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# Vulnerability Assessment and Possible Adaptation Measures for Syria's Coastal areas

***Related to the Project Activity***

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Enabling activities for preparation of Syria's initial national Communication to the UNFCCC, (Project Nr.00045323).

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The project implemented in the ministry of local administration and Environment (MLAE)/General Commission of Environmental Affairs (GCEA), in collaboration with Global Environmental Facility (GEF) and United Nation Development Programme (UNDP) in Syria.

# Vulnerability Assessment and Possible Adaptation Measures for Syria's

# Coastal areas

(INC-SY_V&A_ Coastal areas-En)

National Project Director:

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**March / 2009**

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*This report has been approved unanimously by the technical committee, during the Technical Workshop which took place on 24/ 03/ 2009 in the Dedeman Hotel Palmyra.*

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# 1. Introduction

This study represents a section of a more comprehensive study for the Project No: 00045323 "Enabling activities for the preparation of Syria's Initial National Communication to the UNFCCC". It was carried out by Prof. Amir Ibrahim as the national expert on "Vulnerability and Adaptation of Coastal areas to the projected sea level rise" due to climate changes.

This assuagement takes into account the physical, biophysical and social aspects of the Syrian coastland and the likely impacts of sea level elevation on these elements. The vulnerability and impacts on the major population centers, infrastructure and various land uses were dealt with under different scenarios of sea level rise. Furthermore, investigation and identification of proper policies, strategies and measures as possible adaptations to such impacts to lessen such impacts were presented.
Information presented in this report had been obtained after consultation with various authorities concerned such as Universities, Ministries (esp. Local Administration and Environment, Industry, Agriculture, and Transport-General Directorate of ports), The General Organization for Remote Sensing, the related Directorates, Coastal Municipalities, etc. Publications of various institutions (High Institute of Marine Research, Atomic Energy Commission, Higher Institute of Environmental and Applied Research, General Commission of Remote Sensing) were consulted. This is in addition to the information obtained through a public questionnaire to implement the opinion of a wide range of stakeholders.

It should be stated that quantitative data (and even the qualitative one) on some aspects relevant to this study are very limited or even absent in many cases. Thus, the data presented in this report represents what is available. In addition, and when possible, conclusions on some aspects of this study were drawn on the basis of the practical knowledge about the coastal and marine ecosystems and on the opinion of a wide range of stakeholders retrieved from the questionnaire used for the purpose of this study. This stresses on the need for more research to be done on monitoring and impact of sea level rise on various sectors of the Syrian coast.

The team to conduct this assessment was lead by Prof. Dr. *Yousef Meslmani*, the National Project Director (NPD) and by Prof. *Mohammad S. Abido*, the V and A team Leader.

# 2. Information And Database On The Coastal Area

The Syrian coastal area measures 4200 $km^2$ extending from the Turkish border at the north to the Lebanese border at the south. It includes two governorates; *Lattakia* in the north (2300 $km^2$ with 1139897 inhabitants) and *Tartous* in the south (1900 $km^2$ with 88895 inhabitants) (MOLA 2007). Nearly 25% of the coastal population live in 4 coastal cities located just on the sea shore, *Lattakia* (351305), *Jableh* (66070) *Banias* (39827) and *Tartous* (90209). This is besides the high population densities that exist in many shoreline villages within only few hundred meters near the sea water's edge. Growth rate is estimated to be high (2.58 % for the whole country, NEE 2001).

The official unemployment figures in the two coastal governorates total 88570 unemployed (Labor Force Survey 2005, CBS 2006). The region enjoys a great deal of safety, usually no organized crime and people carry their normal activities without any trouble.

The coastline measures 183 km in length (90 km in *Tartous* district and 93 in *Lattakia* district), forming a straight baseline for a 12 nm[1] (previously, 35 nm) of the territorial waters (Fig. 1). It consists of a narrow coastal plain with a variety of ecosystems, including shelf zones, estuaries, coastal rivers, wetlands and mountains. The coastal region forms only about 2% of the total country area, but it resides more than 11% of the total population (total country populations is about 21.4 Millions; as for 2006, MOLA 2007) and contributes more than 12% to the Gross National Production; Most of the economic activities that form the backbone of the national economy are located in the coastal zone. 38% of cement production and 50% of national oil refining are produced from establishments located just on the shoreline (Ibrahim 2003), and the coastal area forms the food basket of the country; especially for green house farming and fruit orchards (225000 hectares are purely cultivated land and intensive farming is practiced, CBS 2006). Out of the cultivated lands, 58000 hectares are irrigated and 154000 hectares are nonirrigated and depend on rainfall, Only 13000 hectares are left without exploitation, CBS 2006).

Other land uses include buildings and public services (46000 hectares), lakes and marches (7000 hectares), rocky and sandy lands (21000 hectares), steppe and pastures (5000 hectares) and forests (114000 hectares).

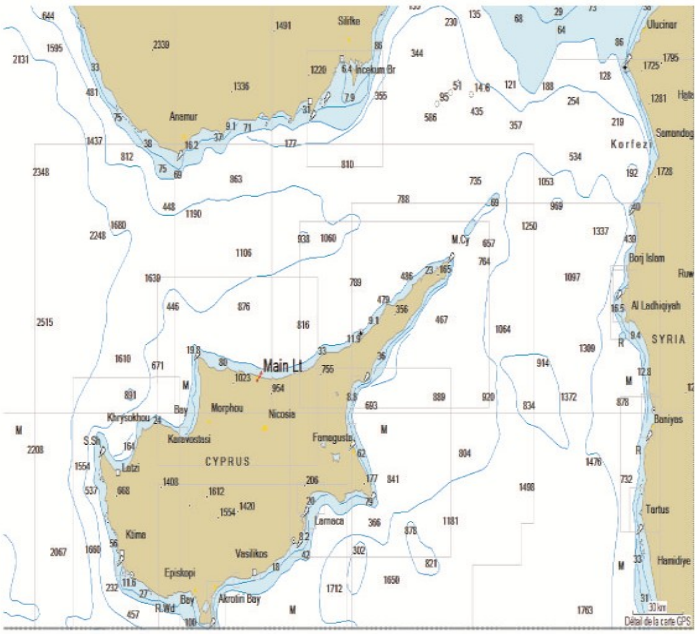


**Fig. (1):** Map of the Syrian coastal area *(Source: Schlitwer 2006).*

[1] **The navical mile** (NM, M, Nm, or nmi) is a unit of length corresponding approximately to 1.852 m. used especially by navigators in shipping and aviation industries.

The coastal area falls in the reach of the fault resulting from the break up of the Arabian Plate from the African Plate since the mid-Cenozoic. The fault represents the northern continuation of the Dead Sea Fault into Syria, extending in south-north direction, parallel to the Syrian coast and merges with the major East Anatolian Fault in southern Turkey (Dalati 2008). This system has been a site of numerous large historical earthquakes. Many historical records of earthquakes were reported in the coastal area, the most recent and devastating ones were on the years 529, 859, 1157, 1170, 1287, 1796 and 1822 AC (Sa'adeh 1984). Therefore, successive *old Lattakia* ruins can be found almost everywhere under the ground, along the shoreline and throughout the coastal area as well.

On Geomorphologic basis, the coastal region can be divided into 5 main distinctive areas (Fig. 2):

a. Shoreline: the shallow water and the area between seawater edge and the beach.
b. Lower coastal plain: the flat, fertile and water rich land. Most human activities concentrate in this area.
c. Coastal plateau: the adjacent hills (100-400m above sea level), less fertility and less water exists.
d. Steep hills: 400-600 above sea level, interrupted by many river valleys.
e. Upper plateau.

Areas (a) and (b) are considered as the most vulnerable to sea level rise because of climate changes. Thus, detailed description will be focused on these 2 areas.

