Figure 1-3, 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.

1 SDII is the annual total rainfall (mm)/number of days with rainfall ≥1 mm.

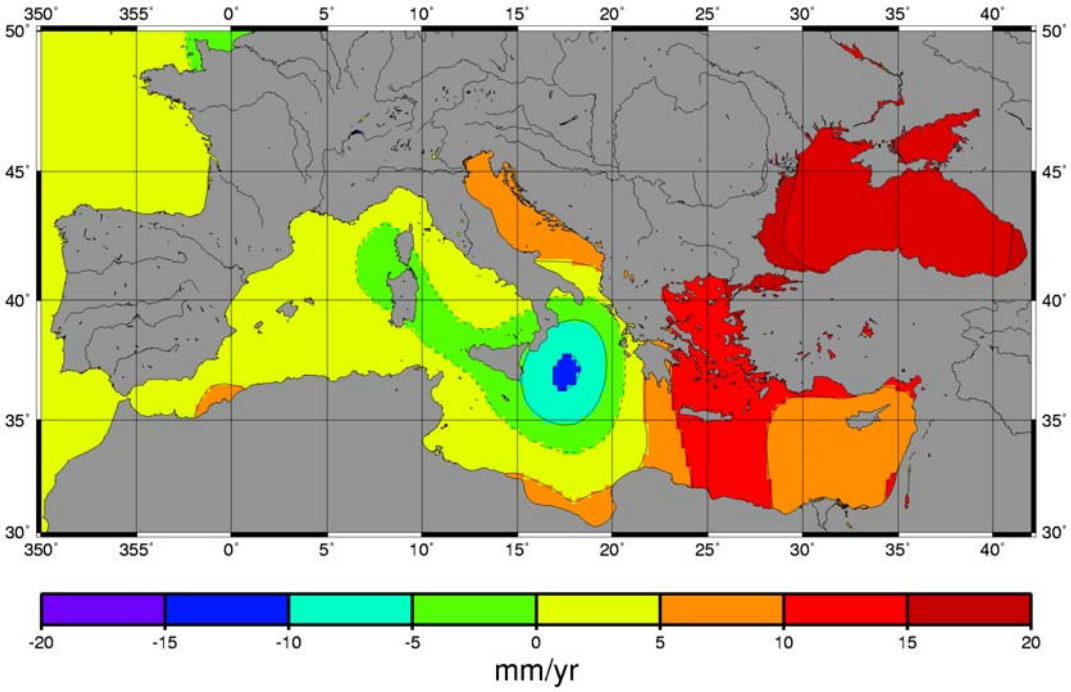

Figure 1-3 Mediterranean Sea level changes as observed during the period between 1993 and 2000

Source: Tourre et al., 2008

Frequency and intensity of storms

Extreme phenomena such as storms and violent winds are expected to increase over the Mediterranean basin, even though those increases are less certain than those of temperature and aridity (Tourre et al., 2008). This prediction contradicts with other claims of a weakening of the storm track over the Mediterranean which seems to be related to a large scale hemispheric change (Bengtsson et al., 2005). According to Christensen et al. (2007), the northwards shift in cyclone activity tends to reduce windiness in the Mediterranean area.

1.1.4. Vulnerability assessment

1.1.4.1. Sensitivity to climate factors

The sensitivity of human settlements and infrastructure to climate change is related to the poor and old infrastructure. It varies across regions, sectors, and communities. The random urban expansion poses tangible stress on the quality of life, the value of infrastructure, water resources and on non-urban classified land resources, such as agricultural, natural and landscape areas (UN, 2008a). The sensitivity of infrastructure and settlements increases dramatically in flood and landslide prone areas (Figure 1-4 & Figure 1-5). Table 1-3 presents information on the likely risks of the different infrastructure/human settlements types to projected changes in climatic and climate-related factors.

Table 1-3 Climate change exposure and the sensitivity of human settlements and infrastructure

