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Abstract

The rapid development of economic construction and urbanization, highly dense population, infrastructure and traffic, all have caused a lot of troubles to the main cities in the Syrian coastal region. In addition, this region which is located on the eastern coast of the Mediterranean Sea, and among Arabian, African and European Asian plates is suffering from increasing the number of natural and man-made disasters such as earthquakes, climate change, flash flooding, and mainly the expected sea level rise. This rise effect often depends on many elements, such as seismic hazard, vulnerability, exposure and emergency response and recovery capability. It is not possible to completely avoid this rise, but the sufferings can be minimized by creating proper awareness of this hazard and its impacts through developing an integrated system of the geographical and environmental data collection and management tools with simulation and decision tools for risk reduction and assessment. Great change becomes to integrated management and more to eco-environmental safety construction, especially to the prevention for disasters destroyed structure as sea level rise. Therefore, the purpose of this chapter is to address the need for an integrated disaster risk management in Syrian coastal zone. This will help to manage the risk of these disasters and hazards in a more effective manner through linking up disaster management more closely and consistently with urban planning and management.

Keywords (separated by '-') Disaster management - Risk assessment - Environmental planning - Climate changes - Sea level rise - Syrian coastal zone - Mediterranean sea

Chapter 24
Disaster Management and Risk Reduction: Impacts of Sea Level Rise and Other Hazards Related to Tsunamis on Syrian Coastal Zone

Hussain Aziz Saleh and Georges Allaert

Abstract The rapid development of economic construction and urbanization, highly dense population, infrastructure and traffic, all have caused a lot of troubles to the main cities in the Syrian coastal region. In addition, this region which is located on the eastern coast of the Mediterranean Sea, and among Arabian, African and European Asian plates is suffering from increasing the number of natural and man-made disasters such as earthquakes, climate change, flash flooding, and mainly the expected sea level rise. This rise effect often depends on many elements, such as seismic hazard, vulnerability, exposure and emergency response and recovery capability. It is not possible to completely avoid this rise, but the sufferings can be minimized by creating proper awareness of this hazard and its impacts through developing an integrated system of the geographical and environmental data collection and management tools with simulation and decision tools for risk reduction and assessment. Great change becomes to integrated management and more to eco-environmental safety construction, especially to the prevention for disasters destroyed structure as sea level rise. Therefore, the purpose of this chapter is to address the need for an integrated disaster risk management in Syrian coastal zone. This will help to manage the risk of these disasters and hazards in a more effective manner through linking up disaster management more closely and consistently with urban planning and management.

Keywords Disaster management · Risk assessment · Environmental planning · Climate changes · Sea level rise · Syrian coastal zone · Mediterranean sea

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24.1 Introduction

World is experiencing an increasing number of disasters by a combination of changes in its physical, technological and social systems. These disasters kill thousands of people and destroy billions of dollars of habitat and property each year. Climate change and unstable land forms, coupled with deforestation, unplanned growth proliferation, tardy communication, bad Disaster Management (DM) make the disaster-prone areas mere vulnerable and suffer more or less by frequent natural disasters. Syria is not isolated from the rest of the world when it comes to the effects of these disasters. To achieve an efficient solution to Disaster Risk Reduction (DRR), this chapter addresses the need for an integrated DM in Syrian Coastal Zone (SCZ) to manage the risks of these disasters [mainly the Sea Level Rise (SLR)] in a more effective manner through linking up DM more closely and consistently with urban planning and management. Section 24.2 presents brief overview of disasters and its effects in Syria during the period 2000–2010, followed by a description of the SCZ. Section 24.3 clarifies the major concepts that revolve around dangers, damage, their interrelations and elements, while Sect. 24.4 presents the SLR and other related hazards such as tsunamis in the Mediterranean Sea in general and in SCZ in particular. In terms of the types of hazards to be classified and spatially selected, Sect. 24.5 explains the physical parameters and factors that can be associated with hazards, and it describes the current and future drivers of coastal changes in SCZ. Section 24.6 discusses characteristics, common effects and impacts of disasters in order to explain the reasoning behind the components of Risk Assessment (RA) methodology, while Sect. 24.7 describes the main effects and impacts of local SLR scenarios with focusing on the Lattakia city and its surrounding areas. Section 24.8 outlines the DM cycle and presents all the practical activities that must be carried out during all the phases of this cycle to minimize the DRR. Section 24.9 outlines the recent processes that have been made through advances in RA and its components. It explains the importance of the strategic tools for RA and their impacts on planning activities to ensure successful urban policies. Section 24.10 presents the maritime activities in SCZ and identifies the vulnerabilities to SLR, gaps, points of strength and weakness, and options to assess adaptation measures. It also outlines the suggested strategic framework for responding to SLR to protect the marine area of Syria. It insists on the importance of the capacity building in achieving successful use of the most advanced technology for DRR. This chapter ends with some recommendations, conclusions and future work.

24.2 Risk of Hazards and Disasters in Syria

Syria is a disaster-prone country with climate and geographical location make it vulnerable and suffering from increasing the number of natural, technological, and man-made disasters. It situated in southwest Asia at the eastern end of the Med.

Sea, and is exposed to significant seismic activity due to its location in the most seismic-tectonic active group in the region where the Arabian, African, and Eurasian continental plates converge as shown in Fig. 24.1. Those areas are tectonically active and cause time to time a lot of seismically events. In addition, Syria experiences related weather anomalies associated with droughts and is prone to floods, landslides and erosion resulting from the combination of heavy rain, steep topography and widespread deforestation. Climate change, industrial development, high population growth rates, rapid economic growth and urbanisation, all has increased the risk of pollution of natural environmental resources, and consequently, amplify the region's vulnerability to environmental challenges and constrain its ability to manage them. Among the major challenges that faces Syria are water scarcity, land degradation, inadequate capacities for waste management, coastal and marine environment degradation, air pollution and global warming, river and shore erosion, etc. Table 24.1 shows the top 5 national disasters with human exposure reported in the last 10 years that have caused widespread damages and losses in Syria. In this chapter, the concentration on the state of hazards in the SCZ mainly the impacts and factors of SLR and other hazards related to tsunamis.

Fig. 24.1 The strategic location of Syria

Table 24.1 The profile risk in Syria in the last ten years

Risk profile		National statistics		
Human exposure		Top 5 national disaster reported		
Hazard type	Population exposed	Disaster	Date	Affected people
Drought	2,027,540	Drought	2008	1,300,000
Flood	25,572	Drought	1999	329,000
Landslide	456	Storm	2004	180
Earthquake	5,370	Storm	2001	172
Tsunami	3,759	Mass mov. wet	2002	23

Source of Data 2009 Global Assessment Report, OFDA/CRED International Disaster Database

24.2.1 The Syrian Coastal Zone

The country is divided into fourteen governorates, of which two are located along the coast, namely Lattakia and Tartous governorates as shown in Fig. 24.2. The SCZ, which is of critical importance to the country and a strategic access to the world, provides important economic, transport, residential and recreational functions, all of which depend on its physical characteristics (e.g., appealing landscape, cultural heritage, natural resources, and rich marine and terrestrial biodiversity, etc.). The region is composed of three markedly different areas: the coastal plain abundant with water and fertile soil, the hilly zone with limited water resources and lower quality agricultural land, and the mountains. The climate in SCZ is typically Mediterranean with dry and wet summers, windy winters and springs. The coastal mountain chain separate Syria's interior from the Med. coast with slopes originally covered in forests of oak and pine. The region accounts for 35 % of the national energy production, 38 % of cement production, 50 % of petroleum refining, the predominant part of the national export is shipped through the port of Lattakia. Due to abundance of freshwater and fertile soil, the area is distinguished

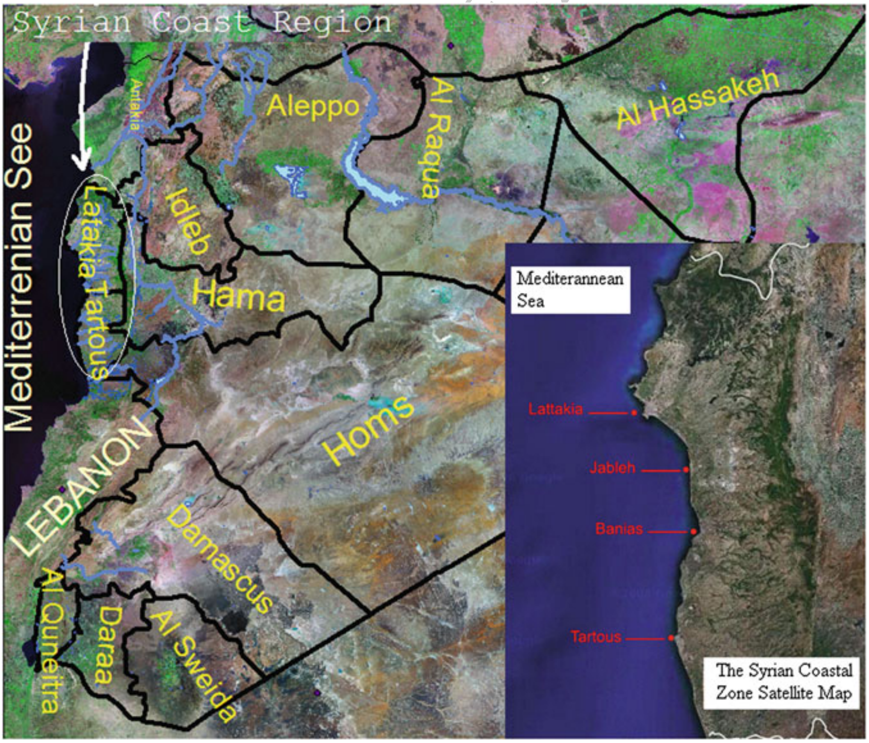

Fig. 24.2 The Syrian coastal zone

by a rich and productive agriculture of the Mediterranean type, with 16 % of cultivated land under irrigation. Syria's coast hosts many archaeological sites and ancient ruins that documented and protected, but some are still poorly excavated. Amongst the most important sites are the ruins and old cities of Lattakia, Jableh and Tartous, Ugarit north of Lattakia, El-Marquab castle near Banias, and Amrit south of Tartous. Arwad, the sole inhabited island in Syria just 3 km off Tartous, was the base of a great sea trading kingdom in the Canaanite era. Many of Syrian's coastal towns and cities have a culture and way of life stretching back over centuries.

Syria has maritime boundaries with Turkey, Cyprus and Lebanon with a 185 km long coastline which includes diverse coastal environments, from cliffs to low-lying areas. This coastline, which is bounded by mountains, represents a narrow plain that is indented by some 350 estuaries, harbours, inlets, bays or fiords. The terrain along the coastline varies from sandy shores (golden sand at Lattakia and black volcanic sand at Ras El Bassit) to rugged, rocky promontories and cliffs as shown in Fig. 24.3. It has to be considered as one of the scarce natural resources of the country, providing a narrow window to the sea for such a relatively large country. The width of the plain varies according to the reach of the nearby mountains; the plain is widest in the north near the port city of Lattakia and in the south near the Lebanese border. According to the Syrian State Planning Commission, SCZ is densely populated with 405 in Lattakia and 370 inhabitants/km^2 in Tartous, while in the narrow coastal plain the density is almost 20 times

Fig. 24.3 The Syrian shoreline varies from sandy shores to rugged, rocky promontories and cliffs

greater than the national average, and 6 times greater than the rest of the coastal region, the hinterland (SPC 2006). This density, which is combined with its strategic and economic importance, places disproportionate pressures on SCZ.

Although the short coastline of Syria, it has a commercial fleet composed of 137 ships and 4 major ports and harbors in Banias, Jablah, Lattakia, and Tartous. The largest 2 ports are in Lattakia and Tartous, and both operate 24 h a day. Lattakia Port comprises 23 quays with a total length of 4,280 m, total area of the port is 1,500,000 m^2, of which 200,000 m^2 is the segregated container yard, and the average monthly activity is approximately 420,000 Mt. Tartous Port comprises 3 piers with 24 berths (total length of the berths is 6,366 m), and average monthly activity is approximately 350,000 Mt. These ports are connected to the railways network (2,342 km) to transport goods to and from other governorates, and neighbouring countries. The road network is back-bone for the country and is vital to the regional international transit network that connects European countries with other Arab countries. The 500 km East–West highway joins these ports on the coastal area in the west of Syria and the western border with Lebanon to the eastern border with Iraq. The Bassel Al Assad International Airport, which is located 25 km from Lattakia, is the only airport on SCZ and supports these networks.

24.2.2 Major Problems, and Challenges in Managing in Syrian Coastal Zone

Coastal margins are the transition between the ocean and the land, and the place where seawater mixes with freshwater and interacts occasionally with the fringing low-lying land during storms or extreme tides. At vulnerable coastal margins, coastal development and global warming are on an eventual collision course (if they have not collided already), which will result in further 'coastal squeeze' between the land and the sea. The developed areas around the SCZ are usually nestled in or near low-lying coastal margins (such as beaches, estuaries and harbours), and will therefore become increasingly vulnerable to the effects of global warming. It is a great national challenge on how Syria will maximize the benefit from its narrow window to the med. Sea, whilst protecting the coastal environment and natural scene. There is huge pressure to develop and occupy the SCZ (for subdivisions, marinas, roads and drainage, etc.). The dynamics of natural coastal processes, including weather systems, sediment transport mechanisms, the hydrological links between the catchments and the coast, are factors that influence the ability of the coast to sustain human activities.

Human actions have exacerbated these problems through the inappropriate location of development and the overexploitation of coastal resources. Human pressures threaten habitats and natural resources of the coastal zone, and with them, the ability of this zone to perform many of its essential functions. Increasing

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Chapter No.: 24 | Date: 15-11-2013 | Page: 487/536

population, both resident and transient, is leading to increased conflict between the competing uses in the SCZ. Low impact uses are frequently being replaced by intensive uses that are more profitable in the short-term but undermine the long-term potential of the coast by reducing its resiliency. Unfortunately, there is no sign that inappropriate uses of the coastal zone are becoming less frequent. In fact, with increasing population, visitors and economic activities, the pressures are increasing. In addition, the coastline is threatened in some parts by coastal erosion resulting from development projects and engineering works. Such works have accelerated erosion of the adjacent shoreline because they did not adequately account for coastal dynamics and processes. SLR, whether as a consequence of climate change or erosion, will present increased threats and costs to sustaining infrastructure and human settlement. SLR resulting from climate change may aggravate this erosion in future and this will be discussed in Sect. 24.5.

Within the framework of this chapter, the ‘case’ to be studied is the main coastal city of Lattakia, which is a highly hazard-prone area that integrate (to a certain extent) several fields of activity, settlement development planning, industrial projects, and disaster risk management, etc. This combination of the hazards and the city’s highly vulnerable social and economic setting produces a dynamic context of risk with the permanent threat of disaster. Therefore, the selection of this case study was based mainly on: the content (i.e., the existence of a certain level of integration development planning and disaster risk management); and the context (i.e., their implementation in an urban environment). In addition, the rapid urban and industrial development in this city, and absence of pollution abatement and treatment facilities resulted in: uncontrolled ribbon development along the shoreline, sprawl of uncontrolled low-density housing development, high pollution of the coastal and marine environment, chemical pollution and bacteriological contamination of freshwater sources due to the uncontrolled disposal of untreated urban solid and liquid waste, waste from villages and farms, agricultural practices, industry and transports, and destruction of wetlands and dunes (due to sand extraction). Section 24.7 will tackles the impacts and effects of the SLR on lattakia.