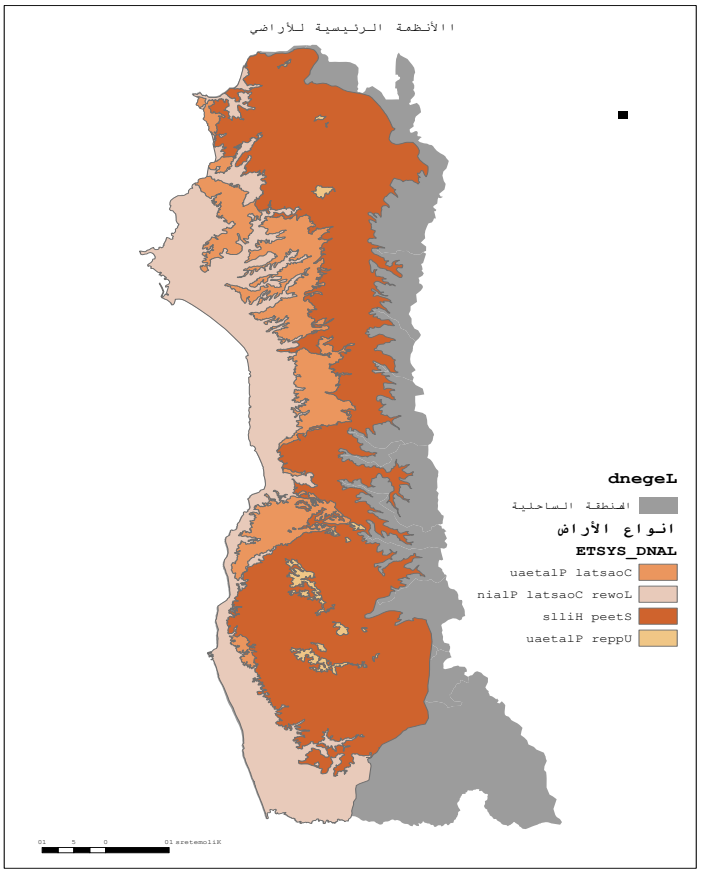


**Fig. (2):** Geomorphologic divisions of the coastal areas (*source: GORS 2006).*

## a. Shoreline

The shoreline is mostly rocky with only about 22% (about 40 km) of sandy beaches. The sea is generally deep with a small (900 $Km^2$), narrow continental shelf (less than 1 km in some places, in the area of *Oum al Tiur- Ras Al Bassit*, the widest point is 16 km, in *Al-Hamidiah*; south of *Tartous*). This continental shelf projecting to a deep plain (water depth of 400–600 m) before running steeply into the Levantine Basin. The shoreline is well known as poor with gulfs and bays, and other similar habitats suitable for biological species nursing and reproduction.

Four islands (*Arwad, Alhbas, Alnamil* and *Abo Ali*) exist in the Syrian continental shelf; the largest one is Arwad (an area of 2 $km^2$ and a coast of 3 km), 3 km off *Tartous* city. This island is heavily populated (4.5 thousands, MOT 2008) and is very important for fishing, for ship buildings and for its historical records. The other three islands are located to the south of *Arwad*, unpopulated and very small in area.

The coastal area contains 15 archeological sites located within a very short distance (mostly less than 1km) from the shoreline (MOT 2003); the most internationally popular ones are *Ras Shamra* (10 km the north of *Lattakia*), *Amrit* (8 km south of *Tartous)* and *Arwad*.

Local incomes of the coastal population depend on three main sources; agriculture, fisheries (esp. marine) and tourism. Services sectors employ fairly large percentage of the labor force.

The dominant agriculture practices in the coastal region are vegetables, citrus and olive trees cultivations. Green house farming is the major agricultural practice in the area. More than 150000 plastic green houses (mainly for growing tomatoes and cucumber) are located in the coastal plain (mostly within a reach of few hundred meters) and supporting about 20000 families (DOA 2008). In addition, about 30000 other families are involved in such farming and make their living from, thousands of seasonal or part time workers from suburbs also work in. The consequential activation to other sectors, such as transportation, cargo etc cannot be ignored; about 9000 vehicles work for the green houses, for example.

Farming practices in the coastal area is controlled and supervised by Farmers Cooperatives, the Farmers Union and the Directorates of Agriculture. A total of 863 cooperatives were already established in the coastal area (CBS 2006), they give loans to members, provide farming substances at a special prices (such as fertilizers, pesticides, irrigation requirements, fodder… etc.) and give agricultural guidance to farmers.

Artisan fishing in the Syrian coastal area is practiced by small-scale fishermen using either trawlers (25 of about 300 hp engines for fishing outside the territorial waters) or small wooden boats “feluccas”, about 1850 with 10-30 hp engines for fishing in the territorial waters (GDOP 2008). The artisanal fleet is distributed at 14 fishing harbours along the coast; the largest six harbours are in *Tartous, Arwad, Banias, Jableh, Lattakia* and *Burj Islam*. Winter storms often cause the loss of boats.

The total marine fish catch is estimated to be around 3677 tons for the year 2005 (MOA 2005, CBS 2006). People are aware of the continuous depletion of stocks caused by many factors, mainly overexploitation and illegal fishing. However, the

fisheries sector is accounted for only 0.002 % of Gross National Product (CBS 2006). Fisheries activities are controlled by 3 Fishermen Syndicates (in *Lattakia, Tartous* and *Arwad*).
In summer, boat trips are common for tourist activities where nearly 600 touristic boats were registered in the coastal area and practice their activity at sea (GDOP 2008). The income per season is approximately 100 000 SYP per boat (Personal interview with fishermen). Some touristic boats are also used for fishing outside the tourist season.
The coastal area is covered by a wide range of touristic complexes which stretches on the shoreline; mainly in *Kassab (Al-Samra), Ras AlBassit* and *Oum AlTiur*, Cote de I, Al-*Rimal Al-Zahabiah* and *Al-Hamidiah*. The area is served by more than 100 hotels of various classes, containing about 10000 beds (MOT 2006). Chalet renting is the other main source of income in the region, the rental rates start from 300 up to 7000 SYP per night, depending on the season and location (Personal interview with owners).

Recently, the shoreline has been put under high level of tourism investments and the governments gave privileges for 4 large-scale touristic complexes, one in *Tartous* (*Antradus* project-200 m US$) and 3 in *Lattakia* (*Jol Jammal*-33 m US$, *Ibn Hani*-350 m US*$, Alkornich Aljonobi*), this is in addition to few hotels (in *Lattakia, Slonfeh* and other places). Touristic camps are numerous in the coastal area and run by various Unions and Syndicates in many places along the coast. The private sector has its own chalets with an active real-estate trade due to the rising rates.

Tentative assessment of sea water temperatures measured just below water surface indicates that it range from 14-16 C° during winter months and 26-29 C° during summer months. (Various research projects at High Institute of Marine Research, e.g Vityaz 1992, Ovchinnikov and Abu Samra 1994).

Salinity of the Syrian marine water (as the entire eastern Mediterranean Basin) gradually increases due to the continuous increase in evaporation rate (as a result of the global increase in air and sea temperatures) and to the general reduction in freshwater discharged to the sea due to damming of the coastal rivers (20 different dams already exist). This affects the balance between evaporation and freshwater influx. Seawater salinity of the Syrian marine waters has been recorded to be between 37 and 39.8 PPT (Various research projects at High Institute of Marine research, e.g. Vityaz 1992).

Rainfall occurring mainly during winter months and, following the morphological differences of the areas, it increases from the coast eastward; starting from 800 mm near the coast to reach as much as 1500 mm in the mountainous area.

The prevailing winds are W to SW. The data collected by the General Directorate of Ports (GDOP 2006), the previously existed Marine Fisheries Branch at *Lattakia* and that confirmed by navy personnel and the experienced anglers indicates that the weather condition on the Syrian coast can be predicted at 15 different occasions. Such occasions repeats them annually and occurs as follows:

**Table (1):** predicted weather condition according to 15 different occasions known by local fishermen *(Source: General Directorate of Ports, Marine Fisheries Branch- Syrian Coast)*

| Arabic local name | | Notes | Duration (days) | Wind speed (m/Sec.) | Wind Direction* | Expected date |
|---|---|---|---|---|---|---|
| 1 | المكنسة Almeknaseh | Rain | 4 | 6- 28 | NW | Nov 15 |
| 2 | باقي المكنسة Baki Almeknaseh | | 3 | 7-20 | SW | Nov 23 |
| 3 | قاسم Kasem | Rain | 5 | 7-24 | SW | Dec 05 |
| 4 | الفيضة الصغيرة Alfeda Alsaghira | | 5 | 6-27 | NW | Dec 20 |
| 5 | عيد الميلاد Christmas | | 2 | 12-28 | N | Dec 29 |
| 6 | رأس السنة Silvestre | With rain | 4 | 12-28 | W | Jan 02 |
| 7 | الفيضة الكبيرة Alfeda Alkabira | With rain | 6 | 7-20 | SW | Jan 12 |
| 8 | الغطاس Ghtas | With rain | 3 | 10-24 | W | Jan 19 |
| 9 | الكرم Karm | Heavy rain | 7 | 10-24 | SW | Jan 30 |
| 10 | الشمس الصغيرة Alshams Alsaghira | Heavy rain | 2 | 10-24 | NW | Feb 11 |
| 11 | السلوم Alslum | Rain | 2 | 10-24 | SW | Mar 02 |
| 12 | الحسوم Alhsum | Occ. Rain | 2 | 7-20 | SW | Mar 11 |
| 13 | باقي الحسوم Baki Alhsum | | 2 | 7-10 | NW | Mar 15 |
| 14 | الشمس الكبيرة Alshams Alkabira | | 5 | 6-17 | SW | Mar 20 |
| 15 | العوة Alaoa | | 2 | 10-24 | W | Mar 25 |

