REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

PAP/RAC

CNRS
National Council for Scientific Research

THE LEBANESE NATIONAL MONITORING PROGRAMME FOR COAST AND HYDROGRAPHY INDICATORS IN THE FRAMEWORK OF ECAP-MED II

FINAL REPORT

September, 2017

Prepared by:

ALI FADEL
LEBANESE NATIONAL COUNCIL FOR SCIENTIFIC RESEARCH
REMOTE SENSING CENTER (CNRS-RSC)

Prepared to:

LEBANESE MINISTRY OF ENVIRONMENT
&
PRIORITY ACTIONS PROGRAMME
REGIONAL ACTIVITY CENTRE

Table of Contents

LIST OF ACRONYMS

CP	Contracting Party
CZM	Coastal Zone Management
DGUP	Directorate General of Urban Planning
EIA	Environmental Impact Assessment
GES	Good Environmental Status
ICZM	Integrated Coastal Zone Management
IMAP	Integrated Monitoring and Assessment Programme
IOE	Institute of the Environment
MOA	Ministry Of Agriculture
MOE	Ministry Of Environment
MOEW	Ministry Of Energy and Water
MOI	Ministry of Interior
MOPWT	Ministry Of Public Works and Transport
MRCZM	Marine Resources and Coastal Zone Management
NGO	Non-Governmental Organization
NCGR	National Centre for Geophysical Research
NCMS	National Center for Marine Sciences
NCRS	National Remote sensing center
MSP	Maritime Spatial Planning
UNEP	United Nations Environment Program

Introduction

Barcelona Convention is the first-ever Regional Seas Programme under UNEP's umbrella that addresses specific aspects in an aim to protect the Mediterranean marine and coastal environment while boosting regional and national plans to achieve sustainable development. This convention included 22 Mediterranean countries including Lebanon.

The current report responds to the call issued by the Ministry Of Environment (MOE) in Lebanon after the adoption of Decision IG.22/7, on "Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria" (IMAP) by the 19th Meeting of the Contracting Parties in 2016, to update the national monitoring programmes in light of the new elements of IMAP.

The following report presents the Lebanese national IMAP monitoring programmes for the indicators of hydrography, land use change and the coastal ecosystem and land change. It brings together information for all the IMAP ecological objectives and common Indicators. It is based on the "Draft Integrated Monitoring and Assessment Guidance" (WG.420/4), as well as monitoring plans or programmes developed by EU Member States under the MSFD[1].

[1] The review of Monitoring Programmes from France (Programme de surveillance: sous-région marine Méditerranéeoccidentale, 2015) Portugal and Spain were found to be particularly relevant and useful. These are available from http://cdr.eionet.europa.eu/recent_etc?RA_ID=611

Chapter 1 Legislations and IMAP concerned national institutes

This chapter overviews the legislation and regulatory requirements to support the development and implementation of National Integrated Monitoring and Assessment Programme (IMAP). It then lists all the Lebanese institutes that may have direct or indirect in Coastal Zone Management (CZM) in Lebanon.

1.1 Legal, administrative or other obligations pertaining to monitoring

From a legal standpoint, environmental monitoring in Lebanon is currently covered, in particular, by the law for the protection of the environment: the Environment Act. Furthermore, Lebanon is Party to several international conventions and agreements, and is thereby expected to apply the provisions for environmental monitoring recommended in some of these. Many international conventions are not applicable by itself and are of no direct interest/impact. Therefore, several conventions are not being applied due to the non-issuance of laws and / or decrees.

<u>Environment Act (Act no. 444/2002) dated 29/07/2002.</u>

The Environment Act (no. 444/2002) is the most important framework for Lebanese environmental legislation. It specifies the principles for environmental action and outlines provisions regarding the conservation of various environments.

This Act has several aspects relevant to environmental monitoring:

- It specifies that environmental monitoring is one of the principles to be complied with to prevent pollution and monitor various environments: water, air and soil (Article 4).
- It makes the Ministry of Environment responsible for specifying environmental quality standards (Article 12).
- Chapter 3 of this Act is devoted to the environmental IT system, whose implementation is supervised by the Ministry of Environment.

Several Decrees have been issued to apply this Act. The Decrees pertaining to Environmental Impact Studies and Strategic Environmental Assessment are particularly relevant to environmental monitoring.

There is no clear law concerning setback zone in the Environment Act (Act no. 444/2002) dated 29/07/2002 published by MOE. However, a work started in 2004 by the Higher Council for Urban Planning on regulations for non-covered regions have concluded to a regulation proposition that recommended regulations for construction, quarries and industrial sites in and around distinguished sites including coastal zones. These recommendations suggest a construction setback of minimum 50 m from the edge of the coastal sites (DAR-IAURIF 2005).

Decree no. 8213 dated 24/05/2012 pertaining to Strategic Environmental Assessment:

The relevance of this decree with respect to environmental monitoring is found, in particular, in its provisions regarding environmental management plans, which must include an environmental monitoring plan (Article 7).

Decree no. 8633 dated 16/08/2012 pertaining to Environmental Impact Studies

In its body text, this Decree does not have provisions explicitly associated with environmental monitoring, but in its Annex 7, it is stated that the environmental monitoring programme, and an assessment of its cost, should appear in the impact study of any project subject to this procedure.