24.3 Disaster, Hazard, Vulnerability and Their Elements

According to the International Strategy for Disaster Reduction, disasters, hazards, risks, and vulnerability are different definitions, but similar concepts (ISDR 2005). A natural disaster is the effect of a natural hazard (e.g., flood) that will leads to financial, environmental or human losses. The resulting loss depends on the vulnerability of the affected population to resist the hazard. This understanding is concentrated in the formulation: “disasters occur when hazards meet vulnerability”. http://en.wikipedia.org/wiki/Natural_disaster-cite_note-1. Therefore, the disaster risk is made up of hazard and vulnerability (i.e., disaster risk = hazard × vulnerability). Hence, it is clear that a risk exists only if there is vulnerability to the

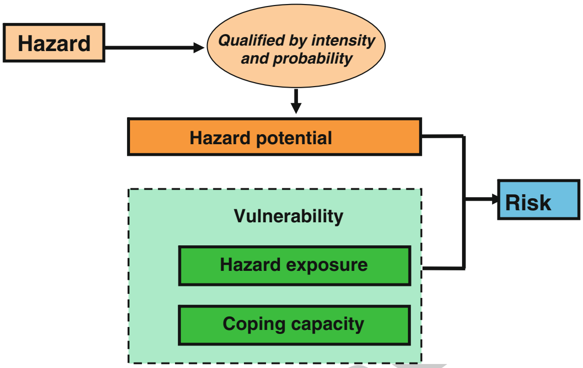

Fig. 24.4 The understanding of hazard and risk components. (*Source* Schmidt-Thomé and Kallio 2006)

hazard posed by a natural event. The following section introduces these elements in details, while Fig. 24.4 graphically depicts the relationship between them.

24.3.1 Disasters

Natural disaster can be defined as "A Disaster is a serious disruption of the functioning of a society, causing widespread human, material, or environmental losses, caused by hazards, which exceed the ability of affected society to cope using only its own resources" (Cuny 1983). In order to understand the term disaster, the term 'hazard' and the human sensitiveness towards it have to be also understood. Generally, disasters normally occur when hazards meet vulnerability, and the potential for a hazard to become a disaster mainly depends on a society's capacity to address the underlying risk factors, to reduce the vulnerability of a community, and then to be ready to respond in case of emergency (Wisner et al. 2004). It is important to note, that there are no internationally agreed minimum criteria for an event to be classified as a disaster. This is due to the variable manner in which hazards impact on population, economies and ecosystems. In this chapter, these events will be connected to the planning activities.

24.3.1.1 Classification of Disasters

It is difficult to classify disasters and draw a distinction between them, but it is useful to define disaster risk management measures. This will clarify and support the linkage among disaster, environment, spatial planning, and development. Only a few disasters, earthquakes for example, occur as purely natural phenomena, while most others (such as forest fires, floods and landslides, etc.) can come about with and without human intervention (Burton et al. 1998). Each hazard has a spatial dimension and the spatial character of a hazard can either be defined by *spatial effects* or by

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Chapter No.: 24 | Date: 15-11-2013 | Page: 489/536

the possibility for an *appropriate spatial planning response*. Generally, disasters can be defined and classified according to their nature as follows:

- *Natural disasters* are of geophysical origin (e.g., earthquakes) and can result from those elements of the physical environment harmful to people and caused by forces extraneous to them. The term 'natural disaster' is not entirely correct, and they are human-made disasters exposed by natural hazards. For example, earthquake disasters show that many people were killed in poorly designed and constructed man-made structures, and not in open fields (Blaikie et al. 1994).
- *Human-induced natural disasters* are of climatic origin (e.g., floods) and caused by the human modification of the environment (e.g., cutting down forests that buffer rainfall). Then, when the flood come the blame on a natural disaster, not on these modifications and that's a human-induced disaster or, it's just poor planning on the part of short-sighted humans (Burby 2006).
- *Technological disasters* are accidental failures of design or management that could have a great perimeter of influence and affecting a relatively larger part of a country (e.g., air traffic accidents and chemical plants) (Smith 2000).
- *Man-made disasters* are resulting from man-made hazards as opposed to natural disasters resulting from natural hazards (e.g., threats having an element of human intent and negligence) (Gardoni and Murphy 2008).

24.3.2 Hazards

The United Nations International Strategy for Disaster Reduction (UNISDR) defines hazard as "A Dangerous phenomenon, substance, human activity or condition that may cause loss of life, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage" (Van Westen, Terlien 1995). Hazardous events vary in magnitude, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing. Their origin can be purely natural (e.g., earthquake) or technological (e.g., accident in chemical plants), as well as a mixture of both (e.g. Sinking of an oil tanker in sea and subsequent coastal pollution).

Within this concept, risk can be defined as the probability of an event happening in a given time span and the magnitude of its impact when it does occur. Risk (*i.e., probable loss*) identification starts with identifying a hazard and then assesses the corresponding vulnerability (*i.e., The possible consequences)*. For natural hazards we can only attempt to reduce the risk not the hazard, either by controlling exposure to hazards or their vulnerability. The dependency of risk is on the three components of hazard, exposure, and vulnerability (Crichton 1999). This chapter deals with coastal hazards that arise from the interaction of natural processes with human use of infrastructure.

24.3.3 Vulnerability

Vulnerability is an essential part of a hazard, and it refers to the susceptibility of people, communities or regions to this hazard. It is a set of conditions resulting from physical, social, economic and environmental factors that increase this susceptibility to the impact of hazards (Oliver-Smith 2004). Vulnerability to climate change is considered to be high in developing countries due to social, economic, and environmental conditions that amplify susceptibility to negative impacts and contribute to low capacity to cope with and adapt to climate hazards. In Syria, there is an urgent need to understand the threats from climate change and to formulate policies that will lessen the risks and to take actions to cope with them (Meslmani 2010). The main factors that have to be taken into account to determine the vulnerability are:

- *Physical factors* are usually materially oriented, and come from the field of land-use and planning, engineering, and building environment (e.g., population density level, the remoteness of a settlement and the site, design and materials used for critical infrastructure and for housing, location and standards of infrastructure, etc.).
- *Social* factors are normally linked to the level of well-being of individuals, communities and societies (e.g., education levels, lack information on disasters, rapid population growth, the existence of peace and security, good governance, degree of respect for human rights, religious or political groupings, etc.).
- *Economic factors* include the economic status of individuals and communities (e.g., lacking in diversity and competition for scarce resources, rapid urbanization, inadequate access to basic socio-economic infrastructure, etc.).
- *Environmental factors* include the extent of natural resource depletion and data on resource degradation (e.g., reduced access to clean air and water, inappropriate waste management, soil degradation, deforestation, etc.).

24.4 Tsunamis and Other Hazards Related to Sea Level Rise

Tsunamis are gravity long waves generated by impulsive geophysical events of seafloor, volcanoes, asteroid impacts and landslides. They can be loosely grouped into those that are generated beyond the continental margins (distant or teletsunami), and those generated on or within the continental margins (local tsunami). Local tsunamis are generated by seismic activity (earthquakes) and volcanic activity and are likely to be in the order of 2.5–3 m above Mean Sea Level (MSL), while distant tsunamis are estimated to have a maximum height of 3.6 m above MSL (Palmer 2008). Figure 24.5 shows the global and relative plate motion in the eastern Med. Sea which can be regarded as one of the main sources of seismic hazards that cause tsunamis and SLR in this region.

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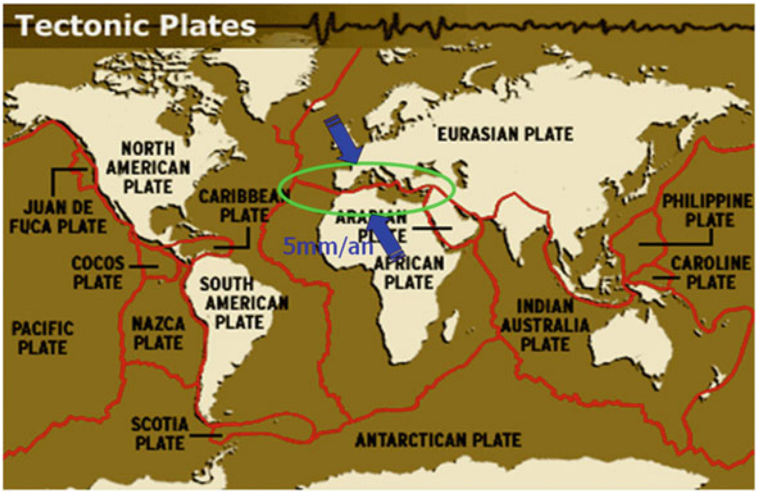


Fig. 24.5 The global seismic hazards and relative plate motion in the Eastern Mediterranean

With regards to the SLR, it results in more frequent coastal flooding that includes inundation of low-lying coastal areas caused by extreme tides and storm surge. It varies as a function of location and time at all spatial and temporal scales for many reasons. In particular, a global SLR has been evident at a rate of about 2 mm/year for the last century as determined from tide gauge records (Oliver-Smith 2009). *Global SLR* refers to the average vertical rise across the world's oceans, while *relative SLR* is the net rise relative to the landmass in a region. The relative SLR is the sum of the local subsidence (or uplift) of the coastal margin and the absolute sea-level contribution in that region. Regional relative SLR, which can be measured using tide gauges around the open coast, is what will affect us locally rather than the average global SLR.

The last assessment IPCC report has given new estimates for SLR that range 18–59 cm until the end of the next century. These estimates exclude the contribution of ice melting to the SLR, and include only the steric component of the SLR due to the heating of the ocean waters and their consequent expansion. Therefore, the numbers given by IPCC are only a lower limit of the SLR that one should expect, and it concluded that there is a consensus that global average sea level has risen by about 1.7 mm/year during the 20th century (IPCC 2007). There is also evidence from coastal tide gauges and satellite radar altimetry that the rate of increase of coastal and global sea level has accelerated from the early 1990s to 3 mm/year. On the other hand as shown in Fig. 24.6, it is predicted that with global warming, global average sea levels may rise 7–36 cm by the 2050s, 9–69 cm by the 2080s, and 30–80 cm by 2100 (Boko et al. 2007). The majority of this change will occur due to the expansion of the warmer ocean water (Nicholls and Tol 2006).

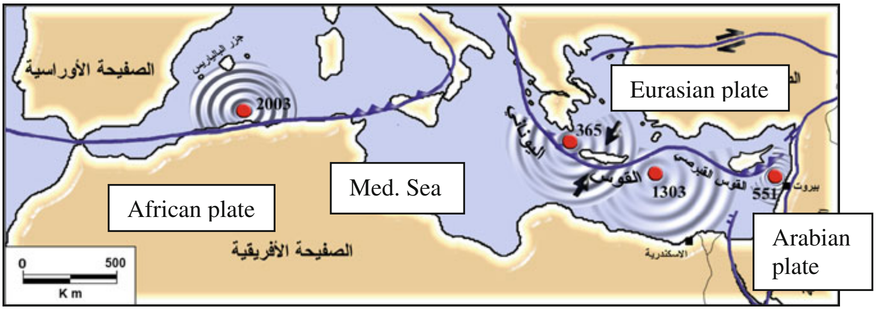


Fig. 24.6 The distribution of the Tsunamis centres in the Med. Sea

Table 24.2 The historic records of the some Tsunamis in the Mediterranean Sea

The damaged city	Magnitude	Date
Alexandria: 50,000 dead	7.0	21/07/365
Beirut: Huge number of people and boats merged	7.2	09/07/551
Alexandria: Huge number of people and boats merged	–	8/1/0303

24.4.1 Tsunamis in the Mediterranean sea

Historical documentary sources of the Med. Sea region contain much information about earthquakes and tsunamis as shown in Table 24.2, while, Fig. 24.6 depicts the distribution of the Tsunamis centres that affected the Arabian coasts in the past. Because of the active lithospheric plate convergence, this region is geodynamically characterized by high seismicity and significant volcanism, and this can be related to the surrounding tectonic sources is the Dead Sea fault system as shown in Fig. 24.5. Furthermore, coastal and submarine landslides are quite frequent, partly in response to the steep terrain that characterizes much of the basin. Some studies have suggested that massive earthquakes which are greater than magnitude 8 may strike this region roughly every 800 years (Manca et al. 2003). However, other studies outlined that not enough is known about these faults to predict how often such quakes might strike (Fukumori et al. 2003).

The first known tsunami in the Med. Sea occurred in the Syrian region around 2000 BC, while the large tsunami that hit Alexandria and killing 50,000 people was in 365 AD Weaker tsunamis have been observed more recently, notably the one generated off the coast of Algeria in 2003. The tsunamis that hit the coasts in the Mediterranean were faster despite travelling at lower speeds because the sea is not as deep as those in the Pacific Ocean (Gerassimos et al. 2005). They affect not only near-field localities, but also remote places in North Africa and in the Mediterranean side of Middle East as shown in Fig. 24.8. Three critical aspects of these tsunamis are: repeat times, maximum size, and zones of effects. However, by far the most common cause is submarine earthquake (Synolakis 2003) which

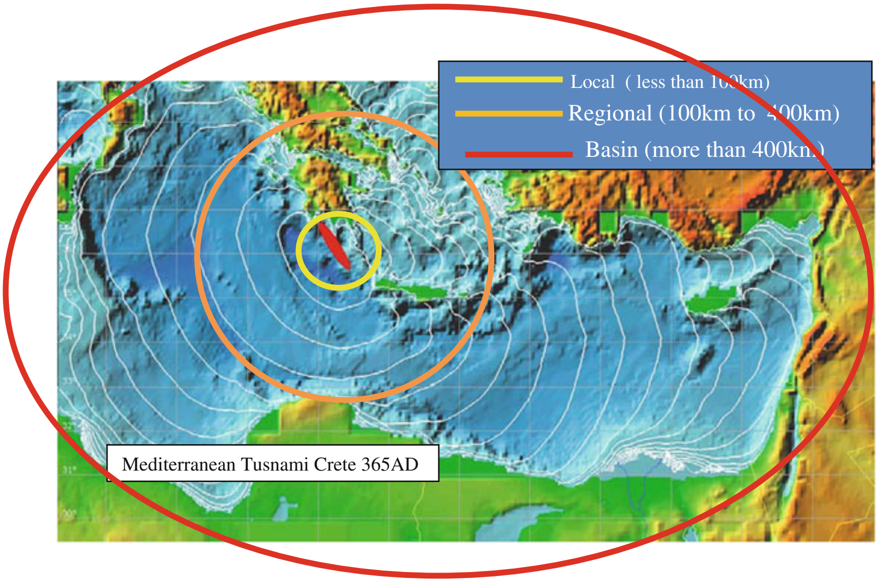


Fig. 24.7 The strong affect of the Tsunami in the Med. Sea (Papadopoulos 2003)

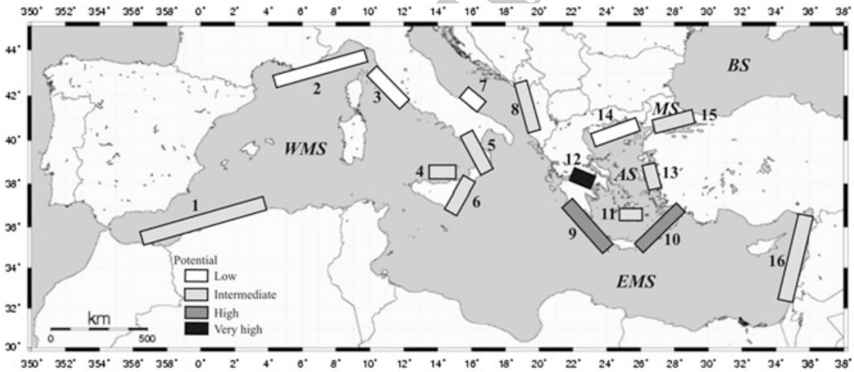


Fig. 24.8 The tsunamigenic zones of the Mediterranean Sea

owning to its occurrence the earth's crust experiences vertical deformations in the form of uplift and subsidence.