	INCREASE IN HOT SUMMER DAYS	INCREASE IN RAINFALL INTENSITY	INCREASE IN EXTREME PHENOMENA SUCH AS VIOLENT WINDS AND STORMS	SEA LEVEL RISE OF 12-25 CM BY 2030 AND 22-45 BY 2050
HUMAN SETTLEMENTS				
Buildings and structures	Definite risk especially in urban areas where the increase in hot summer days may lead to intensification of existing phenomena such as the urban heat island.	Negligible risk except for slums and poor settlements High risk in built-up, flood-prone areas	Negligible risk except for slums and poor settlements	Negligible risk except for slums built on beaches
INFRASTRUCTURE				
Wastewater	Potential risk for additional odor problems	The risk is limited to the capacity of treatment works through greater volumes of storm water	Negligible Risk	Negligible risk
Solid waste	Negligible risk – more rapid degradation of organic material in landfills and open dumps, and more days of odors	Negligible risk	Negligible risk – More frequent blowing of garbage and more days of odors in the vicinity of open dumps	The risk is limited to coastal dumps such as Sidon and Tripoli solid waste dumps
Roads	Negligible risk: The risk is limited to a decrease in the viscosity of asphalt	Negligible risk: The risk is limited to an increase in the formation of potholes	Potential risk to mountainous roads with no adequate structure to prevent road blockages from trees and debris	Negligible risk
Airports	Negligible Risk	Definite risk as B-RHIA is a coastal airport that is sensitive to storm surges that may disrupt operations and pose hazards to passengers		
Ports	Negligible risk	Potential risk of future flood risk with sea-level rise which may cause interruptions to goods movement at ports.		

1.1.4.2. Adaptive Capacity

Adaptive capacity of human settlements and infrastructure in Lebanon is more variable than the sensitivity. The community's adaptive capacity largely depends on how it is designed, the state of its infrastructure and its ability to adapt to new climatic conditions; it is affected by the social, economic and technological conditions. The lack of sufficient infrastructure to carry out the daily functions of the Lebanese community reduces its capacity to adapt to changing environmental conditions. Moreover, the absence of proper planning and implementation in the different infrastructure subsectors results in a low adaptive capacity, unless significant investments are made to improve the public infrastructure, especially roads, wastewater networks and solid waste disposal facilities.

Human Settlements

Urban settlements in Lebanon tend to be densely populated, haphazardly built and lack proper services (Abu-Jawdeh et al., 1999). Urban areas are expanding at the rate of 10 km^2 a year at the expense of natural and agricultural areas (MoE, 2005). For example, Lebanese rivers are deemed to be under great stress from the concentrated urban, industrial and agricultural development in their catchments (MoE, 2005).

The overall headcount poverty ratio[2] reaches 28.5 percent accounting for about one million Lebanese. Nearly 8% of the Lebanese population (almost 300,000 individuals) lives under conditions of extreme poverty (below the lower poverty line) (Laithy et al., 2008). The distribution of extreme and overall poverty rates across governorates in 2004-2005 is represented in Table 1-4.

Table 1-4 Poverty measures by governorate 2004 – 2005

GOVERNORATE	EXTREMELY POOR (PERCENT)	ENTIRE POOR POPULATION (PERCENT)
Beirut	0.67	5.85
Mount Lebanon	3.79	19.56
North	17.75	52.57
Bekaa	10.81	29.36
South	11.64	42.21
Nabatieh	2.18	19.19
Total	**7.97**	**28.55**

Source: Laithy et al., 2008

In the Greater Beirut Area, there are around 300,000 slum dwellers representing 20 percent of the population of the capital city. Slums[3] across Lebanon are divided between (1) refugee camps such as Palestinian refugee camps in Mar Elias, Dbayeh, Bourj Barajneh and Ein El Helwi; (2) housing areas for rural-urban migrants such as Zaaytriyyeh (Fanar area), Hayy Sellom (Choueifat), Roueissat (Jdeideh); and (3) squatter settlements that expanded during and after the civil war, such as Jnah beaches, Horsh El Qateel in Ghobeiri and Laylaki in Hadath. Many of these slums are still damaged from the war period while streets are narrow and often unpaved. They are characterized by limited access to electricity, water, sanitation, health services and other basic services and infrastructure. The quality of structures of 45 percent of buildings in these slums is considered to be poor at best (Fawaz & Peillein, 2003).

Lebanon experiences a number of natural hazards that expose some of the population and their activities to serious threats. The situation is exacerbated with the absence of urban planning and law enforcement of planning regulations that allowed investors to construct in areas that are prone to natural hazards. In Lebanon, floods and landslides are two of the most salient natural hazards that occur in short, annual or decadal, cycles or frequencies. Catastrophic events could be pre-empted to a certain extent by adopting and enforcing adequate regulations that manage and avoid the risks of expected hazards in an urban planning and land management framework (Abdallah, 2002; CDR, 2005).

The adaptive capacity of poor communities residing in slums is low. Further increases in population density in such areas are bound to increase the pressure on public services provision, including demand on the use of infrastructure services.

2 The Head Count Index (P0) is a measure of the prevalence of poverty. It denotes the percentage of households that are poor, as defined by the poverty line, as a proportion of total population. This measure however, is insensitive to the distribution of the poor below the poverty line.

3 Slums are defined in this study as areas of the city where the majority of residents live in precarious economic and/or political conditions, with high levels of vulnerability, and where services and living conditions appear to be lower than other sections of the city (Fawaz & Peillein, 2003).