** Wind Direction: N= North, S= South, W= West, E= East*

The above-mentioned dates are approximate and may occur earlier or later within very few days (usually 1-2 days). In fact it is hardly for these occasions to be mistaken where fishermen take a serious note of them and plan for their fishing trips accordingly. In addition, The General Directorate of Ports in *Lattakia* (GDOP 2006) announced 9 more occasions where the weather conditions can be predicted. These occasions are associated with either winds or storms; their time and duration are as follows:

**Table (2):** predicted weather condition according to occasions known by local fishermen in Syrian Coast *(Source: Local habitants)*

| Notes | | Duration (days) | Type | Date |
|---|---|---|---|---|
| 1 | With rain | 2 | Winds | 20th October |
| 2 | With rain | 3 | Storm | 31st Nov. |
| 3 | With rain | 3 | Rainy storm | 15th Dec. |
| 4 | With rain | 3-6 | Rainy storm | January |
| 5 | With rain | 3-6 | Rainy storm | 12th Feb. |
| 6 | With rain | 9 | storm | 26th Feb. |
| 7 | With rain | 2 | winds | 17th March |
| 8 | With rain | 2 | winds | 17th April |
| 9 | With rain | 2 | winds | 17th May |

As in general, the year can be divided into 2 characteristic periods in regards to prevailing weather condition (especially wind speed). The calm period: lasts from April till September (and sometimes till October), the weather is stable, with low speed winds (usually light air or breeze: 0, 1, 2 or 3 numbers at Beaufort scale, Ibrahim 2008) flowing from the W and SW directions. The rough period: lasts from October/ November till March, the weather conditions are unstable, winds flow from NE, and storms arrive from the SW and W directions. The storms are common in the area but are of short durations (usually less than a day), but sometimes last up to 3-6 days.

Sea currents at the Syrian coast, as that of the Levantine basin, are generally of low speed (13-17 cm/ sec., Vitayz 1992), flow from south to north (in anticlockwise direction), and forms a gyres in the area between *Lattakia* and Cyprus during some months of the year due to the southwards currents flowing adjacent to the coast. Surface currents, which confined to the upper surface layers, may become strong (up to 1m/ sec.) when induced by strong wind forces; usually during the period October/ November till March.

No data were published so far on the tides on the Syrian coastal waters, but it can be said that tideal level is generally low (about 40 cm in most cases, Personal Observations). This low tidal level, combined with slow water currents decrease the dispersion rate of pollutants and increase the impact of pollution on marine life.

No direct measurements of wave heights exist, personal observations were made and waves of up to 7 m were noticed, but most waves are less than 4 m. High wave frequencies are very low and happen only few times of the year. Although the westerly winds can give the highest waves, their duration hardly to exceed 2 days. The most frequent winds which cause storms are south-westerly; these winds usually last several days and cause hazards and inconvenience to sea navigations. On the other hand, NE can be very strong but relatively do not result in high waves in the proximity to the Syrian coast.

## b. Lower coastal plain

The lower coastal plain varies in width from few meters (in *Oum Attiur* area), to several hundred meters (near to *Banias* city) to several kilometers (in *Lattakia* region and *Alhamidyah* region; to the south of *Tartous* city). It is a flat strip broken in the northern part between *Oum Al Tiur* and *Ras Al Bassit* by lateral promontories running directly from the coastal mountains down to the sea. Ninety percent (80.48 $km^2$) of the urban areas are falling in the lower coastal plain and about 11% of the latter is the fertile arable land. Because of the highly developed nature of the coastal region (comparing to rest of the country), a large population density (nearly 500/$Km^{2,}$ direct calculations from CBS 2006) and considerable number of private properties and public infrastructure are located there. The vast majority of these properties are potentially at risk of inundation and flooding associated with future sea-level rise.

The coastal plain starts in the north with Calcareous and Basalt rocks interrupted with an area of sandy rocks covered with sand and gravel in *Ras Al Bassit*; these land features are repeated again in *Oum Al Tiur* (Fig. 3).

South in *Wadi Kandil*, river gravel and down in *Burj Islam*, calcareous rocks are dominant. Most of the remaining coastal plain is dominated by marine sandy rocks with interruptions of sandy/ gravel patches around the river estuaries, and by 2 distinctive wide sand dune areas: The first is 13 km long, just south of *Lattakia*, between the estuaries of *Al-kabir Al-Shimali* and *Al-Sanawbar* rivers (10-15 m above sea level), with a width of few hundreds meters.

This area can be regarded as the most distinctive along the eastern coast of Mediterranean. The second area is 12 km long in *Al-Hamidiah* south of *Tartous* (only 4-10 m above sea level). The uniqueness of these two areas makes them worthy to account for when dealing with any adaptation measure to combat the negative effects of sea level rise.

The road network (6148km, 667 km are central, CBS 2006) runs in two directions; North-South and West-East directions (Fig. 4). The only motorway (100 km) is that which distanced only few hundred meters from water edge and runs along the seashore. It starts 10 km north of *Lattakia* (from the Blue Coast, Cote de *Azur*) and connects *Lattakia* with *Tartous*, extends southward till *Al-Hamidiah* near the border of Lebanon.

This motorway diverts from *Tartous* southeastward to Damascus and is regarded as the main emergency road used for salvage, evacuations….etc. A parallel rail comes from Aleppo and extends from *Lattakia* south to *Tartous;* it is used as passengers and cargo transportation. The West-East roads connecting the coastal cities with inland cities are concentrated mostly in the northern part of the coastal area (*Lattakia* and *Banias* areas).

Other transportation means in the coastal area include domestic and international transportations through *Hmaimem* Airport (capacity 500 000 passengers/ year) near *Jablah,* and the two main commercial ports in *Lattakia* and *Tartous*.