Figure 24.7 demonstrates the strong affects and impacts of 365 AD Crete tsunami waves that arrived at most of SCZ, while Fig. 24.8 illustrates a map of the known tsunamigenic sources in the Mediterranean region and a relative scale of their potential for tsunami generation calculated as a convolution of the frequency of occurrence and the intensity of tsunami events. In this figure, West Med. Sea (WMS), East Med. Sea (EMS), Aegean Sea (AS), Marmara Sea (MS), Black Sea (BS), 1 = Alboran Sea), (2 = Liguria and Cote d'Azur), (3 = Tuscany), (4 = Calabria), (5 = Aeolian islands), (6 = Messina straits), (7 = Gargano promontory), (8 = South-East Adriatic Sea), (9 = West Hellenic arc), (10 = East Hellenic arc), (11 = Cyclades), (12 = Corinth Gulf), (13 = East Aegean Sea), (14 = North Aegean Sea), (15 = Marmara Sea), (16 = Levantine Sea). The tsunami potential of each one zone is classified in a relative scale according to the frequency of occurrence and intensity of tsunamis (Papadopoulos 2003).

24.4.2 Sea Level Rise in the Mediterranean Sea

The SLR in the Med. Sea shows a strong variability in the last century, and according to the satellite readings taken over just the last decade by the Topex-Poseidon mission corroborate observations that sea level trends in this sea are not uniform. As shown in Fig. 24.9, there are both areas of descent (the Tyrrhenian Sea and the body of water south of Italy) and areas of ascent (the eastern Med. Sea). In any case, with a rate of approximately 1.2 mm/year the observed rate of rise is significantly lower than the global average. Based on measurements of available tide-gauges the level in the Med. Sea has risen 1–1.5 mm/y since 1943 till the 1960s, and dropped few centimetres during the period 1960–1993. Then, a quick SLR of 4–5 cm took place during 1993–2000, after this there was no change. Climate figures during 1943–2008 (using marine observations) confirms that the Med. Sea is becoming warmer, salinity is increasing due to a decrease in runoff from the rivers that flow into their basins, and the SLR is accelerating. Since the start of the 21st century this level has already risen by 20 cm (Yáñez 2010).

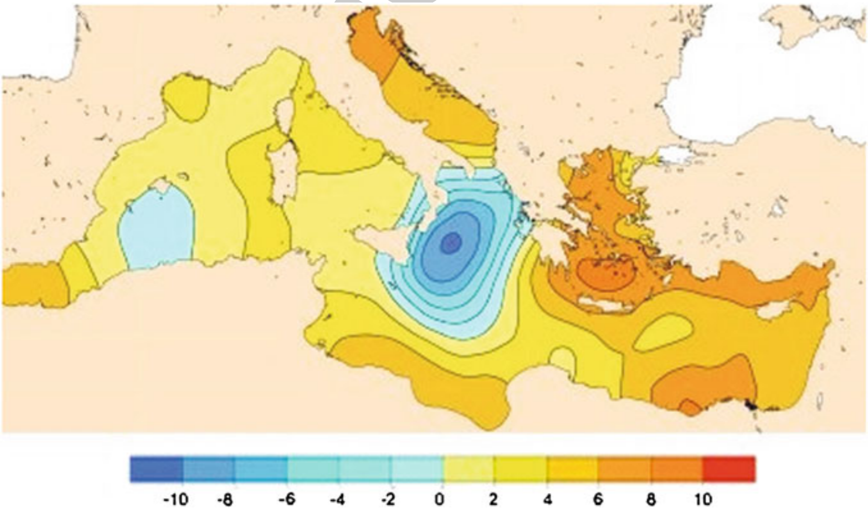


Fig. 24.9 Evolution in Med. Sea levels in mm/y from Jan. 1993 to Oct. 2004, according to the Topex-Poseidon satellite mission

This future rise during the 21st century will be mainly due to thermal expansion (30 cm), and only to a lesser degree the result of the thawing of non-polar glaciers (20 cm), and the Greenland ice sheet (10 cm) (IPCC 2001a). In addition, Med. Coast is considered vulnerable to SLR induced-flooding due to its environmental and socio-economic characteristics. It hosts valuable and sensitive habitats, such as coastal wetlands, as well as densely populated and urban developed areas and highly important economic sectors like tourism. However, SLR has been widely neglected in coastal management and planning along most of this coast (Christopher et al. 2006).

24.5 Factors of Hazards and Disasters

Disasters and hazards are tragic events to development process as they cause losing lives, disrupting social networks, and destroying economics activities. They can be narrowly confined to a locality or threaten entire regions, their intensity and probability can differ by place and this has a considerable influence on the levels of possible damage. They cut across many organizational, political, geographic, professional, topical and sociological boundaries. Therefore, there is a necessary need to integrate information and knowledge about them across many disciplines, organizations, and geographical regions (Schmidt-Thomé and Kallio 2006).

24.5.1 The Common Factors of Hazards and Disasters

These factors play a large role in determining the severity and magnitude of a disaster. They may be more or less applicable to any given society and contributes to determining the vulnerability of this society to disasters. A brief description of them can be outlined as follows: (1) *Poverty* which is the most important factor that increases the vulnerability of people to disaster. (2) *Uncontrolled population growth* that can lead to settlements in hazardous areas susceptibility to disease. (3) *Rapid urbanization and migration* which has an inevitable consequence of competition for scarce resources that can lead to man-made disasters. (4) *Environmental degradation* that can cause or exacerbate many disasters (e.g., deforestation leads to rapid rain runoff which contributes to flooding). (5) *Lack of awareness and information* which is a crucial factor in disasters that can also occur when people (who are vulnerable) have not been educated on how to get out of harm or take protective measures at the inset of a disaster.

In this chapter, the drivers and factors of coastal change and hazards in general and in Syria in particular will be discussed and analysed. They include: winds (e.g., extreme storms), waves (e.g., wave climate), sea-level variability (e.g., seasonal, interannual ENSO and interdecadel IPO cycles), river flow (e.g., extreme storms and base flows), storms and cyclones (e.g., incidence, intensity, tracks,

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 496/536

storm surge), ocean and coastal currents, and the sediment supply to the coast (Fish et al. 2005).

24.5.2 The Common Factors of Coastal Hazards and Disasters

Coast is dynamic geographical feature and constantly changing as the land and sea interact in a variety of ways. The future changes in land use in the coastal zone will be dominated by the effects of climate change and global warming (Jeftic et al. 1992). These major effects will be due to increasing sea level in combination with possible increases in the frequency and intensity of storms, change in patterns of erosion and sedimentation, increased risk of flooding, and change in the distribution and types of coastal habitats, etc. Within this context, the relative SLR can mainly be caused by the *physical and human factors*. Physical factors can be consisted of a combination of sea level change and vertical land movement, geomorphology, storminess, waves, near shore currents, and tides, etc. On the other hands, human factors are mostly related to the coastal engineering (e.g., coastal protection structures), land reclamation, river regulation works (e.g., dam construction), marinas and commercial port development, and unregulated dredging, etc. The main factors of the coastal zone changes can be represented by:

(a) *Changes in SLR* which is very likely to have a profound impact on the shape and nature of the coastline. In terms of coastal hazards, it is the trend in relative SLR that is important (i.e. the change in sea-level relative to the local landmass), and the probable changes will include the coastal erosion and flooding (IPCC 2001b).
(b) *Coastal flooding* (the inundation of land by seawater) occurs frequently in low lying areas of the coast as a result of significant storm events coinciding with periods of high tides, storm surge and high wave energy. In addition, rainfall across catchments that raises river levels will add to the flood risk and particularly in the vicinity of river mouths with the coast (Komar 1998). On the other hands, this flooding is the most devastating natural disaster because of its rapid occurrence, little lead time for warning, and tremendous amount of water flowing with high energy.
(c) *Erosion and accretion* along the coastline is common and have large effect on its shape with time and interaction of the physical and human factors (EUROSION 2004). The rates of erosion are variable due to the range of controlling factors (rock properties, angle of wave approach, groundwater). The predicted SLR (expected to be 0.14–0.18 m by 2050, and 0.31–0.49 m by 2100) could lead to a landwards retreat of the coastline of 15–20 m at beaches along the coastline over the next century (Pilkey and Hume 2001).

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 497/536

(d) *Storm surges* occur when low atmospheric pressure combined with strong winds and are the greatest threat to life and property from a hurricane (Gulev and Hasse 1999). Storm surge is an abnormal rise of water generated by a storm over and above the predicted astronomical tides. The Hurricane Katrina (2005) is a good example of the damage and devastation that can be caused by surge (at least 1,500 persons lost their lives and many of those deaths occurred as a result of storm surge). Typically coastal erosion and coastal flooding of low lying land are associated with storm-surges.

(e) *Extreme weather events* are primarily ex-tropical cyclones and subtropical storms that generate storm surges and this can raise the sea level by 0.5–0.7 m (Berz 2005).

(f) *Temperature rise* which its effects can be seen in shallow estuarine waters and salt marshes or wetlands (Shaw et al. 1998; Ellis et al. 2000).

(g) *Global Warming and Climate Change* are likely to affect most of the physical processes that drive changes along coastal margins. 'Climate change' is defined as any significant change or trend in climate-natural or human-induced, and includes global warming. "There is new and stronger evidence that most of the global warming observed over the last 50 years is attributable to human activities", according to the (IPCC 2001c). Climate change will eventually affect all the drivers, either directly, or through their interaction with other drivers. For example, global ocean tides will be unaffected directly, but tidal propagation characteristics in shallow estuaries and rivers may be altered by deeper or shallower water depths (caused by changes in sediment supply) and/or a higher sea level.

(h) *Coastal habitats* are highly important on all the levels, and not only because of the scarce species of plants and birds that it supports, but also because they can act as a natural dissipater of tidal currents and waves and hence protect sea defences (Möller and Spencer 2002). They are under pressure from SLR, land reclamation for development and coastal squeezes. These squeeze result in steeper and narrower coastal zones when the ability of intertidal habitats to migrate inland in response to SLR is impeded by fixed coastal defence structures (Taylor et al. 2004).

24.5.3 Current and Future Drivers of Coastal Changes in Syria

The Syrian coastline (even it is short) has an array of geomorphological features: sandy shores, cliffs and rocky shore, hilly and flat coastal plains, narrow and wide coastal shelves, and wide variety of wetlands as shown in Fig. 24.3. Therefore, it is important to distinguish between the different environmental drivers of physical and ecological changes in coastal margins as follows:

(a) *Global Warming and Climate Change* Climate change impacts will vary locally as a result of local and regional differences in both the physical forcing functions (e.g., waves, winds, currents, sea level, etc.) and coastal types. Syria

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 498/536

is not a major contributor in the emission of greenhouse gases, but like other countries, it is affected by the impact of probable global climate change that characterized by modifications in global precipitations and increased sea levels. Syria has recognized the importance and threats related to climate change and hence joined international efforts to combat them, ratifying the United Nations Framework Convention on Climate Change (UNFCCC) in 10 December 1995, and signed the Kyoto Protocol on 4 September 2005. Moreover, Syria has been openly realizing the importance of raising awareness on climate change, which would help the implementation of proper measures in order to reduce the possible negative impacts. The UNFCCC of 1992 is one of the recent series of Conventions which most countries have joined to combat this global challenge. The enabling activities for the preparation of Syria's initial national communication (INC project) are being implemented by the Ministry of Environmental, in collaboration with the Global Environmental Facility (GEF) and UNDP (Meslmani 2010).

(b) *Sediment Supply* Sediment sources and pathways sediments sinks can be affected by several factors including: catchment geology and rainfall, river flows, frequency and magnitude of storms river controls (e.g., dams, abstraction for irrigation), sand and gravel extraction for aggregate, ocean wave climate, prevailing winds, alongshore currents, the type of foreshore and its sedimentary composition. Sediment scarcity enhances the effects of storms

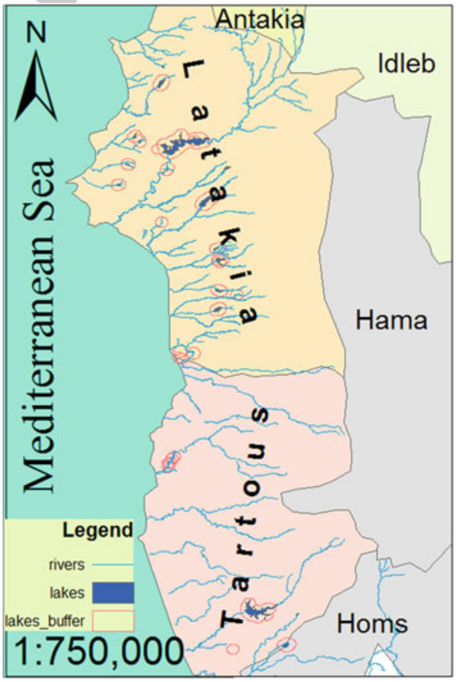


Fig. 24.10 The Surface water system in Syrian coast "Tartous and Lattakia". (Main Rivers and Lakes are surrounded by *Red circle* for clarity)

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 499/536

and SLR and may be more significant than both for erosion of dunes and beach. In the Syrian Coastal Basin as shown in Fig. 24.10, the surface water is the main source of the sediment supply.

(c) *Flash Flood* This disaster is a local problem and needs to be defined in its local and regional context based on: timely observation of rainfall events; and more demand on numerical weather prediction centres to produce more accurate data. The Syrian coastal region prone to flash-flood caused by torrential rain, and during the period 2009–2010, different parts in this region were subjected to heavy rain storms leaded to flash floods.

(d) *Seismic Deformation and Tectonic Changes* can over a short time frame have a much larger local impact on relative SLR than the gradual SLR expected from global warming. Syria has a long history of seismic activity, and over 2000 years of recorded history reveal more than two dozen magnitude 7 earthquakes in the vicinity of these Eastern Mediterranean countries (Ambraseys and Barazangi 1989). A major earthquake hit Syria on May 31, 526, killing approximately 250,000 people. The earthquake was followed by many aftershocks and a great fire that destroyed most of the buildings left standing by the earthquake. On 11 October, 1,138, another big earthquake

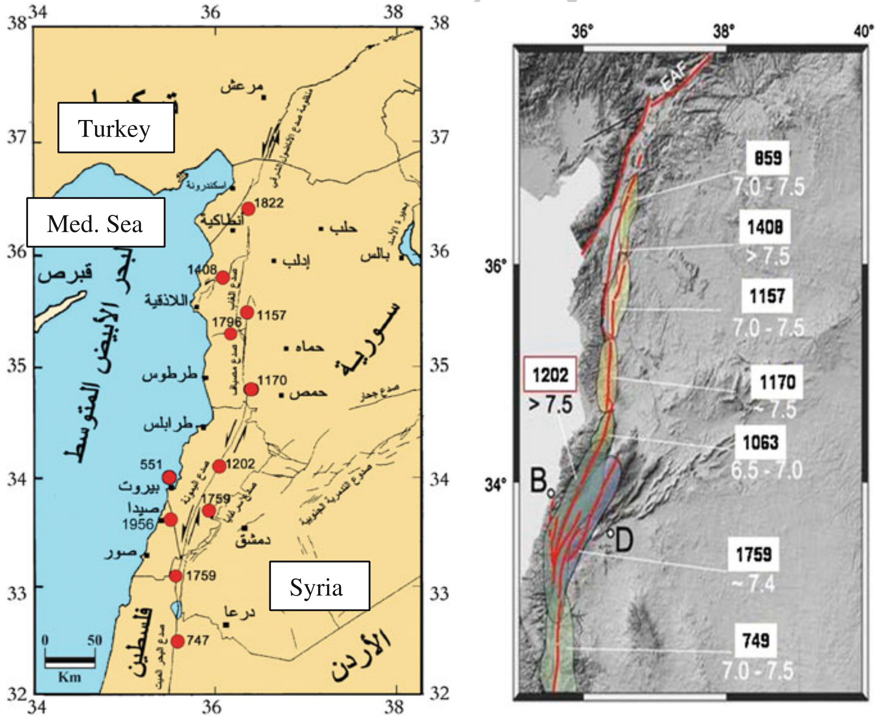


Fig. 24.11 The distribution of the historical seismology surface centres in the North of the West Northern of Syria

occurred in Aleppo and it killed 230,000 people in one of the deadliest seismic events in world history. It was felt over a part of the Eastern Med. Sea, and was accompanied by a tsunami. In 1759, a massive earthquake (estimated at more than 7.0 on the Richter scale) destroyed Damascus and the Lebanese city of Beirut. Today, the western region of the country continues to be the most susceptible to seismic activity (Gomez et al. 2001).