Wastewater Infrastructure

Most of the old sewage network pipelines are made of cement and asbestos cement, while newer pipes are made of glass reinforced plastics. These networks lack proper maintenance and operational control.

The bulk of sewage generated from residential and industrial areas is usually disposed of in streams, rivers and on open land or underground, or discharged into the sea via 53 outfalls along the coast. There is a total absence of a proper sewage control or treatment prior to disposal. Most of outfalls extend only a couple of meters or terminate at the surface of the water. Institutional limitations, poor enforcement of environmental laws and insufficient public expenditure are the main root cause of the inadequate wastewater services (MoE, 2001; UoB et al., 2004).

Currently, the CDR is implementing several projects all over the Lebanese territories to upgrade the wastewater infrastructure and treatment, as well as the provision of sewage networks and treatment plants (see Section 1.1.1). With increasing investments in upgrades, it is expected that the current low adaptive capacity would improve gradually, and the potential risks imposed from climate-related events such as the increase in odors and increase in storm water volumes will be accounted for in the current planning of wastewater infrastructure.

Solid Waste Infrastructure

The disorganized management of the MSW in Lebanon is characterized by rudimentary "collect and dump" approaches. It has been limited by several factors starting with political interference, limited resources, inadequate public awareness, a prevalent NIMBY syndrome and the lack of coherent legal and institutional frameworks. The reckless MSW management practices have proven to be detrimental to the landscape and local environment in many cities and rural areas alike, especially through the emanation of foul odors. Table 1-5 shows the distribution of households by means of waste disposal (MoE, 2005). The solid waste infrastructure in Lebanon varies between urban and rural regions. The principles of sound solid waste management are starting to be better ingrained with the local authorities, who are showing positive signs to move away from the illegal dumping practices towards the proper handling and treatment of waste. Although at the moment, adaptive capacity is considered low, it is expected to increase with time due to better awareness and larger investments streaming into improving the management of solid wastes.

Table 1-5 Number and percentage distribution of households by method of waste disposal

DISTRIBUTION OF HOUSEHOLDS BY WASTE DISPOSAL METHOD*	NUMBER	PERCENT
Dumpsters inside the building	102,149	11.6
Dumpsters near the building	617,979	70.2
Dumpsters placed far from the dwelling	150,928	17.2
Private collection	86,308	9.8
Disposal in designated waste dumps	25,200	2.9
Open dumping in nature	12,859	1.5
Open uncontrolled burning	19,064	2.2
Other	21,759	2.5

* One method or more can apply at a time
Source: CAS, 2004

Transport Infrastructure

Major Lebanese cities suffer from severe congestion and poor traffic conditions particularly in the Greater Beirut Area (GBA). Travel demand is growing faster than the transport systems' ability to accommodate increasing traffic volume. The road traffic in Lebanon was estimated to have grown by 6.8 percent between 2003 and 2004. Disorganized transportation systems add significant pressure on the urban environment in Lebanon causing adverse impacts on society, the landscape, ecosystems and natural resources, and affecting air quality, water quality, soil and biological resources and the overall quality of life (MoE, 2005; UN, 2002). The adaptive capacity of the transport infrastructure is not expected to improve above its current low levels. Despite the investments in road transport infrastructure, it is expected that poor construction, lack of upgrading and the poor compliance to regulatory standards will continue to plague this sector. While the port and airport infrastructures will continue to grow normally and gradually increase their capacity to face changing climatic factors that are known to heavily influence their operations.

1.1.4.3. Vulnerability Assessment Results

The vulnerability of the human settlements and public infrastructure is exacerbated by the different risks and threats mentioned (Table 1-3) as well as by the communities' low adaptive capacity. People living in poverty in regions which exhibit a low rate of infrastructure growth alongside with a high population growth rate are likely to be highly vulnerable to climatic changes. They are more exposed to the potential damages to infrastructure from extreme events.

Under both socio-economic scenarios considered in 1.1.3.1, investment in public infrastructure is expected to increase. However, due to the higher growth predicted in Scenario B, it is more likely that the increase in investment would be larger under Scenario B, thereby increasing the adaptive capacity of communities to climatic changes. However, and due to the higher rural-urban migration expected under Scenario B, it is envisaged that the urban communities will experience higher population densities and increasing pressures on the public infrastructure which might not be met with the increased investments.

Between the two socio-economic scenarios already presented, human settlements could be more vulnerable to climate change under the second scenario. This vulnerability is due to the high population growth, low migration rate and to the fact that investments will be geared towards the improvement, development and re-organization of industries and agriculture rather than towards the amelioration of the aging infrastructure in Lebanon, which would be under more pressure from increasing population densities. Nevertheless, the increase in GDP and the balanced economic development in the second scenario could instigate the adoption of suitable adaptation measures to climate change.