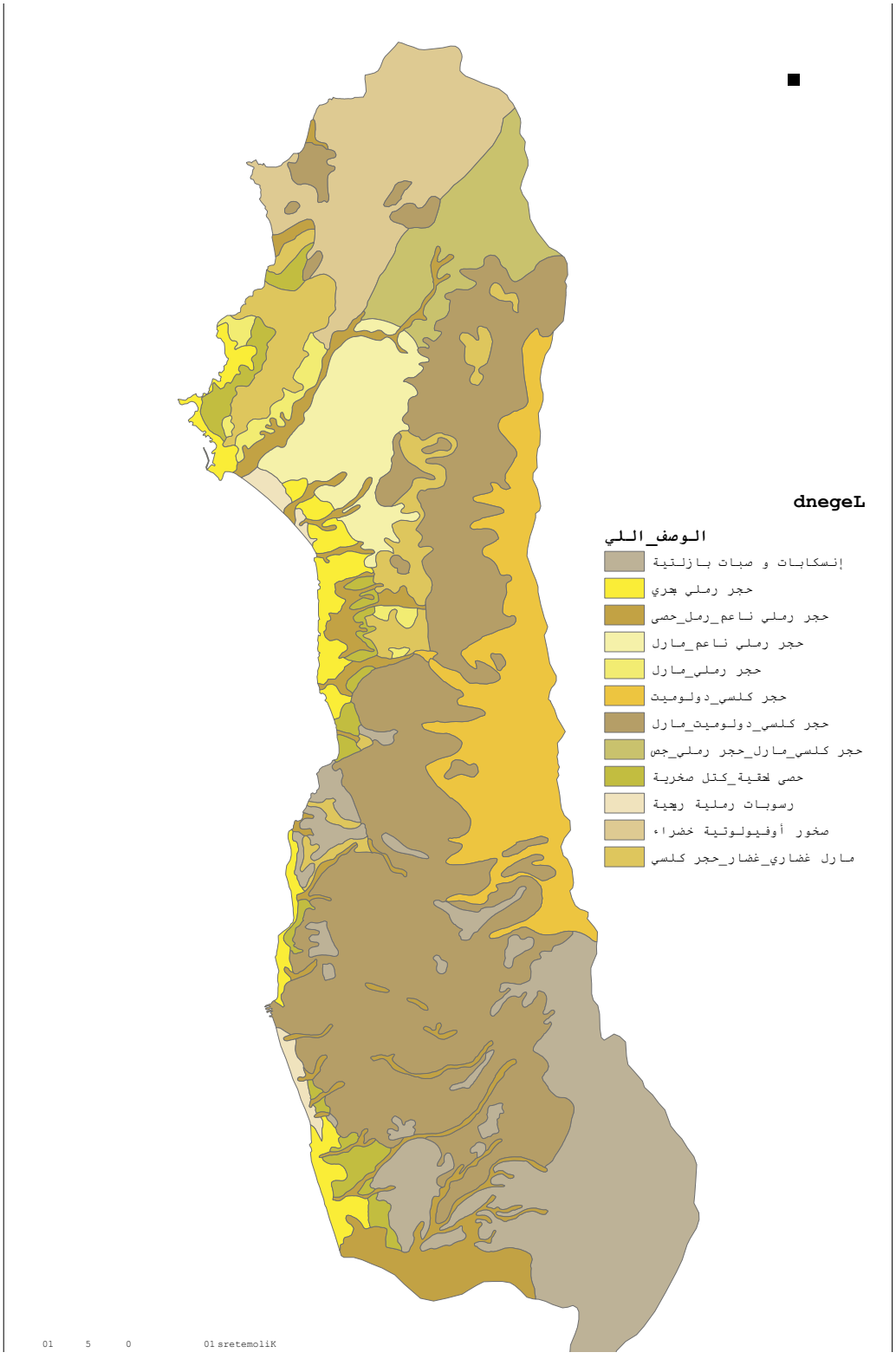


**Fig. (3):** Land characteristics of the coastal areas (*source: GORS 2006).*

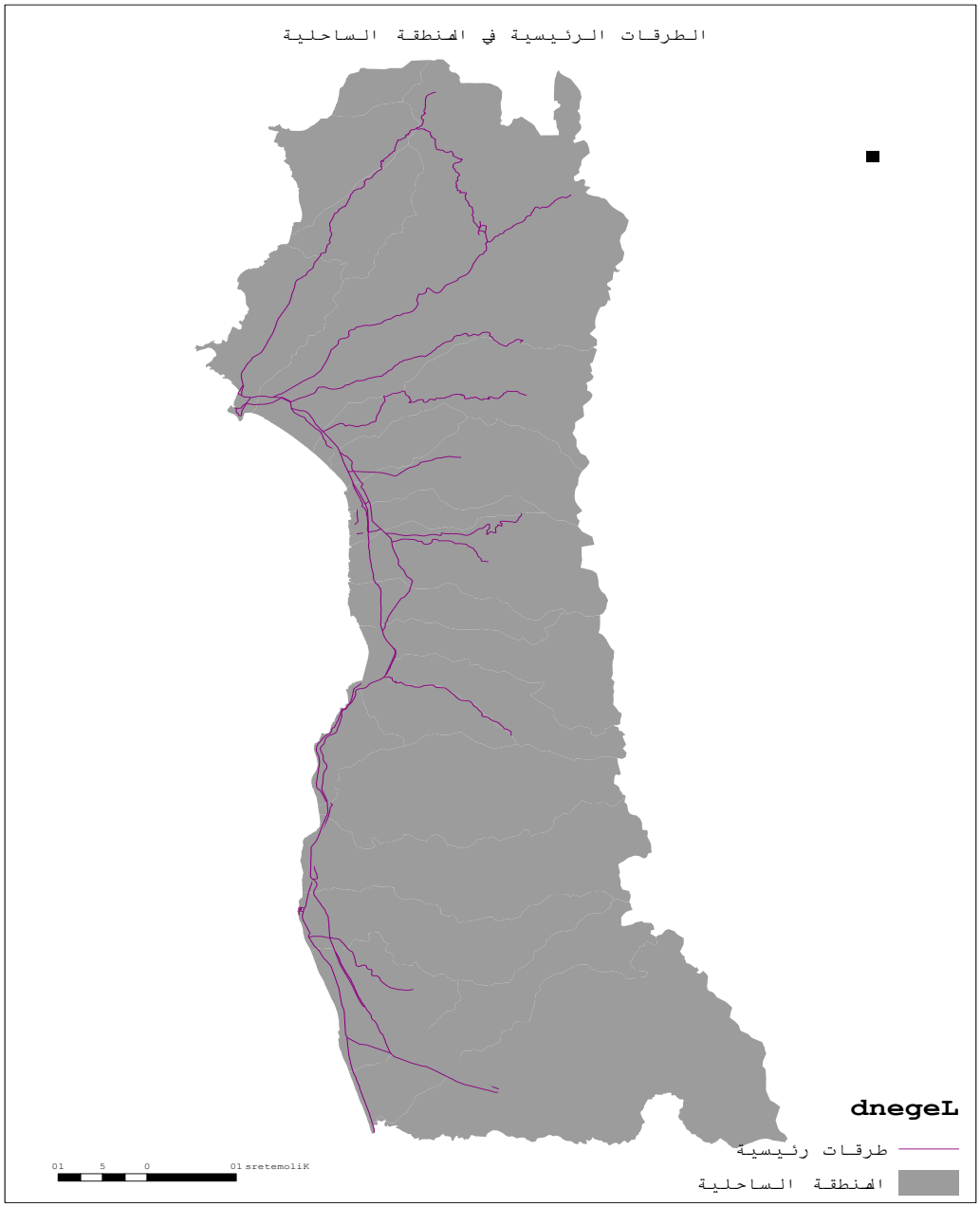


**Fig. (4):** Road network in the coastal areas (*source: GORS 2006*).

Health standard in the coastal area is quite high (CBS 2006), a total of 259 health centers exist and the number of persons per bed averages to 613 (719 in *Lattakia* and 507 in *Tartous*). Similarly, the number of persons per physician averages to 415 (405 in *Lattakia* and 424 in *Tartous*).

The coastal area has the highest education rate in the country. The number of schools (1st and 2nd stages, secondary and technical) is 2157 (CBS 2006). A governmental University (*Tishreen* University in *Lattakia*, with a branch of 4 faculties in *Tartous*) and a private one (*Al-Andalus* University in *Al-Kadmous – Tartous*) are present and offer a wide

range of higher education systems; Governmental, Open, Parallel, Virtual and Private learning, with more than 60000 students. An academy (the Arab Academy for Science, Technology and Marine Transport) also presents in the area.
Relatively, large number of industrial establishments is located in this fertile area. This exerts a heavy pressure on land use and on coastal and marine biodiversity. Negative effects also come about from the touristic activities which are noticeably increased during the last few years.
Fairly large number of industrial sites (Battery factory, wood industry, food processing, beverage, textiles, engines factory, metallurgy...etc, were located in the coastal plain in the vicinity of the shoreline (full information can be found in Ibrahim 2003).
Small-scale industrial units including olive-oil-extractors dominate the coastal area. A thermal power generation station, an oil refinery, petroleum pipelines, cement factory, organic chemicals and oil and phosphate terminals are also present.
Many coastal landfills and wastewater discharging points are also located on the sea shore. Four commercial ports (in *Lattakia, Tartous, Banias* and *Arwad Island*) and 14 fishing harbors are operated on the seashore.
The General Directorate of Ports has 36 surveillance points along the shore to control illegal activities and penalizing violators. Shoreline violation includes sand removal, private utilizations, illegal fishing, dumping ….etc. Likewise, the Directorate of Agriculture has several control points covering all forests in the area. Terrestrial violations include mainly woodcutting, especially in winter for heating or for expanding the agricultural land; the existing law and regulations are very strict in this regard.

The area has an asphalt field (in *Kfriyeh* in the north eastern part of al-*Kabir Al-Shamali* river basin) which has been invested a long time ago. Some crude oil seepage was recently come up from a depth of only 17 meters in several sites inside *Lattakia* city when laying grounds for buildings. Some exploration surveys are now being conducted off *Lattakia* coast, as well as inside the city and the surroundings for more potential oil exploration and evaluation of exploitation (Syria Times website 2008).
Climatically, the coastal region is a part of the Mediterranean humid or subtropical climate, with a gradual increase in rainfall and temperature from the west to the east and decrease from the higher to the lower slopes of the coastal mountains. It also decreases from north to south down to *Al-Bassit* block (PAP/ RAC 1990). Thus, a general characteristic of the coastal zone is a combination of relatively high temperature and medium amount of rainfall. The average annual temperature in the coastal area is almost 20 C°, as compared to 12.5 Cº for *Slonfeh*, the hinterland mountainous area (Eid 2004).
Rainfall in the coastal area is abundant (average annual rainfall well exceeds 1000 mm/ y, CBS 2006) and rain is carried by winds from the Mediterranean Sea concentrate between November and May. The high ridges of the coastal mountains catch most of the rain falls. Frost in the coastal plain is usually unknown in any season, although the peaks of the coastal mountains are sometimes covered with snow.