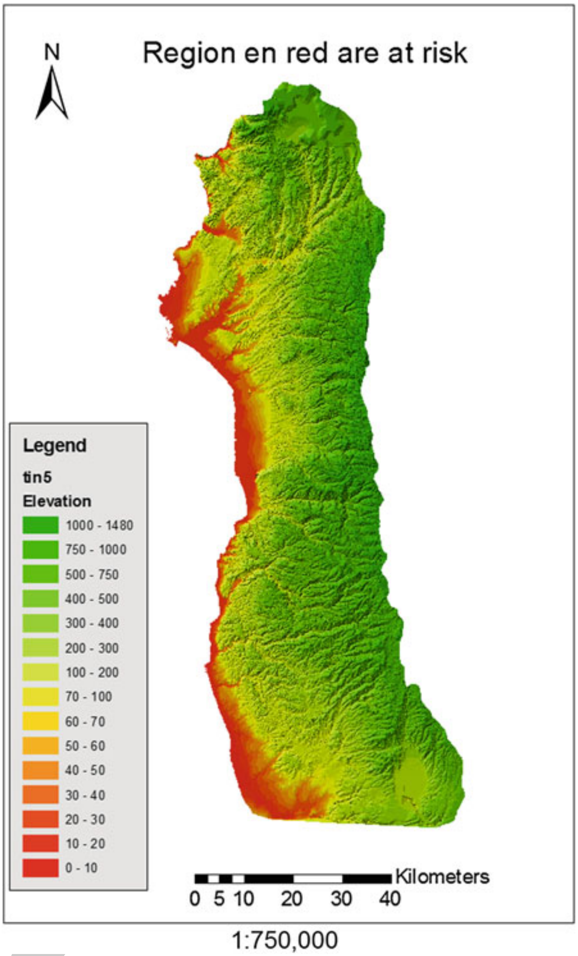
The bulk of the seismicity—and most of Syria's population—is concentrated in western Syria, and is related to the Syrian-African fault system (Dead Sea Fault System DSFS) between Antioch, Turkey, and the Gulf of Aquaba as shown in Fig. 24.11. DSFS formed as a result of the breakup of the Arabian plate from the African plate since the mid-Cenozoic, and is one of the largest continental strike-slip faults in the World. It represents a key tectonic feature in the Eastern Med. region. This call for critical evaluation of seismic hazard involving major cities in Syria so that proper mitigation measures (both structural and non-structural) may be undertaken before it is too late.

(e) *Human activities and other factors* These activities can be seen in coastal developing and infrastructure, coastal engineering structures, beach and dune nourishment, dredging (channels, inlets, canals), river modification (dams, levees), fluid (oil, gas, water) extraction. Other factors, can be seen in storm events (tropical storms, hurricanes, extra tropical storms), daily coastal processes (waves, currents, and winds), geological framework and character, geomorphology (slope and elevation) (Fanos 1995).

(f) *SLR, coastal flooding and inundation impacts* There is often confusion over the difference between erosion and inundation under a SLR, because both cause a loss of land from the coastal margin. Erosion involves the physical removal of sediment from the beach by waves and currents and causing physical change in the coastline structure. Inundation, by contrast, is merely the permanent intertidal submergence of low-lying land or marsh and does not involve sediment movement. However, inundation may facilitate erosion (Leatherman 2001). A rising MSL will initially cause more frequent coastal flooding of peripheral areas of coastal margins by extreme tides and storm surge by the mechanisms. In order to assess the possible impact of SLR on coastal areas, a digital elevation model for the entire coastal zone (DEM) was built using the ArcGIS software as shown in Fig. 24.12. A quick glance at this figure, may suggest that Syria's vulnerability to SLR is low due to the extensive lengths of high rocky or cliffed coast. Also, in this figure with 5 m SLR, some cliffed coasts are eroding at high rates such as in the north of Lattakia, which may worsen with increased storminess and SLR.

However, the most vulnerable areas are where the urban centers, ports and holiday resorts cluster around low-lying portions of the coastline, such as harbours, estuaries, beaches, inlets and bays. The scenario for a tsunami with magnitude of 7.5 Richter and its centre 160 km from the coast is proposed. This will result in

Fig. 24.12 The SCZ vulnerability to SLRs for different heights



SLR caused by a wave that its high will reach till 15 m at the shore and its impacts will expand till 5 km from the coast inside the region within 20 min. With just a 1 m rise in the Med. Sea, more than one million people are predicted to be displaced and 1,000 km^2 of agricultural land will be lost. These high risk areas include parts of Lattakia, Tartoush, Banias and Jablieh. In addition, several other areas, such as those near the Turkish and Lebanese borders have also been identified as risked zones. However, the impacts may cover many aspects including impacts on water resources, agricultural and health resources, and the concentration will be on the city of Lattakia as will be discussed in Sect. 24.7.

Layout: T1 Standard SC Book ID: 310227_1_En Book ISBN: 978-3-642-40694-2
Chapter No.: 24 Date: 15-11-2013 Page: 502/536

24.6 The Common Effects and Impacts of Disasters

It may not be feasible to control nature and to stop the development of natural disasters, but the efforts could be made to avoid them and minimise their effects on human lives and infrastructure. For example, the effects of SLR will vary by location and depend on a range of physical, biological characteristics, and socio–economic factors as will be discussed in the following sections.

24.6.1 Social Impacts

Disasters destroy social network and other impacts can be related to the unemployment: people lost their jobs and forced to migrate to major cities causing problems and loss of security. For example, the heat wave of the summer 2003 claimed lives of 70,000 deaths in most European countries (EEA-JRC-WHO 2008), and the 1999 Izmit (Turkey) earthquake claimed lives of more than 17,000 fatalities. With regards to the social and cultural impacts of SLR, they can be discussed and analysed in terms of how resource use will be affected leading to displacement and resettlement, and how these changes will affect social relations regarding orientations toward the customary environments.

24.6.2 Economic Impacts

Disasters cause serious impact with direct and indirect losses on the economy by reducing the productivity of the national economy (infrastructures, commerce, industry). For example, the economic toll of natural hazards in Europe during 1998–2009 amounted to approximately 150€ billion (EM-DAT 2010).

24.6.3 Environmental, Physical, Ecological, and Geographic Impacts

These impacts can be seen on water, land/soil, crops, lake, forests, livestock, wildlife, atmosphere, energy, pollution, etc. The primary ecological impacts will stem from a rise in temperature, inundation by a higher sea level, and a loss of habitat from increased siltation in some estuaries and harbours, while in others there will be a loss of intertidal areas caused by constraining shoreline protection structures or embankments. The most serious physical impacts of SLR on coastal margins can be: (1) coastal inundation causing landward movement of estuaries, wetlands and marshes, (2) coastal erosion and shoreline change through sediment movement, (3) increased vulnerability to coastal storm damage and flooding, (4) increasing difficulty draining coastal and river lowlands, (5) the possibility of increased sediment loads to estuaries, with projected increases in rainfall intensity and run-off, (6) surface water, river water and groundwater in lowlands increasingly becoming saltier from seawater intrusion, etc. Vast areas of scarce land into the rivers and the ocean were lost due to erosions (Bell et al. 2001).

24.7 The Main Effects and Impacts of Local Sea Level Rise Scenarios: Focus on Lattakia City

SCZ constitutes particularly important regions economically, socially and culturally. In addition to increased tourism activities, tremendous move towards building new industrial complexes such cement and textile factories, power stations, petrol refineries, etc. This zone is therefore particularly vulnerable to the impact of SLR due to its relatively low elevation, salt water intrusion, soil salinization, excessive erosion rates, the deterioration of coastal tourism and the impact of extreme storms and flash floods. This in turn will directly affect the agricultural productivity and human settlements, management and access to archaeological sites, reduce tourism, and result in socio–economic impacts on the inhabitants of these areas. In addition, this coastal zone suffers from a number of problems, including a high rate of population growth, unplanned urbanization, land subsidence, land use interference, ecosystem pollution and degradation and lack of appropriate institutional management systems.

Lattakia has the main harbour and hosts about 30 % of the country's industrial capacity. This city is located in the northern western part of Syria with 229,690 ha of hilly terrenes, and total population about 1,350,000 (2010); 9.1 % working on the agricultural, 0.4 % fishing, and the rest working on industry, commerce, and professional skill, etc. In addition to the main port, there are 5 fishing ports with 677 fishing boats and 1,500–1,800 fishing men. Other vulnerable cities are Tartous, Banias, and Jablieh. Figures 24.13 and 24.14 illustrate the two scenarios for a SLR for 1 m and 5 m respectively, while Table 24.3 shows six scenarios that were developed for a SLR ranging from very low to extreme risk. The likely inundated sea shore area varies between 17.56 km^2 in a very low risk scenario to 118.90 km^2 in an extreme risk scenario. The results of these scenarios indicate that different segments of the coastline are vulnerable to a SLR as a consequence of expected climate change. This rise would have an impact on beaches, urban settings, and agricultural zones. Moreover, additional problems may arise due to salt water intrusion and increase in water and soil salinity. The socioeconomic impact of a SLR on coastal lowlands would vary depending on the flood levels, the degree of land use and development activities. Applying the extreme risk scenario shows that nearly 3.8 % of coastal populations will be affected by a SLR.

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 504/536

Fig. 24.13 The Lattakia's coast line vulnerability to SLR with 1 m high

24.7.1 Population Impacts

Population increase was accompanied by a remarkable increase in population density in most Syrian governorates between 1970 and 2007, and the average population density was 34 inhabitants/km^2 in 1970 and increased to 49 inhabitants/km^2 in 1981. As shown in Fig. 24.16 there is a clear disparity in the levels of population density from one governorate to another, since the highest density was noted in the Damascus governorate, with 7,090 inhabitants/km^2 in 1970 and with the very high figure of 13,152 inhabitants/km^2 in Damascus in 2006. The governorates of Lattakia and Tartous also registered high densities reaching 383 inhabitants/km^2 in Lattakia, and 376 inhabitants/km^2 in Tartous. It was also noted that Lattakia's population would be most severely impacted by SLR within the SCZ. With a 1 m SLR, approximately 8 % of Syria's population would be impacted, and most of this impact takes place in the Lattakia which will have 15 % of it affected with a 5 m SLR. The proposed scenario of SLR in Fig. 24.15 will make Lattakia a disastrous city as most of the population density is concentrated on narrow area of the cost with width of 4.5 km. Table 24.4 shows the different heights of some areas which receive various effects according to their heights. Syrian coastal population is exposed to the effects of SLR as the population is expected to double before the year 2050.

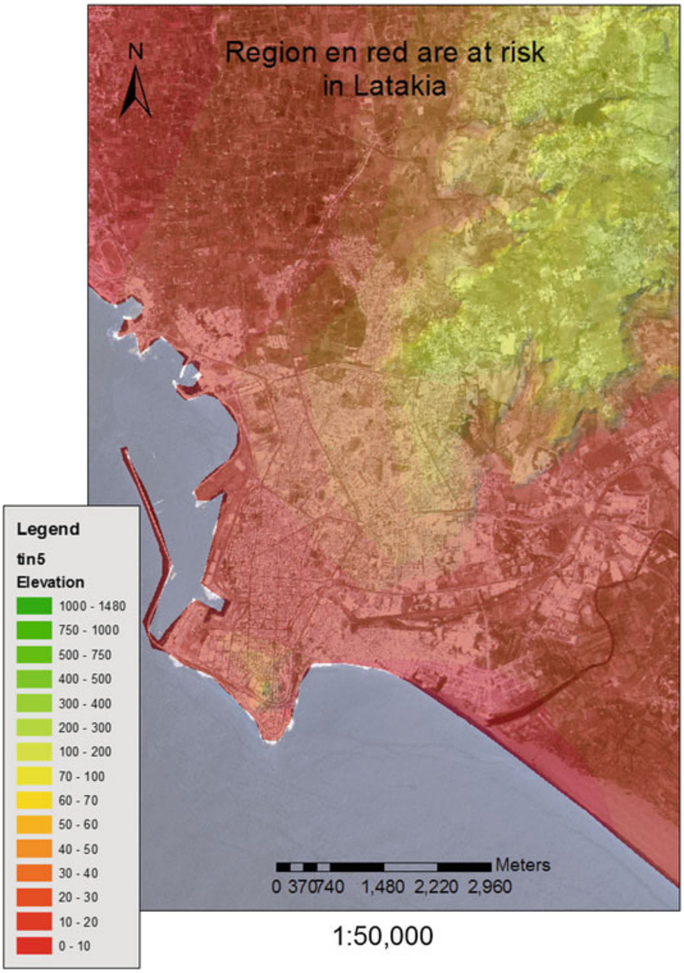


Fig. 24.14 The Lattakia's coast vulnerability to SLRs with different heights

Table 24.3 Inundated areas in 2100 according to various scenarios of a SLR

Scenario	Trend (cm/year)	Variation 2000–2100 (cm)	Inundated area (km^2)
Very low	0.6	63	17.56
Low risk	0.9	90	20.27
Moderate risk	1.3	130	23.89
Intermediate risk	1.9	1.9	27.57
High risk	2.5	250	30.35
Extreme risk	>5	500 up to 750	118.90