Regarding infrastructure, increased investments in both scenarios could render the public infrastructure more resilient to changes in climatic and climate-related factors. The sensitivity of the infrastructure to climate change is low to moderate, but can be evident in the cases of extreme events. The sensitivity of infrastructure is tied to the improvements in construction of new and management of existing stocks. Hence, the overall vulnerability, for both scenarios, is considered low to moderate depending on how much investment will go into infrastructure.

Different vulnerable hotspots were identified below according to their sensitivity and adaptive capacity to climate change (Table 1-6).

Major Urban Agglomerations

Urban agglomerations such as Beirut, Tripoli, Sidon (Saida), Nabatieh, Baalbek, Zahle, are highly vulnerable to the predicted changes in the climatic factors for several reasons:

- The presence of a large percentage of extreme and overall poverty in Tripoli (North), Sidon (South) and Baalbek-Hermel (Bekaa). In fact, two-thirds of the extremely poor population of the whole country is concentrated in four strata or regions: Tripoli, Akkar/Minieh-Dennieh, Jezzine/Sidon and Hermel/Baalbek.
- Lebanon experienced in 2001 an annual slum population growth of three percent and the percent of the population in slums is nearly 53 percent (UN-habitat, 2008b). Usually, these slums are located in the suburbs and on the outskirts of major urban agglomerations (Beirut, Tripoli, Zahle, Sidon, Nabatieh…). Currently, 20 percent of the population of the GBA lives in 24 listed slum areas, though this does not account for all those living in poverty and/or poor conditions (Fawaz & Peillein, 2003).
- Drastic land use changes that were experienced by major Lebanese cities: Urban expansion and development are the main reasons for the urban heat island effect due to the construction materials that effectively retain heat, thus turning those cities to become significantly warmer than their surroundings.

Wastewater, Solid waste, and Transport infrastructure

Infrastructures could be vulnerable to climate change related factors, especially sea level rise and storms, and to extreme high temperatures due to the following.

- The sensitivity of wastewater infrastructure to heat waves and rainfall intensity coupled with an incomplete infrastructure for proper sewage control or treatment.
- The risk of sea level rise on coastal dumps coupled with poor MSW management practices.
- A population pressure on service provision and public infrastructure especially in the urban coastal areas with a high population density coupled with unorganized urban development.
- The state of the road network where nearly 35 percent of the roads are considered poor or critical (Figure 1-2). Mountainous roads are usually narrow, unclearly marked or unmarked in many places, and are subject to closures during extreme events due to thick fog, snow and ice.

Areas prone to floods and landslides

The Lebanese population density in flood prone areas is 294.3 inhabitants/km^2 (UNDP, 2003). The flood prone areas are Central Bekaa, the plains of River Aassi, Wadi Khaled, Akkar and Koura, the coastal plains of Tyre, Qasmiyeh, Sidon and Damour, the coastal zone of Chekka, Batroun and Khaldeh, in addition, to the Nahr Abou Ali area which experiences exceptionally violent torrential floods (CDR, 2005).

High risk landslide zones are those with steep stream basins such as the area of River Abou Moussa, River Qadisha, River el Jaouz, River Ibrahim and River el Kalb. High risk zones also include places with steep slopes often located along faults, especially those of Yammouneh and Wadi et-Taym, but also the promontory at Ras Shaqaa in the district (Caza) of Batroun (CDR, 2005). Figure 1-4 and Figure 1-5 show the areas that are naturally vulnerable to floods and landslides. However, the improvement in construction standards and adherence to building codes can mitigate the risk which buildings in those areas might face.

Table 1-6 Vulnerability of human settlements and infrastructure units

SYSTEM	SENSITIVITY TO CLIMATE CHANGE	ADAPTIVE CAPACITY		VULNERABILITY
Urban agglomerations	High due to the urban heat island effect, presence of buildings in flood-prone areas, and existence of slums and poor communities	Scenario A	Moderate	High
		Scenario B	Low	Very High
Wastewater, solid waste, and transport infrastructure	Low to moderate sensitivity depending on the climatic factor under examination	Scenario A	Moderate	Moderate
		Scenario B	High	Low
Areas prone to floods and landslides	High due to significant risk of flood and landslides	Scenario A	Moderate	Moderate
		Scenario B	High	Moderate