Sufficient rainfall supports intensive cultivation in the coastal area. However, the amount of rainfall in the mountains and its timing varies considerably from year to year, making the rain-dependant farmings at risk. Rainfall diminishes sharply as one move eastward of the coastal mountains and southward from the Turkish border.
The coastal area is well known for its richness with water resources. Surface and ground water resources are estimated to be 2235 million $m^3$, and the water balance embanked in

the coastal dams is estimated as 850 million $m^3$ (records of the Ministry of Irrigation). This quantity, in addition to the contribution of rivers and wells, is used to irrigate a total of 79629 hectares (Ghodban 1998). The General Organization of Remote Sensing in Syria has explored the coastal area for its ground water reservoirs and pointed to the major reserves in *Alkabir Al-Shima* river catchment, *Burj Islam (Nahr Al-Arab), Kinsabba, Giganiah, Morran* (GORS 2006). Likewise, other ground water sources were identified as suitable for bottling (e.g. *Jaobet Al-Rabned, Matta, Bserat Algird and Al-Shagara*).
The excess of freshwater resources in the coastal area has led the authorities to put a plan to transfer 906 millions $m^3$ per year (out of the spare quantity: 1494 millions $m^3$) through a pipeline from the coastal area to Damascus, the capital.

Water wells are distributed everywhere in the coastal area, although new digging permissions are highly restricted, due to the decrease in ground water level and the intrusion of sea water in many area.

However, it is obvious that the available water reserve is decreasing with time, due mainly to the decrease in rainfall and to the increased demands on water resources because of the increased human activities and developments.

Small impoundments that accumulate winter runoffs to supplement rain-fed cultivation and provide some additional summer irrigation are common in the coastal area. Small reservoirs used to store wells and springs waters for additional irrigation are common. Farmers, however, are now turning to sprinkler and trickle irrigation systems to reduce water loses during irrigation; the system which is now largely supported by the governments.
Twenty eight coastal rivers discharge water into the sea (Fig. 5). Most of these rivers are seasonal and many were dammed (20 dams, DOWR 2008) to divert water for irrigation. This made freshwater input to the sea very low. Consequently, the Syrian marine water (as the case in the eastern Mediterranean) is oligotrophic, has low productivity (benthos= 20g/ $m^2$ on 45 m. depth and 0.6 g/ $m^2$ on 200 m. depth for example, Saker et al. 1999) and high salinity (nearly 40 PPT). These situations increase the negative economical impact due to climate change and sea level rise.

Important component of the coastal area is the river valleys which crosses the coastal plain to reach the sea in many places. They are associated with the coastal rivers which can be described as short (usually less than 50 km) and seasonal. Numerous numbers of springs and streams exist in the coastal areas (Fig. 6), their direction is East-West, and cross the coastal mountains. Many springs and streams end to small seasonal rivers penetrating the lower coastal plain to reach the sea forming, as the coastal rivers do, the coastal estuaries which are very important and vulnerable ecosystems.