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 506/536

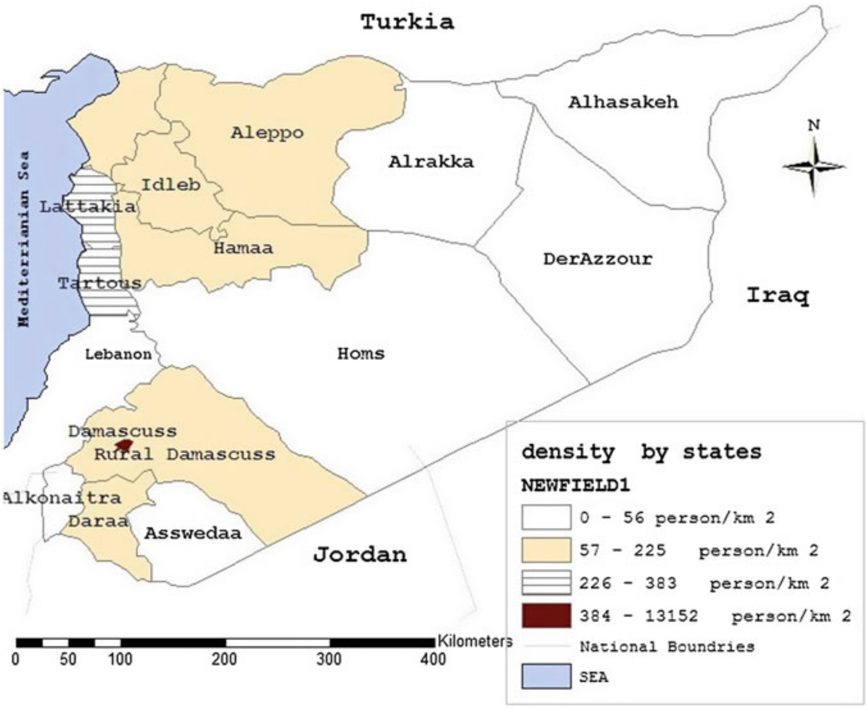


Fig. 24.15 The main Governorates and population density in Syria

Table 24.4 The heights of some areas in Lattakia and their distances from the shore that might subjected to various impacts of SLR

The main locations in the city	Height from the sea (m)	The distance from the shore (km)
Industrial City	7	4.5
The Sporting City	5	0
The Castle	75	1.5
Tishreen University	18	1
The Tobacco Factory	2	0.5
The Southern Sand Area	12	0.65
The Blue Coast Area	3	0
Al-Hussaynee Street	43	1
Saed Zaghloul Street	23	0.5
Abid Nasser Street	10	0
The Besnada Area	85	4.5
The Damsarkhou Area	8	1.5
The Southern Kournesh	30	0
The Main Train Station	15	1.8
The Bahlolieh town	177	15
The Qanjerah town	64	5.25

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 507/536

24.7.2 Environmental, Health and Socio–Economic Impacts

The Med. coast is considered particularly vulnerable to SLR-induced flooding due to its environmental and socio–economic characteristics. It hosts valuable and sensitive habitats, such as coastal wetlands, as well as densely populated and urban developed areas and highly important economic sectors like tourism. However, continuous SLR is expected to enhance rates of erosion of north Lattakia city's coastal zone, and the contingency plans that suggested by the GoS which aim to protect the tourism industry in the first place, but are not directly related to the impact of climate change and SLR. Additional adaptation measures are needed to target climate change and that this will be less expensive for the tourism industry than losing the beach completely. Loss of beaches will reduce the number of tourists in coastal areas, forcing tourism dependent individuals and communities to abandon their settlements and look for jobs elsewhere. The risks may be particularly severe in poor neighbourhoods and slums, where infrastructure is poorly designed. Generally, fundamental and low-lying installations in Lattakia are threatened by SLR and the recreational tourism beach facilities are endangered of partial and even full loss. Moreover, increased water logging and salinity may catalyse insect and pest problems causing health problems (Muslemani 2010). It may lead to group migration of farmers looking for jobs somewhere else. Nearly 2,000 agricultural families (and another 4,000 in the case of the extreme scenario) will be in danger of losing their economic subsistence.

Direct and indirect implications on the socioeconomic systems are important factors that have to be taken into consideration. The loss of land productivity will force a large number of farmers and/or fishermen to move away from the non-fertile land or fishing grounds and go searching for jobs. Table 24.5 shows possible economic losses due to a rise in sea level of 2.5–3 m. Reducing vulnerability to such threats is a major challenge to sustainable development and land use strategies. Coastal defence engineering is costly, while managed coastal retreat implies sacrificing private property and usable natural resources. In this study, the available land-use data, topographic and socio-economic data were used to calculate the

Table 24.5 Possible economic losses due to a SLR of 2.5–3 m along the SCZ

Scenario	Total economic loss (in millions of S.P.)
Citrus plantations	13,205
Olives	432
Greenhouses	8,303
Crops	15,023
Forest	191
Sandy soil	1,800
Urban areas	10,900
Total	49,854 ≈ 1 Millions USD

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 508/536

approximate numbers of people expected to be affected by SLR. It is estimated that with a SLR of 1 m in Lattakia will cause a displacement of almost 350,000 people and the loss of about 10,000 jobs. Also, changes in the ecological system of lakes will reduce fish catches and drive away a large portion of fishermen and their dependants.

24.7.3 The Impacts on the Water Resources

Syria is one of the Mediterranean countries that has proved vulnerable to water stress caused by climate change and SLR. A combination of salt water intrusion due to SLR and increased soil salinity due to increased evaporation are expected to have direct impact on quality of shallow groundwater supplies and drainage conditions, agricultural productivity and socioeconomic and health implications. SLR is expected to cause a landward shift of the salt wedge and to increase the rate of saline seepage to the topsoil of the coastal region. The main source of water in the coastal region is the surface water and due to the high rate of rain full that feed the springs rivers. The main coastal rivers are: the Northern Big Rive with length

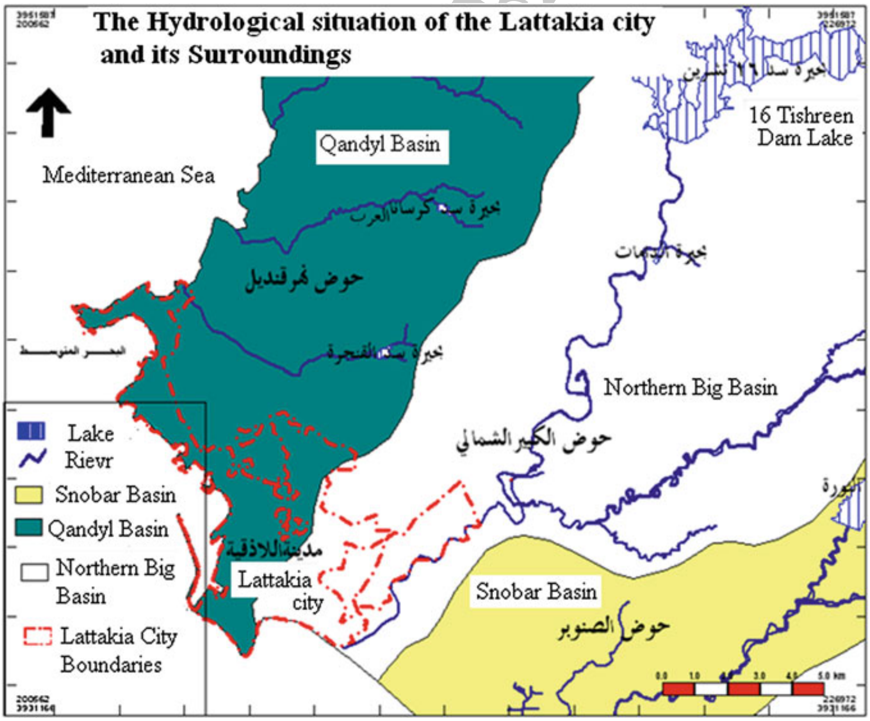


Fig. 24.16 The hydrological basin of the Lattakia city and its surroundings

Layout: T1 Standard SC Book ID: 310227_1_En Book ISBN: 978-3-642-40694-2
Chapter No.: 24 Date: 15-11-2013 Page: 509/536

of 96 km, the Southern Big River with length of 56 km, the Sin River with length of 6 km. Also, there are many lakes and surface dams with storage capacity of 357 MM^3. The accelerated SLR and the stronger influence of tidal flows penetrating these lakes will enhance the changes in the salinity conditions of these lakes which may affect their ecology and fisheries as shown in Fig. 24.16.

During the last decades, after the construction of the several dams, sediment input in some parts of the coast has been strongly reduced, and this resulted in serious shore erosion and salt water intrusion. Moreover, the construction of human-made waterways for irrigation and transportation has trapped an already depleted sediment supply to the some large coastal zones. The protective sand belt of some parts of the SCZ is facing rapid erosion, which has been a serious problem since the construction of the several earth dams on these rivers. SLR is expected to destroy weak parts of this belt, which is essential for the protection of lakes and the low-lying reclaimed lands. The impacts will be very serious as an important part of Syria's fish catches are made in these lakes.

24.7.4 The Impacts on the Agricultural and Food Resources

The agricultural sector plays a significant role in the Syrian national economy contributing about 30 % of the GDP. It supplies the overall food needs of the country and provides the domestic industry with agricultural row materials. It is expected that with a 1 m SLR, approximately 8.5 % of Syria's agricultural extent would be impacted, and this percentage reaches 25 % with a 5 m SLR. Livestock and fisheries are also vulnerable to the impacts of climatic changes and SLR. Moreover, climate change will probably affect water resources and that might pose another problem for agricultural and food production. It was deduced that the large incremental impact of SLR on agricultural areas in SCZ arises in Lattakia and its surroundings as shown in Fig. 24.18.

It is very difficult to precisely evaluate the socioeconomic impact of SLR on

Table 24.6 Impacts of SLR on Land-use/Cover

Scenario	Very low risk: 0.6 m	Extreme risk: 5–7.5 m
Land cover	Area in sq km	Area in sq km
Citrus and other plantations	3.14	37.51
Forest	0.41	2.21
Olives	0.19	1.51
Greenhouses and field crops	2.05	33.63
Sandy soil	0.99	7.98
Urban areas	5.12	16.73

local communities in affected areas. Based on land use categories in these areas, a rough examination of economic losses as a result of SLR alone reaches

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 510/536

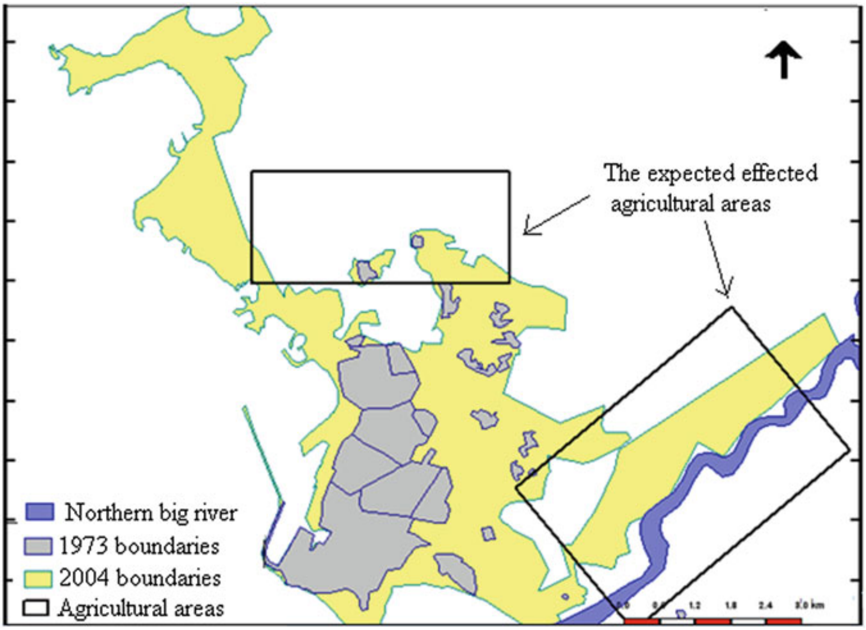


Fig. 24.17 The informal expansion of the Lattakia city and the expected effected agricultural areas by the SLR

50 billion Syrian Pounds as shown in Table 24.6. This figure represents direct average economic losses resulting from permanent disappearance of 4,108 ha of agricultural and forested areas, 450 ha of beach and 1,090 ha of urban area. However, these losses may go down to 10 billion S.P. in case of a SLR of 0.6 m and may reach 84 billion S.P. if the extreme SLR scenario is justified (FAO 2007) (Fig. 24.17).

24.8 Disaster Management Cycle and Risk Reduction Measures

Disaster Management (DM) is a multidisciplinary area that involves monitoring, preparing, warning, forecasting, supporting, evacuation, search and rescue and then re-building society when disasters occur. It requires response, incident mapping, establishing priorities, developing and implementing action plans to protect lives, property, and environment. Several and exact interconnecting steps are typically required to generate the type of action that needed by the DM community (Alexander 2002). With regards to the Risk Reduction (RR) measures, can be defined as any system, procedure, process or device that are intended to

Layout: T1 Standard SC Book ID: 310227_1_En Book ISBN: 978-3-642-40694-2
Chapter No.: 24 Date: 15-11-2013 Page: 511/536

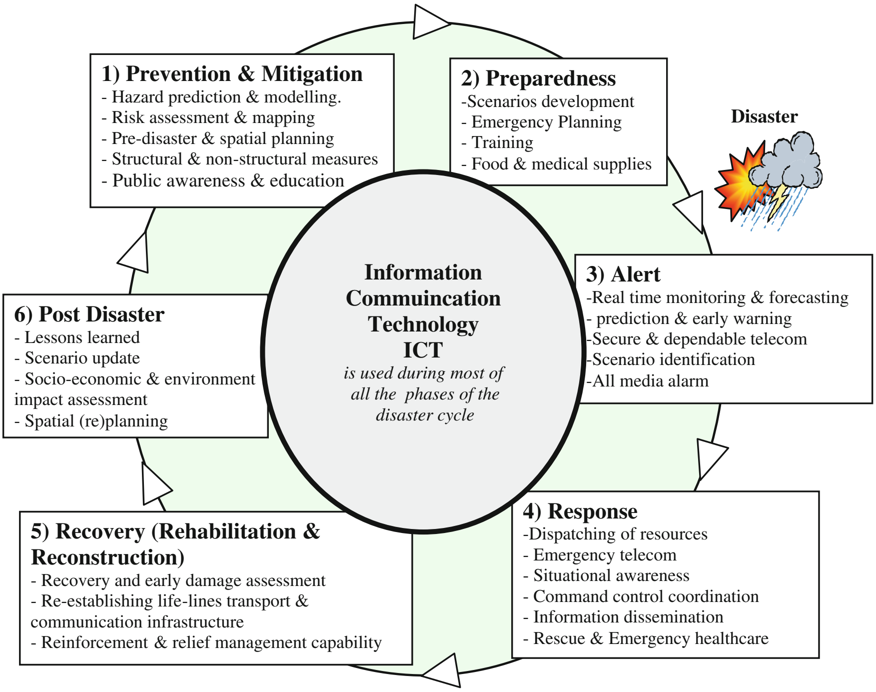


Fig. 24.18 The disaster management cycle

eliminate hazards, prevent hazardous incidents from occurring or reduce the severity of consequences of any incident that does occur. These measures can be recognised while identifying hazards and employers should be able to identify a range of control measures immediately, both the existing measures and possible alternatives. The following sections present the general framework for the DM cycle and all its phases that differ according to the type of a disaster.

24.8.1 Disaster Management Phases

DM activities, generally, can be grouped into six main phases that are often illustrated in the so-called risk or DM cycle. These phases are related by time and functions to each other, and to all types of emergencies and disasters. Each phase involves different types of skills and data from a variety of sources, and the appropriate data has to be gathered, organized, and displayed logically to determine the size and scope of DM programs. Figure 24.18 depicts the framework for DM cycle with its six phases as follows:

24.8.1.1 Prevention and Mitigation Phase

Prevention and mitigation phase represents the reduction of long-term risk to human life and property from any kind of hazard taking place before the disaster occurs. It includes pre-disaster activities that prevent a disaster, identify and assess the risk, minimize the possibility of its occurrence or reduce its potential effects. These activities can consist of: registering past disasters and major natural events, carrying out precise studies that include specific geological and climatic hazards and their causes in the national or regional setting, updating of hazard maps and vulnerability profiles, determining and analysing the potential, origin, characteristics and behaviour of the hazards. Other post-disaster legislative activities that requires building codes in earthquake prone areas, limits building in earthquake, and insurance programmes (Pearce 2003).