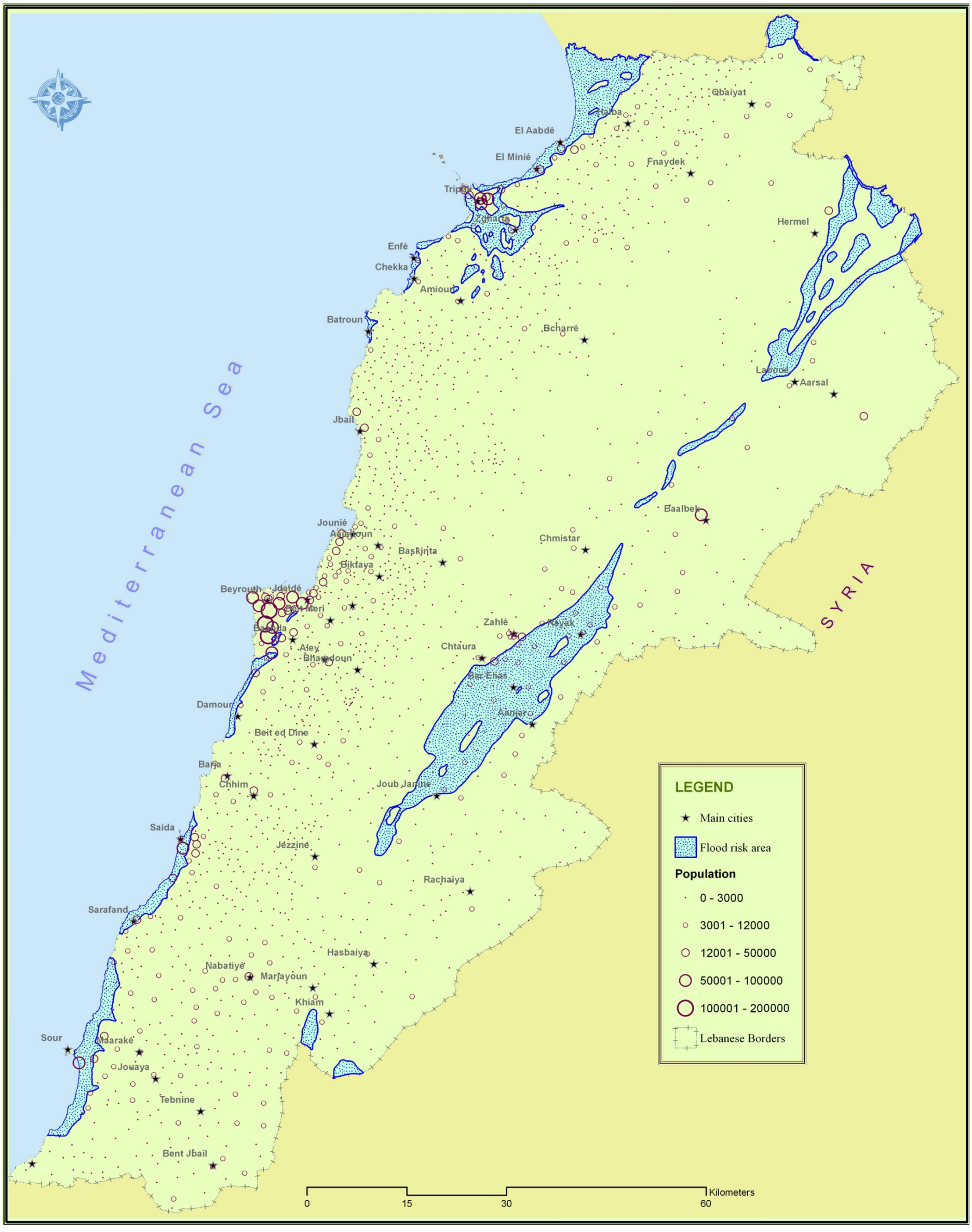

Figure 1-4 Flood risk areas versus population distribution

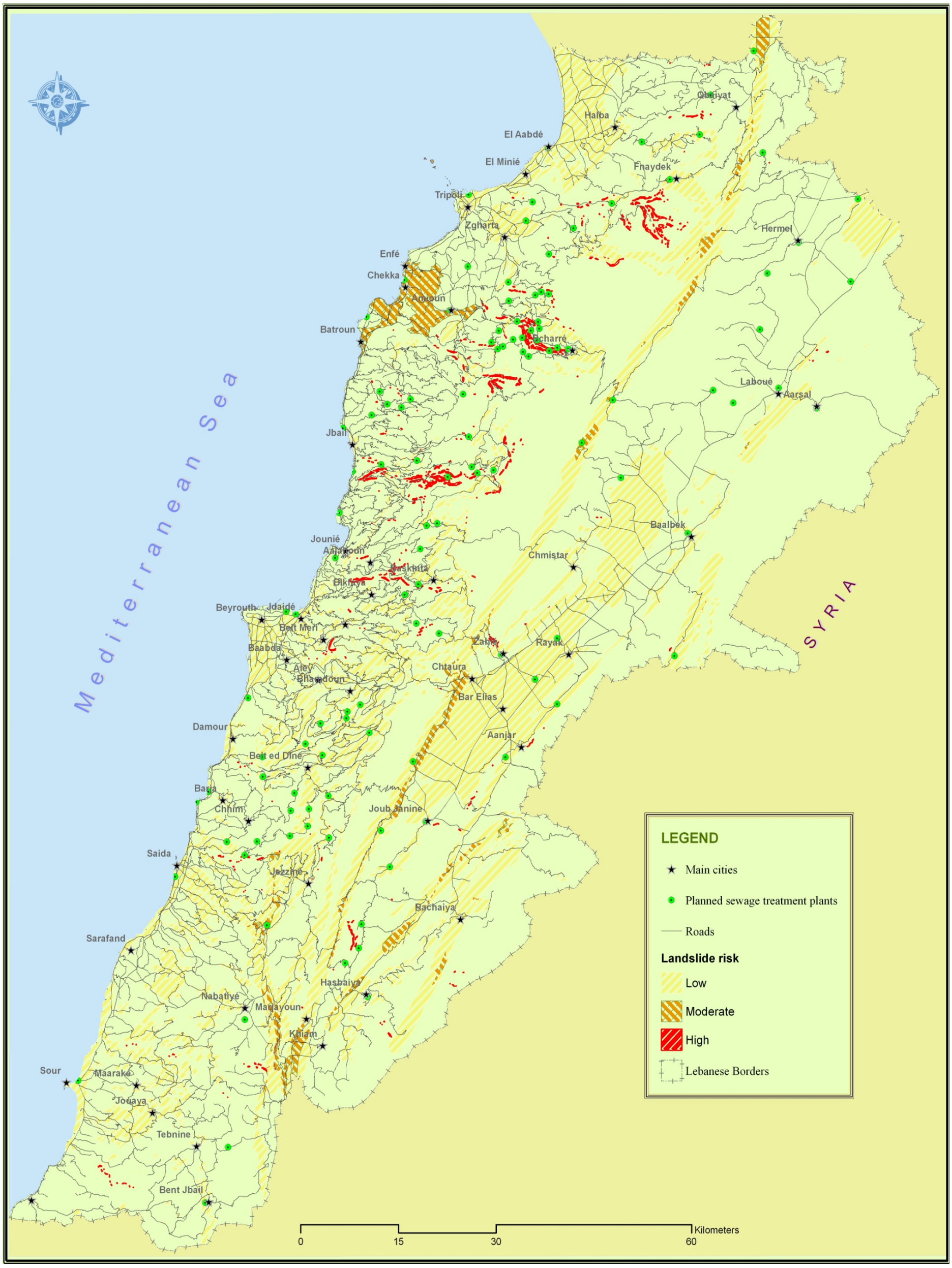

Figure 1-5 Landslide risk versus roads and sewage treatment plants

1.1.5. Impact Assessment

The predicted changes in climatic factors that affect human settlements and infrastructure are uncertain. The uncertainty in the predictions of rainfall intensity and storms' frequency does not allow for an accurate determination of likely climate change impacts on infrastructure and human settlements. Therefore, development may or may not be affected by climate change.

1.1.5.1. Selected Impact Indicators

The following indicators (Table 1-7) were selected to assess the impact of climate change on the vulnerable systems identified, under each of the two socio-economic scenarios.

Table 1-7 Indicators for analysis of climate change impacts on vulnerable systems in Human Settlements and Infrastructure

VULNERABLE HOTSPOTS	INDICATORS	RELEVANCE
Urban agglomerations	Cost of living	Communities in areas with high population density and in slums are expected to have a reduced quality of life and face increasing expenditures to insure themselves against climatic changes (e.g. increased cooling expenditures, flooding from intense rainfall events and possible sea level rise in coastal slums)
Wastewater, solid waste, and transport infrastructure	Rate of growth in infrastructure	Rate of growth in infrastructure measures the state of development as well as the capacity to progress further under new climatic conditions
Flood and Landslide prone areas	Number of population living in disaster prone areas	Population living in disaster prone areas is affected negatively with flooding, landslides, mud slides…

1.1.5.2. Impacts from climatic and non-climatic factors

The impacts of climate change on infrastructure and the population take place through various ways. Physical infrastructure is directly affected by climate related changes while the economy of the areas of concern is affected in an indirect way. Notwithstanding, the most likely impacts are presented below.