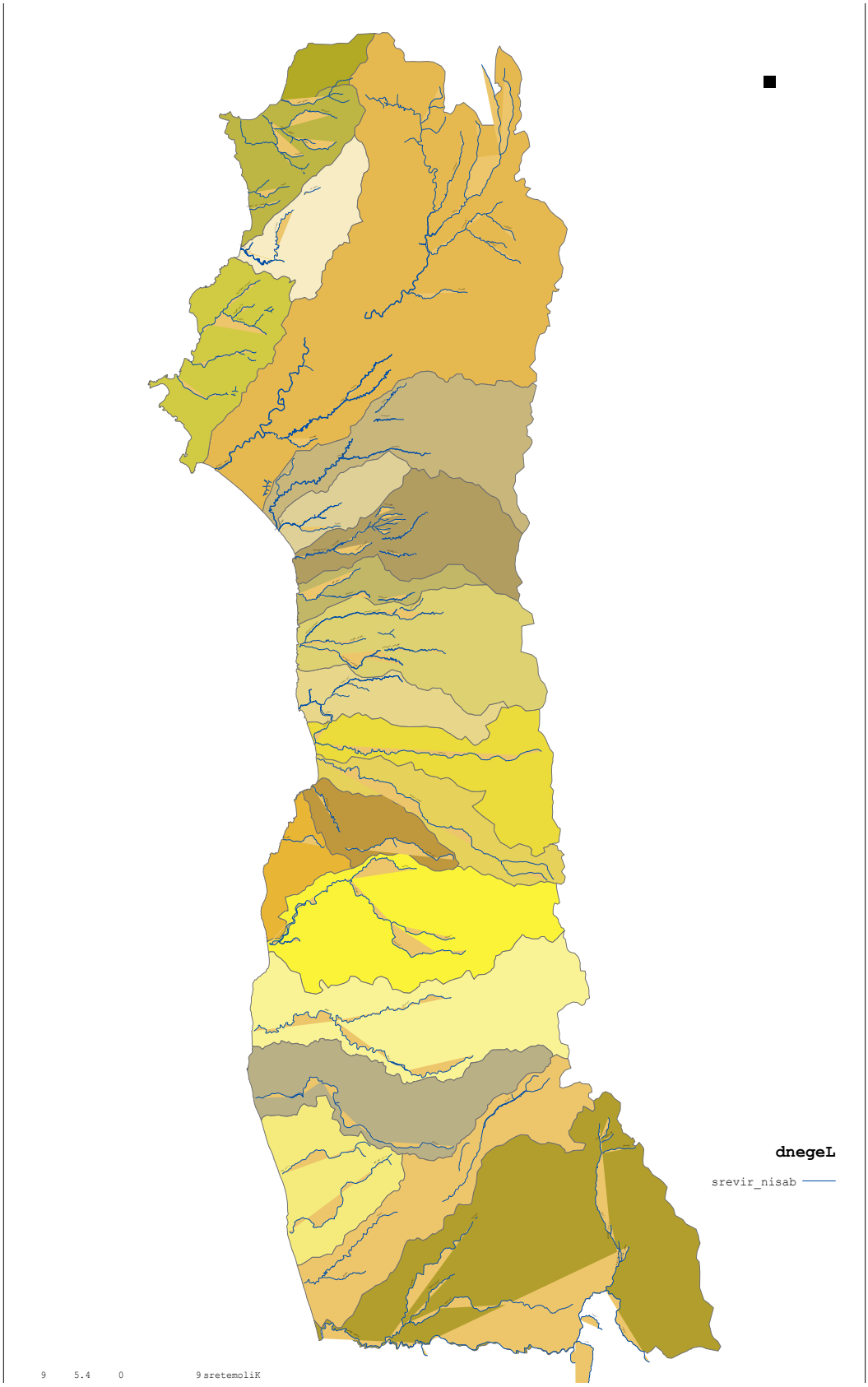


**Fig. (5):** Location of rivers in the coastal areas (*source: GORS 2006*).

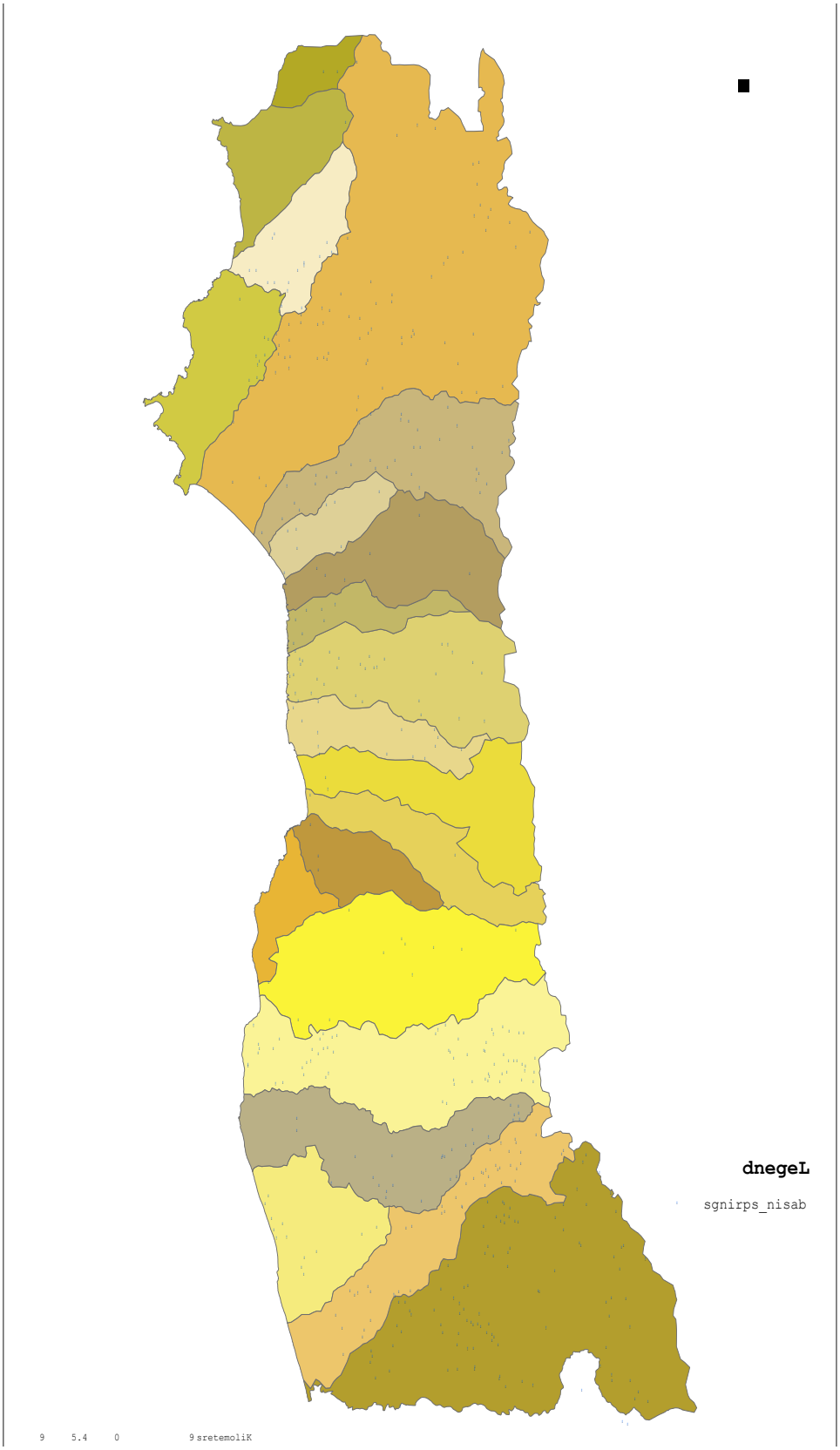


**Fig. (6):** Location of springs in the coastal areas (*source: GORS 2006*).

The large number of rivers and streams, combined with the sandy structure of soil (on the shoreline and in the lower coastal plain) make the land susceptible to various levels of erosions (Fig. 7), especially where the coastal mountains steeply project towards the sea (e.g. in the northern parts between *Oum Al Tiur and Al-Bassit* and *near Banias city.*

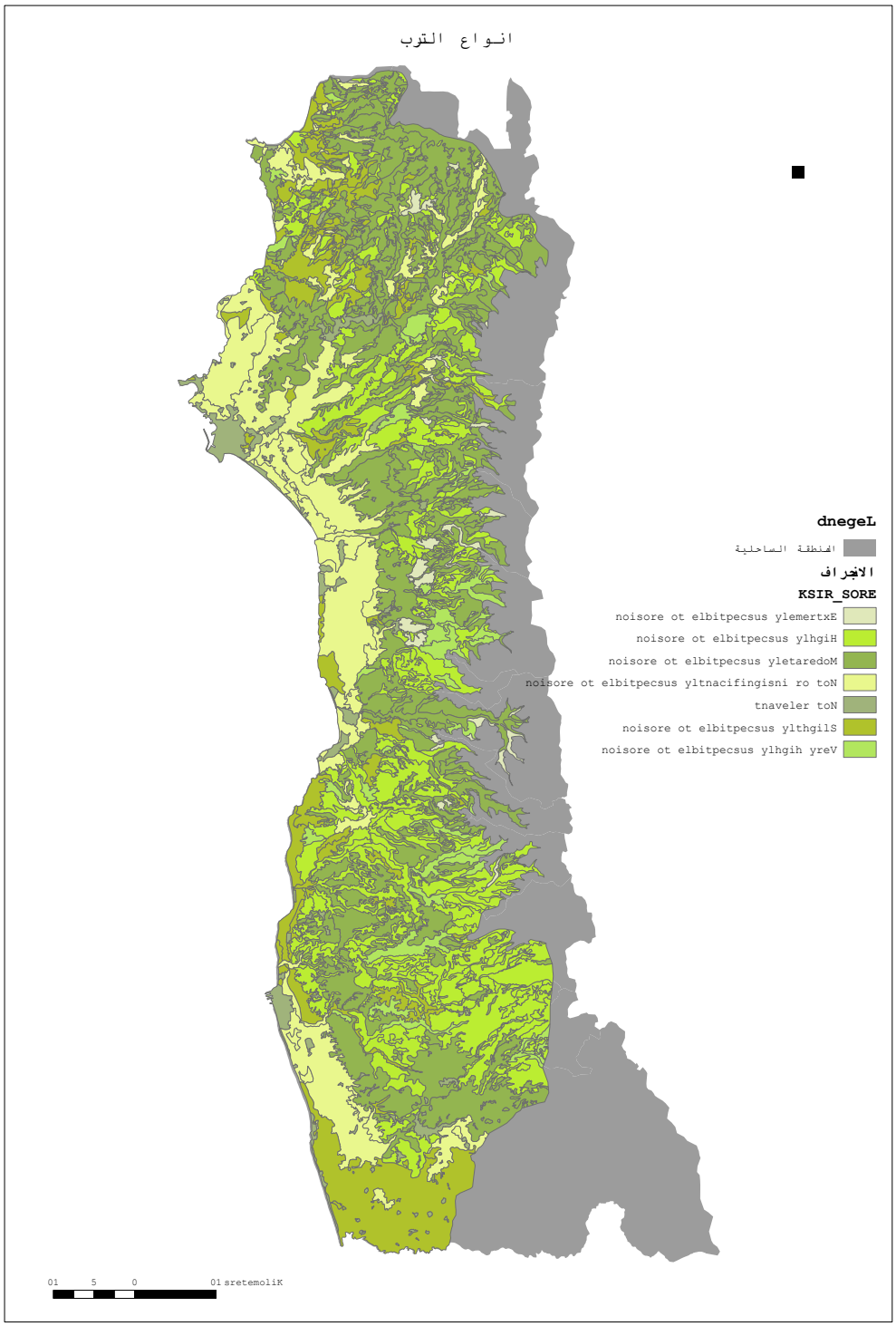


**Fig. (7):** Soil susceptibility to erosion in the coastal areas (*source: GORS 2006*).

The coastal area, offers a good source of groundwater either from the carbonate interiors or from exploitation of the huge amounts of freshwater flow offshore from the submarine springs into the seabeds. It is estimated that 17 freshwater springs occur along the shoreline, some of these submarine springs became the major source of freshwater to anglers at sea. They are located in *Tartous* governorate, mostly in *Banias* area; only one is discovered recently in *Borj Islam* (to the area north of *Lattakia*). It became evident that the seashore area may provide huge quantities of freshwater resources necessary for domestic and agricultural purposes.

In this context, several freshwater pathways have been identified by the Syrian GORS, in *Tartous* and *Banyas* areas. The aim was to look for the possibility of trapping the freshwaters as they run inland before discharging into the sea (Carlo and Ammar 1998). Freshwater pathways were found to be distributed along the area from 34 55 12 N; 35 54 24 E in the South to 35 13 45 N; 35 58 20 E in the north. Further north, only one submarine freshwater spring is located in *Burj Islam* area.

The balance between the coastal ground water and sea water exists throughout most of the year, but saltwater intrusion occurs in *Al Hamidyeh* coastal plain, close to the border with Lebanon, near *Banias, AlBassa* and north of *Lattakia (Dimsarko* area, and northward to *Wadi Kandil*). This happens mainly during the dry months due to uncontrolled overexploitation of the limited amount of freshwater confined into the aquifer there. Land Stalinization is continually increasing and heading to a level by which agricultural production will be severely affected. The solution for that is to identify alternative freshwater sources, which can be used for irrigation.