24.8.1.2 Preparedness Phase (Preparation and Emergency Management)

Preparedness and emergency management phase which is a short term action includes measures taken in advance to ensure effective response to the impact of a hazard. These measures should be undertaken as soon as a disaster warning has been received, and are related to timely and effective warnings, evacuation, and temporary property protection. The preparations on how to respond in case of an emergency to save lives and minimize disaster damage have to be made and developed by several complementing bodies such as governments, organizations, and individuals. Some non-exhaustive examples of these preparations are; building up and strengthening local and national disaster preparedness capabilities, implementing developmental plans that provide resilience to disasters, carrying out and mounting training disaster preparedness exercises, and installing EWS.

24.8.1.3 Alert Phase

Alert phase supports EW process such as real time monitoring and forecasting, secure and dependable telecom, and all media alarm. An effective EWS can be achieved by the provision of timely and accurate information through identified institutions that allow groups and individuals exposed to a hazard to cooperate and take serious actions that avoid or reduce the risk and prepare for effective response. Some practical studies has been carried out in the domain of flood control and management using decision support system based dynamic optimisation and spatial planning (Saleh and Allaert 2009b).

Layout: T1 Standard SC Book ID: 310227_1_En Book ISBN: 978-3-642-40694-2
Chapter No.: 24 Date: 15-11-2013 Page: 513/536

24.8.1.4 Response Phase

Response phase is the implementation of set of actions that provide short-term emergency aid assistance for causalities and save lives during and immediately following the occurrence of the disaster. These actions can include: search and rescue operations, evacuation, emergency medical services, emergency shelter, medical care, and mass feeding, etc. Response mechanisms refer to the actions to be taken and pre-planned for disasters between the community and the responding agencies. These mechanisms allow for a structured response to different disasters and ensure that response actions and resources are not duplicated (Murphy and Gardoni 2007).

24.8.1.5 Recovery Phase (Rehabilitation and Reconstruction)

Recovery phase represents the final step of post-disaster actions within the DM cycle and starts when the disaster is over. This phase includes actions that assist a community to recover and restore the living conditions of the affected population and then return to a sense of normal after a disaster. These actions are divided into main two sets:

- *Short-term recovery actions* that restore services and systems and return their vital life support to minimum operating standards. These actions can include cleanup, assuring injured people have medical care, temporary housing or shelter to citizens who have lost homes in the disaster, access to food and water, etc.
- *Long-term recovery actions* that may continue for a number of years until the entire disastrous area is either completely restored or redeveloped for entirely new purposes (that are less disaster-prone). These actions can include community planning, replacement of homes, water systems, bridges, developing measures for future prevention (e.g. watershed management, resource conservation, etc.).

24.8.1.6 Post Disaster Phase

Post Disaster phase includes lessons learned, scenario update, socio-economic and environment impact assessment, Strategic Environment Assessment (SEA) and spatial re-planning (Oliver-Smith 1992). With regards to the this phase and to the obtained results related to the SLR, it has been stated that the Government of Syria (GoS) had been working for the past 30 years on sea erosion reduction and shore protection measures particularly by constructing dams on the main rivers in the coastal areas. Furthermore, water institutions and centres are working on all the aspects to reduce or eliminate some of the negative impacts of SLR on water resources. It has planned to improve water sanitation coverage for urban and rural areas, and optimise the use of water resources by improving irrigation efficiency and agriculture drainage-water reuse. There is an urgent need to construct concrete sea walls to protect beaches from SLR. In addition, several measures could be utilised to deal with the impact on the coastal zone corridor, including beach nourishment (deposition of sand onto the beach), construction of breakwaters, setting regulations to restrict development in vulnerable areas, changes in land use and Integrated Coastal Zone Management (ICZM) principals.

With regards to the SEA, which is a decision-aiding tool, can effectively complement the process of strategic planning of the post disaster phase. It can be considered a dynamic process in which the environmental considerations are assessed and reassessed as they are changed or adapted, then investigating all the significant environmental effects and considering relevant alternatives for making decisions. The main focus is "*How SEA can effectively be linked to planning in order to contribute to DRR in SCZ?*" This can be achieved by answering the following question: How can implementation of SEA strengthen the efforts to integrate environmental considerations in planning the current and future master plan of the city of Lattakia? With regards to the environmental pollution problems in this city are solved by introducing environmental management techniques such as control of pollution at source and providing of sewage treatment facilities, etc. However, environmental risks are not being controlled completely by such solutions. Presently, in some cities, the environmental aspects are not usually considered while preparing master plans or regional plans and the process is skewed towards developmental needs. The environmental aspects are to be induced into each of the developmental activities at the planning stage itself and are to be well co-ordinated and balanced. The present work details the need for usage of environmental planning as a tool for environmental protection and the priority actions needed to be taken in Syria.

Problem analysis and necessary measures can be determined after planning alternatives have been assessed. The more complex the alternatives are, the more likely formalised assessment methods like cost-benefit analysis or value-benefit analysis have to be taken into consideration. After the discussion of all alternatives has been completed, the third phase of the planning process can begin. The relationship between comprehensive spatial planning and sectoral planning divisions is a crucial factor for mitigating spatial risks. In the following section, risk assessment and management will be understood as the systematic application of management policies, procedures and practices to the task of identifying, analysing, assessing, treating and monitoring risk. Figure 24.19 depicts the proposed geographical locations of the expanding and re-planning the city of Lattakia considering some control measures of the impacts of SLR and other related hazards such as building some dams to control the flash flooding, and where to build the settlements far from the effect of industrial city and the effect of SLR.

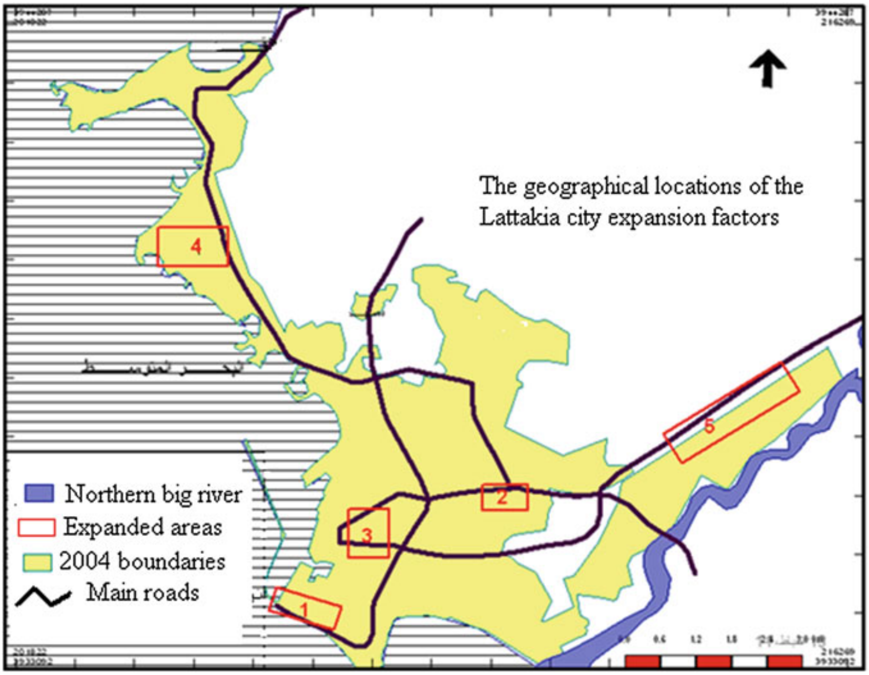


Fig. 24.19 The proposed geographical locations of the expanding Lattakia city considering some control measures of the impacts of SLR and other related hazards

24.8.2 Disaster Management and Disaster Risk Reduction Planning Activities

The square of the Lattakia city was doubled 4 times in less than of 40 years, and this indicate that the city is great centre, but in the absence of the regional planning and DM. For the proposed master plan for the city of Lattakia as shown in Fig. 24.20, the main steps of DM planning process will be described and complemented by a description of how the steps of risk assessment and management can be integrated into the spatial planning process for the city to reduce the risk of SLR and other related hazards.

During the DM planning process, several steps have to be considered to bring DRR and development planning concerns closer as follows: (1) The collection step of basic data on disaster risk and the development of planning tools for tracking the relationship between development policy and disaster risk. (2) The dissemination step of best practice in development planning and policy for reducing disaster risk. (3) The assessment step for providing a climate change scenario, and consisted of: (a) hazard assessment (historical profile of disasters, predications of trends in natural disasters related to climate change), (b) vulnerability assessment (geographical locations, transportation networks, communication networks, shelters in the event of

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 516/536

Fig. 24.20 The master plan of the Lattakia city

disasters, water and sanitation, health, livelihood), (c) capacity assessment (DM plans in project areas, coping strategies of communities, role of people in activities of mitigating disaster impacts, proposed adaptation measures). (4) The planning step is to find safer master plans through integration development plan into DRR. This step can include finding scenarios for training (climate change, codes) and identification of issues and properties. (5) The implementation step of the proposed plan through several projects (with cooperation of co-financing with local governments). These projects can include construction of shelters, roads, sanity, distribution of rescue and warning equipment, etc.

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 517/536

24.8.3 Advances in Disaster Risk Reduction and Management

In recent years, policies for disaster risk reduction and management have shifted from defence against hazards (mostly by structural measures) to a more comprehensive and integrated risk approach (as shown in Fig. 24.20). Within Integrated Risk Management (IRM), the full DM cycle should be taken into consideration when dealing with any type of disaster. The implementation of IRM is currently taking place at both international and national levels and is promoted by several initiatives (IDNDR 1999). In the 2005 World Conference on Disaster Reduction, Hyogo Framework for Action (HFA) was launched as a global plan for building the resilience of nations and communities to disasters during the period 2005–2015. HFA has been adopted by 168 governments (including Syria) with aim to reduce losses from disasters substantially by 2015 in terms of lives, social, economic and environmental assets of communities and countries. More specifically, the *three goals* of HFA are: the integration of disaster risk reduction into sustainable development policies and planning, the development and strengthening of institutions, mechanisms and capacities to build resilience to hazards, and the systematic incorporation of risk reduction approaches into the implementation of emergency preparedness, response and recovery programmes.

According to the national report on the status of progress in the implementation of the HFA in Syria (2009–2011) (SYR-HFA 2011), http://www.preventionweb.net/english/hyogo/progress/reports/v.php?id=17404&pid:223//substantial work has been done on this subject at national, regional and international levels, and can be classified as follows:

1. The development of legislation governing the structure and operation of DM, incorporating the subjects of preparedness and DRR in government development plans and linking it with the sustainable development process.
2. The database for hazards is being analyzed to be used in the future regional planning, also work is undergoing on improving coordination and cooperation between various stakeholders to unify and develop this database.
3. There are EWSs being developed for different types of risks such as wild fires through installing new equipments for predicting the occurrence of fires, and EWSs for oil spills and oil pollution on beaches. With regards to EWS towards drought, work is under going to use remote sensing, and automated monitoring system for meteorology which can help in predicting dust storms. In addition to the above, there is an EWS for predicting earthquakes placed near seismic faults.
4. With regards to the professional DRR education programmes, an MSc degree in the field of disaster and risk management in cooperation with Damascus University has been established. It aims to prepare specialized team in disaster prevention and response in which the author of this chapter has been participating in establishing the course and teaching activities.

5. The cooperation and strengthening partnerships between the public and private sector are reflected in the modern industrial cities through the identification of risks and prevention procedures. In addition to that the private sector puts under the disposal of governments agencies concerned with disaster mitigation all the available capabilities such as materials, equipments and human resources that can enhance the ability of society to response and reduce the risks.
6. Laws and legislations have been put under implementation to ensure the safety of hospitals, schools and other governmental constructions. Also, the executive instructions have been issued to ensure correct construction and taking into account public safety conditions in all buildings that are newly created. In addition, effective interests have been carried out in schools through the system of preventive maintenance and periodic inspections.
7. The 11th Five Year Plan (FYP) (2011–2015) had added a clear strategy for safety through prevention, EW, preparation, response, recovery and rehabilitation. It includes DRR in its strategies, but the essential point is in the implementation of these strategies and the availability of necessary funds.

The overall challenges that face the GoS in proper implementation of HFA are: there is still lack of knowledge towards DRR on different levels, and the emergency management plans are still lacking the prevention phase of the DM lifecycle.

24.8.4 Complementing Disasters Risk Management

This section focuses on capacity building in relation to disaster risk management, and includes principles for training and tools that can be useful to build up skills at all levels. It presents the most recent processes that have been made through advances in EW and observing systems, communications, and how this is helping to understand the physics of hazards and promote integrated observation and modelling of the disaster. In addition, it outlines the use of the field tools and data cross-checking in identifying hazards and vulnerability. Then, it discusses the role of good governance, decision support and advocacy in providing proper process of implementation of the whole DM cycle.

24.8.4.1 Capacity Building

Within the context of the DM, the capacity building can be defined as "the efforts aimed to develop human skills or societal infrastructures within a community or organization needed to reduce the level of risk" (ISDR 2005). It is essential that human and institutional resources are adequately trained to reduce disaster risks. Building national capacity for natural disaster mitigation and management can take the form of advisory services, training, workshop, field projects and

Layout: T1 Standard SC Book ID: 310227_1_En Book ISBN: 978-3-642-40694-2
Chapter No.: 24 Date: 15-11-2013 Page: 519/536

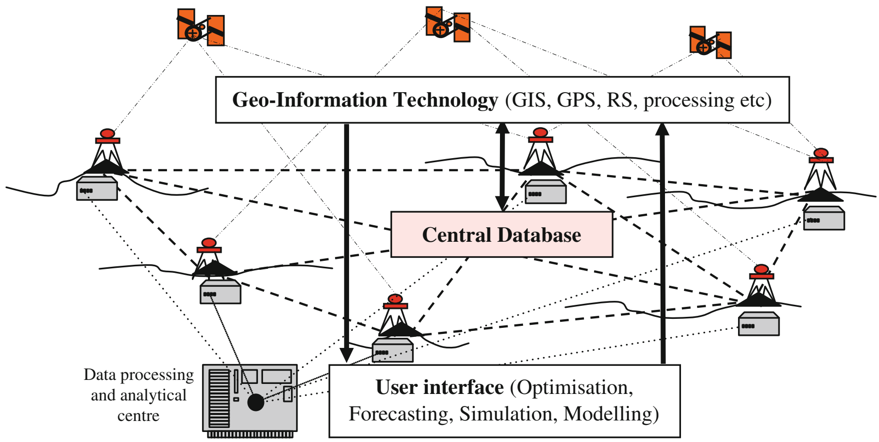


Fig. 24.21 The real-time warning network and its database structure

publications, and accesses to technology or other forms of technical assistance intended to improve institutional efficiency, etc.

24.8.4.2 Geo-Information Technology

In recent years, the focus of DM community is increasingly moving on to the more effective utilization of advanced geo-information technologies that enable communities at risk to prepare for, and to mitigate the potential damages caused due to disasters. Using these advanced technologies, a real-time EW network has been designed to consider the real life applications of DM as shown in Fig. 24.21. This network utilizes the strengths of the most advanced geo-information technologies and centralized databases, dynamic optimisation and geospatial models, data collection, internet, information communication technology, and expert systems, etc. EWSs can help to monitor natural hazards, plan response activities, identify affected populations and their needs, assess the flexibility of existing instruments or the functioning of markets or facilitate targeting of beneficiaries. This will have potential to provide valuable support to decision making through providing and representing spatial data, and dynamic models in analysing and representing temporal processes that control the disaster. More information about the scientific research based dynamic optimisation and geo-information technologies for DM&RR can be seen in (Saleh and Allaert 2011).