Impacts on buildings

A rise in sea level, as a result of climate change, would place coastal settlements and buildings at a high risk of inundation. The situation would be aggravated in case of a combination of storm surges with sea level rise. Furthermore, extreme weather events would jeopardize old buildings and facilities due the accelerated degradation of materials. Hence the maintenance costs and the potential of structural failure during extreme events are expected to increase (Assaf, 2009).

Impacts on public and service infrastructure

The projected changes in climate could lead to several damages in the transport infrastructure, water, and wastewater networks. Most of the expected damages are already being witnessed in different regions all over Lebanon however due to the poor and aging infrastructure which is highly vulnerable to snowy or sandy storms and to torrential rain.

An increase in the frequency and intensity of hot days could lead to a decrease in asphalt viscosity, resulting in a degradation of the quality of paved roads, e.g. potholes and cracks, and an increased

risk of traffic and traffic accidents. Moreover, an excessive expansion in bridge joints and a deformation of the metal components of bridges are expected to occur as a result of the projected extreme hot waves.

The runways at the B-RHIA, located at about eight kilometers from the city centre on the west coast of Beirut, as well as coastal roads and bridges could be threatened by frequent closures and inundation due to the high tides and storm surges in the winter season. Operations at the B-RHIA could also be disrupted with a high frequency and intensity of sandstorms or thunderstorms which would dramatically pose hazards on flights into and out of the international airport.

Extreme cold events such as intense rainfall events and snowy storms could threaten mountainous roads due to an increased risk of mudslides and rockslides. Such slides happen every year in Lebanon during the winter season and cause disruptions. Such events could increase peak volume and sediment loading into wastewater treatment plants leading to inadequate efficiency in treatment and overflows, if the capacity for treatment is exceeded (Assaf, 2009).

Socio-economic impacts

Socio-economic impacts on human settlements and infrastructure are numerous. They are identified as the consequences of climate change effects on the different economic sectors. Any financial losses in the infrastructure that supports agriculture, fishing and tourism and that might result from climate change will reduce the quality of life, the level of income and induce a loss or a reduction in employment opportunities. An increase in water demand could occur due to the potential length of drought periods, to groundwater pollution and to salinization of aquifers. The ecosystems would not be able to supply goods and valuable services which will affect the quality of life (Ernie, 2009). Moreover, areas where the population relies on electric fans or air-conditioning during the summer season may see increased pressure on household budgets as average temperature is predicted to rise with time.

The vulnerability of human societies to climate change could vary with economic, social and institutional conditions. Less-advantaged populations might not afford adaptation mechanisms such as air conditioning, heating or climate-risk insurance. The poor might already have in place certain coping mechanisms, which however might not be sufficient if climate change impacts transcend their ability to adapt (Wilbanks, 2007).

1.1.5.3. Summary of impact assessment

The following steps were used in assessing the likely impacts of future climatic changes on human settlements and infrastructure systems:

- Physical and economic indicators that would measure changes in the vulnerable 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 systems were found where the vulnerability of these systems is high. Table 1-8 below identifies the impact of climate change on a specific indicator for every vulnerable hotspot.

Table 1-8 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	
Urban agglomerations	Cost of living	Scenario A	Slight increase	Financial losses in the infrastructure that supports the different economic sectors, resulting from climate change will reduce the quality of life, the level of income and induce a loss or a reduction in employment opportunities	Moderate increase	Scenario A	Moderate increase
		Scenario B	Moderate increase			Scenario B	Moderate increase
Wastewater, solid waste, and transport infrastructure	Rate of growth in infrastructure	Scenario A	Moderate increase	High tides and storms surges could lead to the closure of roads and airport, possible flooding of wastewater assets, collapse of waste into the sea from coastal dumps	Moderate decrease	Scenario A	Stable
		Scenario B	High increase			Scenario B	Moderate decrease
Flood and Landslide prone areas	Number of population living in disaster prone areas	Scenario A	Stable	Intense rainfall could lead to flood as well as mud and rock slides in mountainous areas	Moderate decrease	Scenario A	Slight decrease
		Scenario B	Slight decrease			Scenario B	Moderate decrease

1.2. ADAPTATION MEASURES

Determining the adaptation strategies to climate change is a difficult and complex exercise due to the innumerable uncertainties and estimations in climate change projections. Adaptation requires both adjustments to present climate as well as to future climate. The ability to adapt is often dependent upon social and economic factors. Several adaptation measures that could be adopted are listed below:

- Integrating the transportation and land-use planning at the level of planning of new infrastructure or rehabilitation of those affected by climate change. This measure consists of taking into consideration the high-hazard areas in urban planning and construction activities through:
  - Restricting development and settlement in regions at risk of landslides or flood;
  - Adopting flood-sensitive urban planning; and
  - Adopting water-sensitive urban planning that may reduce surface runoff and enable aquifer recharge employing relatively inexpensive measures.
- Adopting a better design of building envelopes through the use of suitable design techniques and building materials. The aim is to reduce cooling demand and render constructions capable of withstanding more extreme climatic conditions. The build and design of infrastructure should follow more robust standards, especially for the critical components, in order to limit the development of urban heat islands. It could be implemented through using climatic design values that have been calculated from historical climate data under the assumption that the average and extreme conditions of the past will represent conditions over the future lifespan of the structure (Jáuregui et al., 2001).
- Adopting protection measures;
  - For historic settlements and sites: whereas the problem of such structures should be addressed through their gradual transformation or translocation, such measures are often quite expensive.
  - For coastal installations: through planning a retreat inland to protect them from coastal hazards and to make the coastal zone less artificial. It could be managed by making it illegal to build on a strip of 100 or more meters and by introducing risk prevention plans.
- Preparing an emergency management plan in case of extreme weather conditions and events. This preparedness should be incorporated into routine operations in collaboration with emergency management agencies. This plan could include forecast techniques and information systems between weather bureau/meteorological offices and individuals through local government/offices (Jáuregui et al., 2001).
- Anticipating floods in vulnerable areas through hard engineering measures (dams, levees, diversions…) and/or nonstructural methods (acquisition of properties, fiscal and financial incentives, regulations, warning systems/evacuation plans…) (Jáuregui et al., 2001).

Table 1-9 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 1-9 Adaptation Action Plan

IMPACT	PROPOSED ADAPTATION STRATEGY	ACTIVITIES	RESPONSIBILITY	PRIORITY (ST/ MT/ LT)	INDICATIVE BUDGET (USD)	SOURCES OF FINANCING/ IMPLEMENTATION PARTNERS
Decrease in the rate of growth of public infrastructure due to possible, more frequent severe damages from extreme events	Increase the resilience of infrastructure to climate change impacts	Integrating the Transportation and Land-use planning at the level of development of new infrastructure or rehabilitation of those affected by climate change Improve the design and construction of access infrastructure Preparing a contingency plan for wastewater and waste infrastructure etc. Issue the decrees that require SEAs and EIAs for all development strategies and plans and make sure that climate change risks are taken into consideration in the planning phase and that contingency plans are prepared. Introduce professional training courses for architects and engineers on designing climate resilient structures	CDR Directorate General for Urban Planning (DGUP) Ministry of Public Works and Transport Strategic Planning Unit (SPU) Higher Council for Urban Planning (HCUP) Municipalities Order of Engineers	ST-MT	1,000,000 USD (technical assistance)	World Bank European Investment Bank (EIB)* Bi-lateral agencies Adaptation Fund* GEF
Decrease of population density in areas prone to floods and landslides due to relocation	Anticipate floods and extreme events in vulnerable areas	Preparing an emergency management plan in case of extreme weather conditions and events Implement hard engineering measures such as construction of dams, levees, diversions and non structural methods such as acquisition of properties, fiscal and financial incentives, regulations, warning systems/evacuation plans Public awareness on reducing damages from extreme events and floods Adopting flood sensitive urban planning through taking into consideration in the design of buildings, roads, solid waste and waste water treatment plants the potential impacts of climate change such as floods, landslides, rainstorms high tides…	CDR Directorate General for Urban Planning (DGUP) Higher Relief Commission Municipalities	ST	USD 1,000,000 (technical assistance for project formulation)	World Bank European Neighborhood Partnership Instrument (ENPI)* Bi-lateral agencies' technical assistance programs UN-ESCWA UNDP The European Commission's Co-operation Office: EuropeAid* GEF
	Improve the efficiency and readiness of relief commissions during climate change induced catastrophes for a better intervention	Ameliorate the coordination between HRC and other governmental committees, regional offices or nongovernmental organizations Establish regional offices of HRC in coordination with municipalities and local NGOs Establish the "Unit Management Disaster" that should include NCSR, Order of Engineers, HRC as well as the relevant ministries Periodically train or build capacity of technicians, employees, municipal members etc. on emergency intervention in case of floods/landslides or any other climate induced impact.	Council of Ministers HRC CDR Municipalities Governmental committees Nongovernmental NGOs	MT-LT		High Relief Council budget International Relief Organizations Local Relief Organizations

*http://www.climatefundsupdate.org/listing, accessed in August, 2010

1.3. RECOMMENDATIONS

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 human settlements and infrastructure such as urban population density as well as the population density of different regions and areas. 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 on indicators such as distribution of slums and squatter settlements all across the country, cost of living, rate of growth in infrastructure, number and density of population living in disaster prone areas, etc.

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