### c. Coastal Plateau, Steep Hills and Upper Plateau

A "chain" of coastal mountains parallels the lower coastal plain; averaging 1200 m in height (the highest peak is that of *Al Nabi Yunis*, about 1575 m). Because it is influenced by the western sea wind (which is laden by moisture), the land of the western slopes are more fertile and thus more heavily populated comparing to the eastern slopes (which is influenced by the hot and dry winds coming from the desert).

The coastal area has an alluvial plain, becoming quite wide south of *Lattakia;* the low basaltic hills in the south and along the coast near *Banyas* are undulate marl hills and rugged calcareous mountains. Many deep valleys cross the mountainous area (usually related to faulting) making the terrain of the coastal area extends inland. The landmass represents a very thick carbonate sequence, consists of an alternance of dolomite, dolomite limestone and limestone, bedded with flint nodules, and covered by basalts in its southern half of the region, and by marls in its northern half.

Despite that the coastal region has a uniform drainage basin (called the coastal basin) that outflows into the Mediterranean, the area is divided into 13 different local sub-basins; 7 of them are totally confined within a short reach of the shoreline (Fig. 8). Each of these sub-basins should be regarded as a separate unit when dealing with sea level rise.

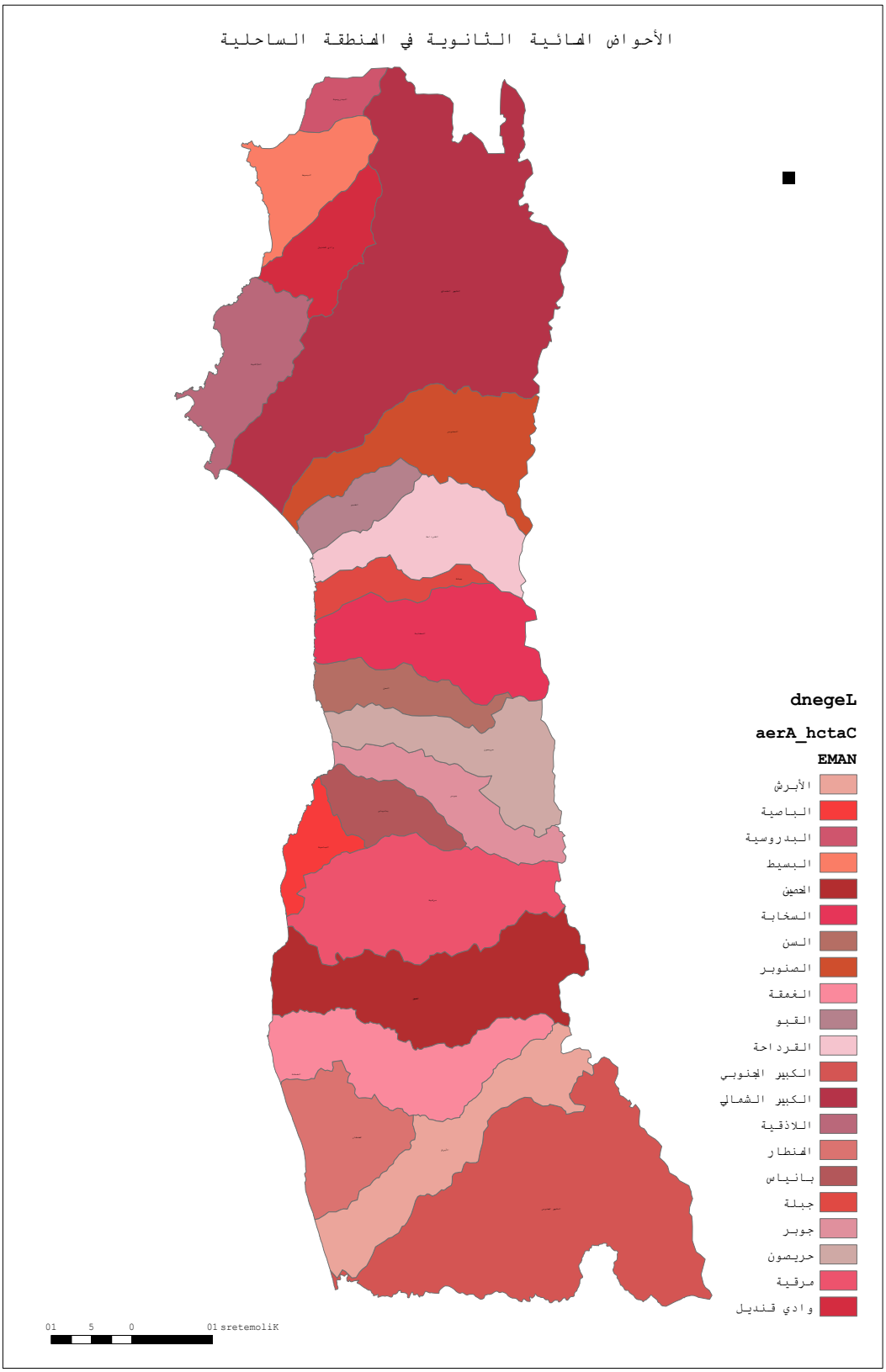


**Fig. (8):** Sub basins of the coastal areas (*source: GORS 2006*).

Forests concentrate in the middle and higher elevations of the coastal mountains and cover most of the coastal mountain ranges. This area has 21334 hectares of forests which accounts for 36.2 % of the country forests (MOA 2006). Grass and coarse vegetations grow in this part of the coastal areas. The fire has recently come to large areas of the coastal forests and has not left much. However, there has been influential effort from the government to rehabilitate the coastal forests in the cleared land.

In regards of the protection measures, two forest protected areas were announced by the Ministry of Agriculture and Agrarian Reforms; in *Oum Al Tiur* (1000 hectares; on May 1999) and in *Al-Bassit* (3000 hectares; on 29 May 1999). These protected areas are characterized by great floral diversity of trees, herbaceous and arborescent plants containing many endemic, rare and endangered species, some of which are at the westernmost edge coast. In 2008, the ministry of Local Administration and Environment in collaboration with the Regional Activity Center for Specially Protected Areas (RAC/ SPA) has proposed the area between *Oum Al Tiur* and *Ras Al Bassit* (about 15 km) as a coastal and marine protected area (within a reach of 50m of the beach and 6 km offshore). The only other protected area declared on the coast is that of *Fanar Ibn Hani* (also by Ministry of Agriculture and Agrarian Reforms; Decree No. 23/ T dated 19 July 2000) with the space of 1000 hectares.

The area is rich in cultural and archaeological heritage, natural touristic sites and contains large percentage of the country freshwater resources. Tobacco farming, which has a distinctive contribution to the national income (total production in 2005 was 28.8 thousand tons, CBS 2006), is practiced only in the coastal area.

The coastal communities, however, do not have enough knowledge about sea level rise and the related consequences due to climate changes**.**

## 3. The Maine Sector Related Impacts

Taking into account the above-mentioned situations of the Syrian coastal ecosystems, sea level rise may have substantial consequences on various sectors of economy, the most important impacts are:

- Sea level rise may be projected to adversely affect several physical, ecological, biological, and socioeconomic characteristics of the Syrian coastal zones, which are already under stress.
- Sea level rise can cause devastation to the coastal properties especially when associated with strong storms; storms as strong as 10 force at Beaufort Scale may happen few times of the year on the Syrian coast. The most likely properties to be affected are those located near the sea and almost as low as sea level, such as the chalet in *Fanar Ibn Hani, AlBassit*…etc. As sea level rises, the potential property damage from strong storms and winds, associated storm surge will be increased dramatically, especially that the construction design and safety did not take into account the forces generated by sea level rise.
- The major coastal cities such as *Lattakia, Jablah, Banias* and *Tartous* (and other populated are situated at sea level-would be very vulnerable.
- Effect on the emerged beaches used as nesting sites of marine turtles, and loss of traditional beaches through inundation.