24.8.4.3 Field Tools and Data Cross-Checking (DRR in Practice)

It is assumed that any information gathered in the field will be cross-checked where possible with other existing data sources (e.g., government, NGOs, Red

Layout: T1 Standard SC Book ID: 310227_1_En Book ISBN: 978-3-642-40694-2
Chapter No.: 24 Date: 15-11-2013 Page: 520/536

Cross/Crescent organisations, geological surveys, meteorological data, health records, International Crisis Group publications, newspapers and academic journals, etc.).

24.8.4.4 Good Governance, Decision Support and Advocacy

Governance is the proper process of decision-making and implementation of the whole DM cycle. It brings together the actions of several actors at all levels, including ministries, international organizations, research institutes, universities, and NGOs. Advocacy can be thought of as a means of favourably influencing the wider political, economic, social and environmental context where these factors contribute to the vulnerability of a community. With regard to the legal aspects and key players in Syria, an integrated legislative and managerial base covering the entire SCZ does not exist. The development of coastal governance based on the principles of ICZM is an ongoing process in Syria as will be seen in the Sect. 24.10.

24.9 Risk Assessment (Hazard and Vulnerability Analysis)

Within the concept of DRR, risk assessment is carried out to identify which hazards are more likely to occur and to have the biggest impact on a community's or individual's assets. It is a systematic tool to integrate science with state-of-the-art geo-information technology to better understand the complex interaction of hazards, community and infrastructures, and then to help managing individuals safety risks.

24.9.1 Components of Risk Assessment

The main components of risk assessment are *hazard analysis* and *vulnerability analysis* that allow assessing the risk facing communities. This can be done by identifying the hazards which are most likely to occur within a given time-frame and to determine which of them will have the greatest magnitude of impact on the assets and livelihood options of a community. Over time, some changes can occur in terms of vulnerability of a community, types, causes, and intensity of the hazards that are face. Therefore, hazard analysis is concerned with identifying the underlying causes that influence the occurrence of hazards and provides more details about their frequency, seasonality, geographical area of the hazards' occurrence, etc. The importance of undertaking a hazard analysis can be illustrated by looking at the specific hazard of a SLR occurring in the East Med. Sea. There is high probability that the SCZ will experience a SLR sometime in the future, but as they are very infrequent, the likelihood in any one year of experiencing a SLR is very low. However, when the underlying causes that create SLR are studied, a more informed picture begins to emerge as shown in Sect. 24.5.3.

The *hazard analysis* usually includes: (a) *hazard identification*: to recognize particular types of natural disasters that have the potential of occurring within a region. (b) *profiles of hazard events*: to identify past incidences of natural disasters within each region. (c) *community profile*: to compare overall county property statistics to those within the pertinent hazard area. (d) *Estimated losses and vulnerability analysis*: will be determined using the hazard analysis, individual parcels and property asset data.

RA and risk management can be understood as corresponding instruments for achieving disaster resiliency that has to be seen as important objective for planning policy. Based on the above, risk management can be defined as adjustment policies that intensify efforts to lower the potential for loss from future extreme events. This shows that risk management is characterised by decision making of stakeholders which is a normative, politically influenced strategy about tolerating or altering risks. Therefore, within the DM planning and development, the task of urban planners relates to gathering, processing and presenting data to allow a series of questions to be answered so that decision-makers can formulate successful strategies. The following questions are of concern in this context: (1) What is the level of risk that the society is willing to accept? (2) What are the protection goals for the different protection objects that are threatened by specific hazards? or (3) What are the foreseeable environmental effects from a planned object in case of an occurred hazard? After selecting of the spatially relevant hazards, the first question in this sequence is: *what is the risk?* In other words, what would be the expected losses in human life and property? Therefore, deriving risk components have to be identified after selection the type of hazards.

24.9.2 Selection of Spatially Relevantly Hazards

Every hazard has a spatial dimension (i.e., disasters take place somewhere), hence the spatial character is defined by spatial effects that might occur if a hazard turns into a disaster. However, the occurrence of spatially relevant hazards is limited to a certain disaster area, which is regularly or irregularly prone to hazards (e.g. river flooding, SLR) (EPSON 2006). Spatially non-relevant hazards occur more or less anywhere (e.g. flash floods). The main question is: *Which of the existing hazards are of relevance in the context of the spatial planning?* The selection of hazards can be carried out following these steps: *Risk type* in which a list of possible hazards in the country is compiled firstly. Then, *spatial relevance* of the hazards is assessed secondly. Mainly, the selected hazards are classified according to the effect of climate change which is currently can be regarded as the major impact (Gornitz et al. 1994). In this research, the selection of SLR as relevantly hazard is based on its spatial effects that might occur if it is turns into a disaster that affect the whole SCZ as shown in Fig. 24.20. This figure depicts the proposed

Layout: T1 Standard SC Book ID: 310227_1_En Book ISBN: 978-3-642-40694-2
Chapter No.: 24 Date: 15-11-2013 Page: 522/536

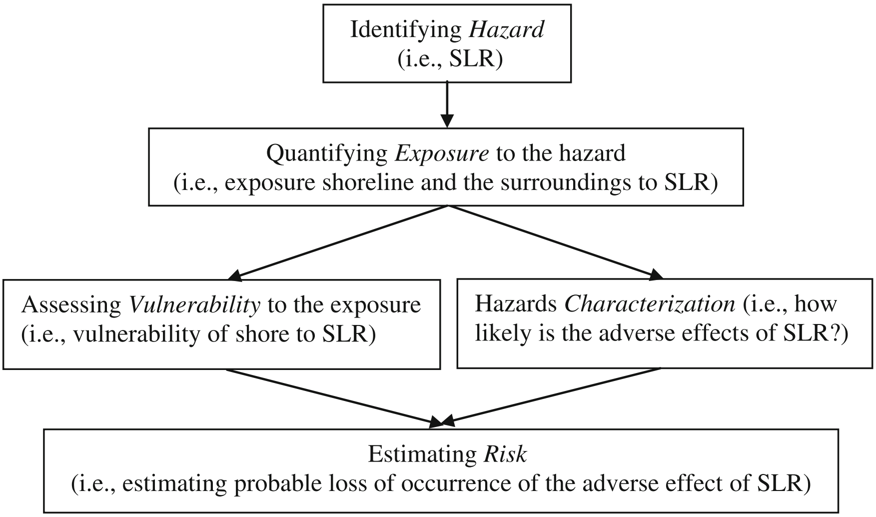


Fig. 24.22 The conceptual flowchart of risk assessment components

geographical locations of the expanding Lattakia city considering some control measures of the impacts of SLR and other related hazards

24.9.3 Analytical and Planning Tools for Deriving Risk

Risks are dynamic by nature, and therefore, a successful RA should be able to provide reliable information on where, when, how and why a hazard and disaster are likely to occur. Analytical and planning tools can help to systematically look at hazards in terms of risk they pose, their causes, characteristics and potential controllability. They help to analyse vulnerabilities and subsequent impacts in terms of their negative influence on livelihoods in order a sensible risk assessment can be made. These tools can also be used in fieldwork with communities to assist them in understanding their risks and suggesting DRR measures. The flowchart of Fig. 24.22 illustrates the methodology for risk estimation by explaining the main steps of deriving risk as follows:

24.9.3.1 Identifying the Hazard

The hazard identification step is based on scientific and technical findings, and involves the estimation of the probability of occurrence a damaging hazard (e.g., What is the probability of a SLR to occur within a specific period of time in a given area?). Usually, the sectoral planning divisions are responsible for this stage due to their specific competencies. Therefore, to achieve an effective planning process, a thorough coordination and cooperation have to be carried out between the spatial planning office who is in charge of the preparation of zoning instruments and other relevant authorities.

24.9.3.2 Quantifying Exposure to the Hazard

The step of quantifying exposure to the hazard (i.e., at risk) includes the determination of many important components within a given area that is threatened by a certain hazard (e.g., SLR). These components can be population, buildings, civil engineering works, economic activities, public services, utilities and infrastructure, etc. In ideal situation, existing hazard and risk maps (with an appropriate spatial scale) provide an important source for the necessary information that support obtaining high quality results as shown in Fig. 24.20 which presents the proposed geographical locations of the expanding the city of Lattakia under consideration of some impacts of SLR and other related hazards. This will allow various planning authorities to make the comparability between the risk assessments that were carried out to this given area that exposed to the SLR. Similar to hazard identification in first step, the spatial planning authority requires the support of the sectoral planning divisions during this second step.

24.9.3.3 Assessing Vulnerability to the Exposure

The assessing vulnerability to the exposure step (i.e., vulnerability of a building near the coast with respect to the SLR) is based on risk analysis using human geography and construction engineering, etc. It involves the estimation of the degree of loss for a given suffered situation for the different scenarios based on the impacts of the SLR on the city of Lattakia as shown in Table 24.6 [e.g., resulting from the occurrence of a SLR of a given magnitude and expressed on a scale from (0 no damage) to (1 total damage)]. This scientific and deterministic step characterizes the risk analysis as a mathematical calculation that includes the analysis of a hazard and its consequences.

24.9.3.4 Hazard Characteristics

The characteristics of a hazard can assist in ensuring the most important information that identifies this hazard. This information has to be recorded and could include the following items: (1) *Causes of the hazard* which are often a combination of the hazard itself, human practice and governance issues (e.g., the causes of drought can be related to poor land-use policies, etc.). (2) *Intensity of the hazard* which includes strength, extent and duration that are related to seasonality,

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 524/536

frequency and location (i.e., how the SLR is severe?). (3) *Frequency of the hazard* which is the period between the occurrences of hazards (e.g., SLR every two years). (4) *Location or the boundaries* of a place that affected by a hazard (e.g., extensively alongside shore up to 5 m contour line above river height in case of the SLR). (5) *History and trends of the hazard* which are particularly important to capture the effects of environmental degradation attributed to global weather changes. (6) *Controllability* which is the degree to control the impacts of hazards as many of them are outside of the human control or partially controllable (e.g., the rainfall is outside the human control). In some cases where the community cannot influence the frequency, intensity or scale of a hazard, this community needs to focus on strengthening its capacities to respond and recover from its impacts.

24.9.3.5 Estimating the Risk

The risk estimation step (i.e., probable loss) is based on several factors such as urban planning and human geography, economy, relevant statistics, individual parcels and property asset data, etc. Therefore, risk perceptions can be incorporated in norms, practices and probability calculations. With respect to an individual's perception of risk, there are many factors this perception such as familiarity with a risk, control over the risk or its consequences, proximity in space and time, scale of the risk or general fear of the unknown ("dread factor"). An important and interesting aspect of risk perception is the variation in different cultural regional and national contexts. When the risk has been determined, planners need to decide whether it is *within tolerable limits*. The following strategic tools for RA are not meant to be all-inclusive, but rather to present and explain a few of the techniques used to develop and assess risk at a community level.

24.9.4 Strategic Tools for Risk Assessment

This section discusses the importance of the strategic tools for RA especially dealing with the general aspects of gaps of infrastructure and knowledge necessary to identify and assess present day conditions. The shortage of long-term data and information on various aspects of disasters and hazards (e.g., climatic variations and its impacts) makes it very difficult to make decisions at early times. For example, missing data with respect to the SLR can includes: time series data concerning climatic parameters, data on tide gauges at a number of strategic positions indicating land subsidence, socioeconomic and health data in highly vulnerable areas, and accurate topographic data of the vulnerable low land areas. The following tools for risk assessment will support bridging these gaps.

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 525/536

Table 24.7 Relative risk ranking of a hazard

Relative Risk Ranking		*Likelihood* (How many individuals get effect from the SLR)		
		Unlikely (no effect)	Likely (some effects)	Very likely (many effects)
Severity (How effects do individuals get?)	Moderate	Lower	Lower	Medium
	Serious	Lower	Medium	Higher
	Severe	Medium	Higher	Higher

24.9.4.1 Hazard Ranking by Risk

Once all potential hazards have been identified, the priority should be to work on the highest ranked hazard first, and then the risks have to be controlled by the use of appropriate procedures or devices. In ranking the hazards, attention must be given to control methods which are already in place to mitigate the hazard (e.g., elimination, substitution, engineering controls and administrative controls, etc.). However, some tasks may have specific hazards that are beyond the scope or experience of local management (e.g., chemicals and radioactive materials, etc.). In these cases managers must seek appropriate expertise to help with the assessment and development of hazard control. It is possible to rank hazards on a simple graph that plots magnitude of impact with respect to an individual or community against the probability and frequency of a specific hazard occurring. Also, hazards can be ranked using tables as shown in Table 24.7.

24.9.4.2 Strength, Weakness, Opportunity and Threat Analysis

Strength, Weakness, Opportunity and Threat (SWOT) analysis of policies, measures and programs can be a useful tool in the initial phase of a RA to guide the community to capture and identify its overall areas of development. The benefits of this analysis are the identification of the links between each of the perceived "threats" which relates to the community's "weaknesses", the "weaknesses" to related "opportunities", and the "opportunities" to related "strengths". The items at which the most links converge indicate the priority threats to be mitigated, weaknesses to be corrected, opportunities to be seized, and strengths to be reinforced.

Identification of the SWOT analysis is essential because the subsequent steps in the planning processes might come as a result from this analysis. With regards to the impacts of SLR and other related hazards on the SCZ, a critical SWOT analysis has been presented as shown in Table 24.8, and concluded that: (A) most of the coastal cities are vulnerable to the impacts of SLR not only through direct inundation, but also due to salt water intrusion. (B) shortage of institutional system for climate change and SLR has limited proactive planning and development of policy to adapt to potential impacts which cover all sectors of development. (C) shortage

Table 24.8 An example of results from a SWOT analysis for a SLR disaster

Item	Strengths	Weakness	Opportunities	Threats
Flash flood and flood management	Local knowledge of water resources, flash and seasonal floods	Lack of people centered EWSs, and other information about DM	Well established water constructions, and flood management systems	Information about floods are not reaching the population in time
Institutional structure	GoS has developed some institutional structures for adaptation including integration among vulnerable sectors, A national committee for climate change has been formulated	GoS is still in the process of developing and implementing some regulations that have proved to be efficient such as EIA, ICZM	Integrating capacities and coordinating activities easier now since all sectors and research centres are encountering problems of climate changes and SLR	Time delays means loss of opportunities for adaptation and economic loss
Disaster management	Autonomy for the local governmental administration	Lack of integration of environmental conservation in local development plans and policies	Ability to carry out development plans and policies without macro management from national level	Local government show little interest in investing in environment and disaster risk reduction
Awareness of decision makers	Most of decision makers in Syria are well aware of the SLR and other hazards related Tsunamis	Awareness does not mean action of any kind and priorities of immediate needs are preferred	The early the GoS start working on managing these hazards the more they save lives and protect properties	More programs will be implemented with no consideration to climate change, and more damages over all sectors on the regional scale
Awareness of the community	Vulnerable communities are aware of the SLR and other hazards related Tsunamis in Syria	weak enforcement of regulations, and still missing of many practices in the community	Now increasing with community feeling heat waves and flash floods	Continuation of over consumption, unplanned urban development and interference of land use

systematic observation of coastal changes, (D) lack of integrated geographic data basis of indicators (e.g., land subsidence in particular), and (E) vulnerability to SLR and its implications on water resources, food security, tourism and public health for all coastal Syrian cities cannot be overlooked.

24.9.4.3 Environmental Impact Assessment

The SWOT analysis can be complemented by Environmental Impact Assessment (EIA) which is a policymaking tool that provides information on the environmental impacts of hazards. EIA could be used to assess risk in coastal areas facing SLR, or to assess the impact on food security. With regards to the current situation of EIA in Syria, the main shortcomings can be identified: the absence of binding EIA related legislation, weak environmental institutions and authorities, lack of awareness and experience, lack of environmental data, lack of coordination and cooperation, the weak role of private and public sectors in EIA.

24.9.4.4 Hazard and Risk Maps

Following the SWOT analysis, the community can benefit from developing hazard/risk maps that display the detailed geographical SCZ that might be negatively affected by SLR as shown in Figs. 24.13 and 24.14. These maps, that created using geo-information technology, can help to locate this hazard and provide its historical record, and to identify its risk that support decision makers to find solutions or take precautions. Mapping can be carried out of a single hazard (flood map), or it can take form as a multiple hazard map which combines all the present hazards in one map to give a composite picture of the situation for a given area. Multiple maps have the possibility of providing common recommendations for mitigation techniques, outlining sub-areas that require more information, specifying the needed hazard-reduction techniques, and land-use decisions benefiting all hazard considerations simultaneously (Saleh and Allaert 2011).

24.9.4.5 Cost-Benefit Analysis of Prevention and Mitigation Measures

One of the main questions when preparing the mitigation measures to control hazards is: *If the risk is not within "tolerable limits", what are costs of the various prevention and mitigation measures?* Cost-Benefit Analysis (CBA) is a necessity tool in establishing the feasibility of prevention and reduction measures. This section illustrates how CBA and RA can be incorporated into the urban planning process from the point of view of both prevention and reduction procedures. Scenarios of these procedures can be used to illustrate how RA is used as an input in a CBA, as well as how the results of this analysis are likely to be interpreted by decision-makers. For example, the World Bank and USA Geological Survey calculated that economic losses worldwide from natural disasters in the 1990s could be reduced by US$280 billion if US$40 billion were invested in preparedness, reduction and prevention strategies. For Lattakia city, it will be wise to establish high rock barriers against SLR as a coastal hazard and this requires GoS to plan for it, and to manage development planning activities to minimize loss of property due to SLR as shown in Fig. 24.24. In this situation, the estimation cost for developing these protective structures has to be fully considered as a wise investment because the potential loss of the important infrastructure and populated areas through a SLR would be so disastrous.

24.10 Maritime Activities and National Responses to Protect Syrian Marine Area

In the last five decades, the SCZ witnessed the development of large maritime facilities including the Banias oil terminal, the commercial sea port of Lattakia and the oil terminal of Tartous, etc. Hence, the problem of climate change is being taken seriously, and low lying land in the SCZ is considered to be at risk especially from the effects of SLR. In particular, cities of Lattakia, Banias, and Tartous, which are major industrial and economic centres, are expected to experience serious environmental impacts, if no action is taken. The GoS considers several actions in cooperation with global communities to protect the risked areas and to decrease the effects of the climate change by serious research work and setting new environmental regulations (Meslmani 2010).

24.10.1 Maritime Activities

With regards to the coastal governance, protection of marine areas, and maritime activities, the establishment of effective marine governance is a challenging prospect in Syria. A wide range of activities that compete for coastal and marine space are governed by a complex and uncoordinated array of legal and administrative arrangements. In order to try and achieve a more integrated approach to coastal management issues in Syria, governance models based on the concepts of ICZM have been developed (PAP/RAC 2008), which include: (a) policy should be developed in an integrated manner, rather than on a sector by sector basis. (b) marine and coastal areas should be treated as a single zone rather than as differently administered and managed separate units. (c) a long-term approach to coastal and marine governance is required because of the long timescales over which coastal and marine systems operate. (d) a governance system that allows all stakeholders to contribute to policy formulation will be more effective. It has also been recognised that achievement of these concepts

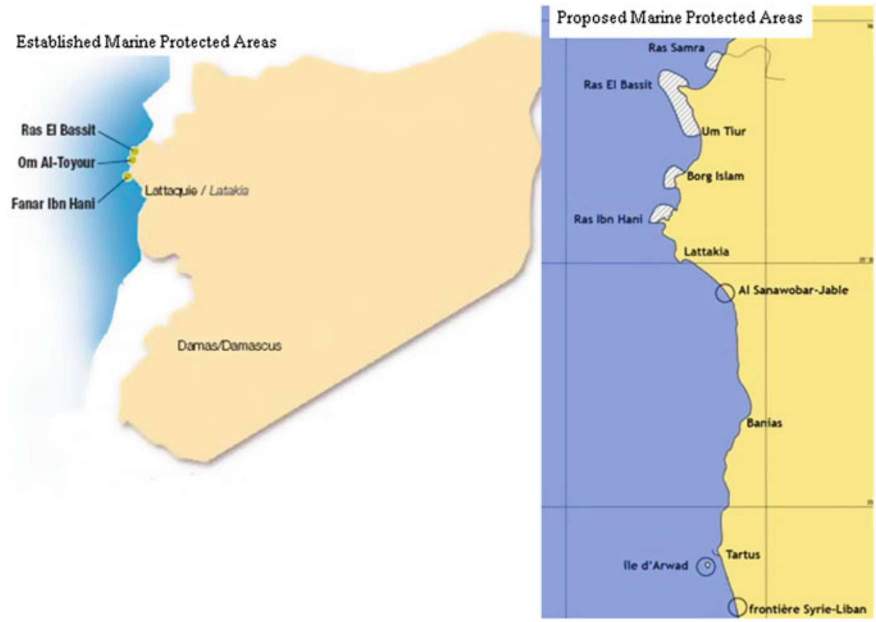


Fig. 24.23 The established and proposed marine protected areas—Syria. *Source* Policy Research Corporation based on the Network of Managers of Marine Protected Areas in the Mediterranean, www.medpan.org and RAC/SPA (2004), Regional Project for the Development of Marine and Coastal Protected Areas in the Mediterranean Region (MedMPA)—Recommendations for the elaboration of a national plan to develop marine protected areas in Syria

will need to involve the incorporation of spatial planning into the administrative process.

The GoS has recently approved new regulations to include ICZM into developmental plans needed for better management of coastal resources and protection. This makes it necessary to have a strong institutional monitoring capability in addition to a decision support capability for adoption of options for adaptation. With regards to the marine environment, Syria's continental shelf is naturally characterised by low bio-productivity due to the high salinity of the coastal water, relatively low freshwater inputs, a slow sea current and a low tidal level. Furthermore, a high degree of pollution of the coastal and marine environment puts pressure on the future of fisheries in the SCZ. The strongest impact of human activities on the marine environment is water pollution mainly caused by untreated wastewater discharges originating from the cities.

According to the network of managers of Marine Protected Areas (MPAs) in the Mediterranean (RAC/SPA 2004), three MPAs have been defined in Syria's territorial sea with a total size of about 50 km^2, and are: Fanar Ibn Hani, Om al Toyour, and Ras El Bassit as shown in Fig. 24.24. The Om al Toyour area is recognised as an Important Bird Area (IBA) which is a global partnership of

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Chapter No.: 24 | Date: 15-11-2013 | Page: 530/536

conservation organisations that strives to conserve birds, their habitats and global biodiversity (IBA 2012). In December 2004, national and international experts proposed a number of additional MPAs in the framework of the 'Regional Project for the Development of Marine and Coastal Protected Areas in the Mediterranean Region (MedMPA)' (UNEP/MAP 2008). These established and proposed MPAs in SCZ are visualized in Fig. 24.23, and as follows:

(A) The northern coast which is dominated by Ras Shamra area and represents the potential of a cross-border MPA in terms of biodiversity. It was considered as high, particularly as regards the monk seal, marine turtles and cetaceans.
(B) The sector lying between Um Tiur and Ras El Bassit areas has limited interests in terms of marine biodiversity, but it identified as an area of great landscape interest (e.g. rocky cliffs, underwater caves). This sector is already protected since 1999 and there is a potential for turtle nesting beaches at certain places.
(C) The sector lying between Ras Ibn Hani and Borg Islam areas which is already a protected area (since 2000, 10 km^2) rich in marine biodiversity and turtles.

24.10.2 Practical and Institutional Adaptation Measures

For Syria to mitigate and adapt to the effects of SLR and other related hazards, the GoS will have to respond effectively to some urgent needs such as establishing a strong coastal monitoring, assessment and law enforcement system hence identifying and protecting vulnerable areas. In addition, there is an urgent need to activate ICZM committee and to incorporate climate change in the EIA, to promote awareness and community resilience, and to create new opportunities at safe areas. Another action taken by GoS is the 5 Years Development Plan prepared for coastal governorates considering several crucial suggestions for mitigating and adapting to the expected SLR. This plan encourages greater coordination between governorate bodies responsible for enforcing environmental policies, urban and developmental planning and regulations to improve the quality of coastal protection measures. It also introduces measures to reduce coastal zone erosion such as raising environmental awareness amongst governorate staff and private developers, and developing an action plan to prevent erosion and to protect Syrian coastline from further erosion (UNEP/MAP 2008).

A national adaptation strategy is in progress with consideration of the following aspects: (1) upgrading adaptive capacity through establishment of institutional system for monitoring, building data basis, modelling and upgrading awareness. (2) adopting a proactive policy in planning and enforcing regulations for follow up. (3) carrying out research on renewable energy, salt tolerant plants, and desalination. (4) considering geo-engineering activities for protection against SLR. Based on these aspects, it is therefore recommended to carry out: (a) establishing institutional capacity which includes monitoring systems and human capabilities for climate change in general and SLR impacts in particular. (b) enhancing

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Chapter No.: 24 | Date: 15-11-2013 | Page: 531/536

Fig. 24.24 The proposed high rock barriers against SLR on the coast of Lattakia

adaptive capacity through encouraging establishment of rainwater storage systems, upgrading water management and development of integrated coastal zone planning. (c) establishing monitoring and EWSs for coastal subsidence, flash flood, and SLR, etc. (d) establishing high rock barriers opposite to the density population areas, the sporting city, and other important tourism structures to protect them from SLR and reduce its impacts as shown in Fig. 24.24. These barriers can be built in an attractive shape to attract tourists or can be planted by trees. (e) planting a green built with 200 m width full of palm trees parallel to the coast, and this will separate this coast from agricultural area. This will reduce the initial effect of the tsunami and at the same it can be lung for fresh air that minimise the pollution. (f) it is suggested to establish a SLR monitoring network of 11 sea level gauges that will be positioned around the open coast and spanning the entire coast.

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 532/536

24.10.3 The Suggested Strategic Framework for Responding to Sea Level Rise in Syria

The urgent need for integrated adaptation infrastructure and institutional capability for monitoring, building data base, and periodic assessment and risk reduction in Syria is an important prerequisite for proactive planning and sustainable development. Therefore, a general strategic framework for responding to SLR and other hazards will be planned taking into accounts various national activities and recent experience of preparedness in the frame of DRR (UNEP/MAP 2008). The strategy which is based on the need for a tsunami and SLR warning system in the SCZ, should respond to pressure on and from coastal hazards by including: (1) building infrastructure and institutional capabilities for monitoring, modelling, vulnerability assessment and development of policies, measures and enforcement of regulations. (2) carrying out research on water availability and management, food security and salt tolerant plants, coastal extreme events and water conservation programs. (3) creating development plan and enforcement of SEA and EIA in it, and taking into account climate changes and SLR implications.

One of the main reasons to monitor the Lattakia coast and other coastal cities using advanced EWSs is the potential of earthquakes resultant from the Afro-Syrian fault as explained above. Once the earthquake is identified, the warning centres use sea level data to confirm that a tsunami was generated or, if there are no changes in sea level, to cancel the alert messages. There are three main sources/causes of tsunamis: submarine earthquakes, landslides, and volcanic eruptions (Annunziato et al. 2009) and (Dawson et al. 2004). The main elements of EWS can include the following: (1) tsunami hazard and RA, (2) seismic monitoring and earthquake detection, (3) sea level monitoring and tsunami detection, (4) dissemination of warnings and mitigation programs and public awareness. In this system, tsunami hazard assessment is a key element and requires knowledge of past tsunami occurrences and possible sources, their likelihood of occurrence and their effects along the threatened coasts. In addition, the compilation of tsunami catalogs and inundation mapping constitute the main components of tsunami hazard assessment (Saleh and Allaert 2009a; ISDR 2004).

24.11 Conclusion

It is almost impossible to prevent the occurrence of SLR and other related hazards. However, it is possible to reduce their impacts and damages by adopting suitable disaster mitigation strategies. RA and management should be incorporated within the planning activities process to achieve greater sustainability and at least resiliency of society's development. DM is a dynamic process and consists of different kinds of knowledge: technical (e.g., modelling of phenomena, simulation, data management and telecommunication), human aspect (e.g., modelling of behaviour,

Layout: T1 Standard SC | Book ID: 310227_1_En | Book ISBN: 978-3-642-40694-2
Chapter No.: 24 | Date: 15-11-2013 | Page: 533/536

training and learning), and organizational and managerial aspect (e.g., planning, cooperation of stakeholders, information and communication, etc.). However, some conclusions about these aspects can be outlined as follows: technology-oriented decision support has drawbacks (e.g., modelling and simulation are essential, but there are limits, telecommunications often fail in crisis situations, GIS usefulness depends on updating, and sensors provide field data, but their reliability is limited, etc.). On the other hands, the human and organizational aspects are essential and can play important role: to face the growing complexity of situations, to cope with unplanned situations and crisis, to establish a synergy among the many stakeholders, and to learn from experience and share knowledge. In the close future, the most profound changes affecting SCZ will be driven by climate change, particularly by rising sea level. Hundreds of thousands of people are likely to be displaced by SLR, accompanying economic and ecological damage will be severe due to recurrent droughts, inequitable land distribution, and over dependence on rain-fed agriculture. Many major challenges will have to be successfully and equitably confronted by proper management and adaptation to the consequences of climate change and the competing human demands on coastal land. Adaptation plans are mainly focusing on increasing the adaptive capacity of the different systems, by changes in processes, practices, or structures to reduce risk of these disasters. In Syria, the priority of these plans is the high vulnerable systems to climate change from the perspectives of food production, rural population stabilization, and distribution of water resources. Therefore, the high vulnerability of the agricultural sector put it on top of the priority list of adaptation plans. In addition, the Syrian adaptation capacity is challenged as it comes in conjunction with high development pressure, increasing populations, water management that is already regulating most of available water resources, and agricultural systems that are often not adapted to local conditions.

This chapter summarises that most of the Syrian coastal cities are particularly vulnerable to potential impacts of SLR. It ends with a set of analytical conclusions and adaptation recommendations: (1) almost none of these cities have established an effective institutional capability for adaptation with particular emphasis on monitoring capabilities. (2) they should carry out massive programs for detailed vulnerability assessment, investigate open options for adaptation and develop strategies, policies and measures in all sectors of development. (3) they need to build up resilience for vulnerable communities and carry out proactive planning for ICZM and development in non-vulnerable coastal areas. (4) Regardless of the expected magnitude of the SLR, taking action for adaptation is necessary whether there is a SLR or not. (5) A multidisciplinary research project based on a national proposal for maximum size and disaster scenarios for extreme SLR in the eastern coast of Med. Sea has to be carried out as soon as possible. Finally, since DM is only one of many issues that decision-makers face, efforts must be made to raise awareness of the benefits of disaster mitigation.

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