- Increasing soil erosion, due to the increase in rainfall effect on the deforested areas, steep lands and beaches.
- Erosion threatens the high ocean sides of the densely developed resorts and is generally regarded as having more immediate problem than inundation of their low level bay sides.
- Dramatic losses of ecological habitats and coastal wetlands: The ranges occupied by many species will become unsuitable as sea level rises. This poses a significant risk of additional losses to the already threatened coastal wetlands in the region.
- In sand dune habitats (such as in *Al-Bassah and AL-Hamidiah*) which contain many plant and animal species that are totally associated with sandy substrates and unable to thrive elsewhere. Presently, such species are under severe pressure from land reclamation and tourist development which largely diminish their ecological habitats. Populations of many species may disappear due to fragmentation of their habitats.
- Raising coastal water tables and increasing salinity of estuaries and aquifers: A serious impact could be the eastward migration of saltwater up the coastal rivers of *AlKabir Al Shimaly, AlHosien, AlKabir, AlJanobi.*
  Saltwater may also seep into the coastal aquifers, affecting these critical water supplies. Effects are expected on the ground waters and submarine freshwaters.
- Severe winters and windstorms are expected. Tidal waves, storm surges, and hazards may increase and modify littoral transport systems. Over 120 kilometers of coastal highways can be occasionally flooded. More severe weather could make these roads impassable. Evacuation from the high-risk areas during major storms will pose serious problems because many evacuation routes are close to flood-prone areas.
- The main ports, resorts and hotels along the coastline, archaeological sites and the industrial plants relying on marine water intake will directly be affected.
- Fishery activities, fishing harbors and coastal aquaculture will also be under the threat.
- Heat waves will result in droughts and more forest fires and ground water exploitations.

## 4. Adaptation Options Including Policies, Strategies And Actions

Adaptation measures that may reduce sea level rise impacts may include the followings:

- Establishing contour stones terracing in the cleared areas, building concrete construction and improving the marine vegetation cover on steep slopes will help reducing the effect of sea level rise.
- To compensate for sand losses from erosion, additional sand would have to be placed on the beaches. This could be achieved by special constructions, which encourages sand nourishment. This may remain a viable option through but could become significantly more costly.
- In general, the effect on coastal wetlands will be minimized if the amount of sand or soil buildup parallels the rate of sea-level rise, or if the wetland by itself is able to move inland.
  However, if sand and soil accumulations are unable to keep pace with rates of sea-level rise, or if wetland movement is blocked by coastal developments, bluffs or

constructions (such as sea walls, jetties…etc.) the wetland will be eventually lost by inundation, although the intensity of impacts will vary from place to place.

- The potential consequences of climate change are not yet being undertaken into consideration when coastal managements were considered; e.g. the Integrated Management Plan of the Syrian Coastal Zone (1992). It is of special importance to begin adaptation of the coastal zone with regard to development.
- Natural vegetation and wildlife may at least partially acclimatize and adapt naturally to sea level rise. Adaptation procedure may be enhanced through creation similar sand dunes and reducing habitat fragmentation to assist the natural genetic diversity to work towards suitable adaptations.
- National Strategy and a series of Action Plans should be developed to take into account various means of sea level rise impacts on the coastal areas and various adaptation measures needed.
- Enhance capacity building and conducting research project related to sustainable conservation and development.

## 5. Vulnerability Assessment of Coastal Areas To Sea Level Rise And Possible Adaptation Measures

- Syrian coastal area is vulnerable to sea level rise due to climate change that will be reflected in shoreline erosion, increased storm intensity and frequency, changes in rainfall, and related flooding. This is in addition to changes in saltwater intrusion into groundwater aquifers, thermal stratification, water acidification, habitat loss, species migrations and changes in species composition and population dynamics.
- Preparing for these impacts will be achieved through the government policies and strategies. The integrated coastal zone management strategy will play an important role in identifying vulnerabilities and foster adaptation to sea level rise and climate change. Syria has made two studies on the integrated coastal zone management. Such management plans should be modified to incorporate the effect sea level rise. The challenging factor now is to include various adaptations strategies for a variety of sea level rise scenarios and adjust those management strategies accordingly.
- On a long run, the shoreline of many coastal areas, such as *Oum Al Tiur, Joun Jablah (south of Lattakia)* and *Al Hamydiah,* will be specifically vulnerable to sea-level rise, as the slope of these areas is so gentle where a small rise in sea level produces a large inland shift of the shoreline.
- Increasing atmospheric $CO_2$ concentrations may decrease the calcification rates of the Marine Vermited Terraces and reduce growth rates of the organisms living on.
- Appropriate programs should be initiated on a regular basis to determine the trend of sea level rise and their effects on the coastal area.
- Coordination between research institutions should exist and the work should be concentrated on the programs concerning climate changes and sea level rise.
- Increase involvements and participation in international activities related to sea level rise. Syria is a party of many international and regional conventions and treaties related to environment and climate change. This facilitates international assistance in this regard.

- Many Syrian coastal sites (e.g. *Ras Shamra*) are of international importance and it may be possible to seek international assistance to maintain such protected areas.
- New policies are to be developed to take into account public infrastructure, site-level planning, wetland conservation and restoration, historical shoreline preservation, seashore construction setbacks, building elevations, and armoring shoreline against sea level rise.

## 6. References


- Carlo, T. and Ammar, O. (1998): Groundwater exploration by satellite remote sensing in the Syrian Arab Republic, RSC Series 76, FAO 1998.
- CBS (2006): Statistical Abstracts, Central Bureau of Statistics, Syria.
- Dalati, M. (2008): Monitoring of Earthquakes Activities along the Syrian Rift System (Left-Lateral) by using Remote Sensing and GIS Database. Geophysical Research Abstracts, Vol. 10,
- DOA (2008): Official records of the Directorate of Agriculture in the coastal areas, Lattakia–Tartous, Syria
- DOWR (2208): Official records of the Directorate of Water Resources in Lattakia, Ministry of Irrigation, and Syria.
- Eid, Y. (2004): Report on predominant climatic situation in the Syrian coast.
- GDOP (2008): Official records of the General Directorate of Ports, Ministry of Transport, and Lattakia-Syria.
- Ghodban, A. (1998): Water resources and their usage in Syria. Workshop on water resources in Syria.
  2-4 May 1998. Supreme Council of Science, Ministry of Higher Education-Syria.
- GORS (2006): General Organization for Remote Sensing, Damascus, Syria.
- Ibrahim, A. (2003): National Diagnostic Analysis (NDA) of Syria, technical report UNEP/MEDU.
- Ibrahim, A. (2008): Textbook on Marine Meteorology, Arab Academy of Science, Technology and Marine Transport. *Lattakia*-Syria.
- Meslmani, Y., and Hoff, H., (2008): Impacts of Climate Change on water sector and adaptation in the MENA region and Syria. Modernization Programme for the Syrian Water Sector and German Development Cooperation - GTZ, Damascus, Syria. June 2008. (Arabic report).
- Meslmani, Y., and Faour, G., (2009): Syrian Sea Level Rise Vulnerability Assessment 2000-2100 (GIS). (INC-SY_V&A_Syrian Sea Level Rise); United Nation Development Programme (UNDP) / GCEA. Damascus, Syria. March, 2009.
- Meslmani, Y., Mawed, K., Khaleel, I., and Eido, M., (2009): Vulnerability Assessment and Adaptation of Climate Sector in Syria. (INC-SY_V&A_ Climate); United Nation Development Programme (UNDP) / GCEA. Damascus, Syria. March, 2009.
- Meslmani, Y., and Ali, M. K., (2009): Evaluating the Vulnerability of Forest Sector in Syria to Climate Changes. (INC-SY_V&A_Forest); United Nation Development Programme (UNDP) / GCEA. Damascus, Syria. March, 2009.

- Meslmani, Y., and Eido, M., (2008): Climate-Changes-and-the-Mediterranean-Environmental-and-societal-impacts. (INC-SY_ Climate Changes and the-Mediterranean); United Nation Development Programme (UNDP) / GCEA Damascus, Syria. June 2008.
- MOA (2006): Official records of the Ministry of Agriculture and Agrarian Reform, Directorate of Forestry, Damascus-Syria.
- MOLA (2007): Records of the Ministry of Local Administration and Environment, Damascus-Syria.
- MOT (2003): Official records of the Ministry of Tourism, promotion and marketing Dep't. Damascus, Syria.
- NEE (2001): National Economies Encyclopedia: Asia and the Pacific, Syria. London.
- OCEANOLOGY: English Translation, VOL. 34, NO. 1, August 1994.
- Ovchinnikov, M. and Abu Samra, F. (1994): Investigations of the winter regime in Syrian Waters of the Eastern Mediterranean Sea.
- Oceanology: Vol.34 (3): 428-431.
- PAP/RAC (1990): Preliminary study of the integrated plan for the Syrian coastal region, P.7 (CCP/1988-1989/SY/PS) Split.
- Sa'adeh, G. (1984): The concise in *Lattakia* history. Al-Sharkiah Establishment for puplication and industry, *Lattakia*. 61pp.
- Schlitwer, R. (2006): Ocean Data View, http://odv.awi-bremerhaven.de, 2006
- Vitayz, (1992): The Syrian-Russian joint exploration mission in the Eastern Mediterranean Feb. 12 – Mar. 11, 1992.