Other legislation is relevant to IMAP implementation, in particular, the Ministerial Orders pertaining to standards for bathing water quality (Order no. 216 dated 08/04/1993) and to standards for reducing air, water and soil pollution (Order no. 1/52 dated 12/09/1996).

Mandatory environmental monitoring is also introduced via protected area management plans. This is the case for the Palm Islands Nature Reserve Management Plan. This was drawn up and approved for the period 2000-2005; however, due to lack of funds, it has not been updated since it expired.

The Directorate General of Land and Maritime Transport has been involved in the enforcement of laws and regulations relating to coastal control including navigation and ports, and controlling and sanctioning their violations. No clear provisions is are available on coastal defence infrastructures. Legal documentation related to ports lack proper environmental conditions especially regarding the construction and the exploitation of maritime transportation vehicles and facilities. This loophole has led to disregarding environmental issues during the construction of harbours. Indeed, EIA studies were only implemented on a small number of harbours. This is due to the fact that the concept of the EIA studies was adopted by the legislator in Law 444/2002, decree no. 8633/2012, and decisions no. 229/1 and 230/1 dated 16/11/2012.

1.2 Compliance with Laws and regulations

There is a lack of court practices related to the environment in general which would allow a proper assessment on the level of compliance/non-compliance of the laws and regulations presently in place (MRCZM-IOE-UOB, 2014).

1.2.1 Occupation of the maritime public domain

Decrees 17614/1964 (exploitation of the public maritime domain) and 4810/1966 (Regulating the occupation of the maritime public domain) issued by the MOPWT have established the procedure pertaining to the exploitation of the public maritime domain. The poor implementation of the issuance of permit procedures for the exploitation of the maritime public domain has led to environmental and ecological deterioration, and the interruption of the shoreline due to trespasses by public.

Each permit is renewable on a yearly basis and no reference is made to the unconditional right of the public authority to recover or reclaim the "leased" section of the coast. The renewal application is submitted to the MOPWT and forwarded to the DGUP, without any coordination or consultation with the MOE. The latter only has an indirect role in the process through the Higher Council for Urban Planning in which the Directorate General of the Environment is a member, in addition to the evaluation of the EIA studies which shall be submitted to the MOE.

1.2.2 Permits pertaining to the extraction of sand and gravel from the maritime public domain

The Lebanese Coastal Zone is characterized by a diverse geological structure consisting of sandy and rocky shores which has led to many harmful practices, such as the suction of sand and the extraction of gravel. The lack of environmental standards for such activities has led to the proliferation of these practices. The law prohibits the extraction of gravel and sand from the maritime public domain and seabed, but provides for an exception. Thus, the law allows the extraction of gravel, sand and sediments in certain cases based upon a decision of the Minister of Public Works and Transport, if such activities aim at cleaning ports and harbors, or if the extracted material is necessary for natural defense purposes for water filters. The law does not set any environmental restriction for public interest, except for taking into consideration the maritime public domain, preserving the beauty of the beach and keeping a distance of at least ten meters between the authorized site and any private properties, roads, railways or public facilities.

1.2.3 Permits for marine navigation

Legal documentation related to maritime transportation (ports and ships) lack proper environmental conditions especially regarding the construction and the exploitation of maritime transportation vehicles and facilities. This loophole has led to disregarding environmental issues during the construction of harbors. Indeed, EIA studies were only implemented on a small number of harbors. This is due to the fact that the concept of the EIA studies was adopted by the legislator in Law 444/2002, decree no. 8633/2012, and decisions no. 229/1 and 230/1 dated 16/11/2012.

1.2.4 Permits for wastewater discharges

The Minister of Public Works and Transport is entitled to license the disposal, filling or incineration, in territorial water or underneath the seafloor of territorial water, of materials that do not produce, inter alia, heavy metals, phenols, halogenated compounds, petroleum products, pharmaceutical by-products, peroxides and azides, ethers, chemical wastes, asbestos, and their derivatives, etc. These operations should not be carried out without proper monitoring of the possible impact on the maritime environment. However, the implementation decrees remain missing.

1.2 Legislation gaps

There is an obvious overlapping prerogatives of the various ministries and local authorities that makes it hard to maintain a GES on the Lebanese coast. Moreover, there is no unified fines, penalties and criminal sanctions related to environmental infractions and crimes (MRCZM-IOE-UOB, 2014).

1.3 National institutions and organizations concerned with IMAP

Several institutions are concerned with environmental conservation and CZM in Lebanon. These are that could therefore play a role in implementing IMAP in Lebanon.

The main institutions/stakeholders involved in CZM that could therefore play a role in implementing IMAP in Lebanon are:

- The Ministry of Environment (MOE)
- The Ministry of Public Works and Transport (MOPWT)
- The Ministry of Energy and Water (MOEW)
- The Ministry of Public Health
- The Ministry of Agriculture (MOA)
- The Ministry of Interior (MOI) and Municipalities
- The National Center for Marine Sciences (NCMS) affiliated to the National Council for Scientific Research (CNRS)
- The National Remote Sensing Center (NRSC) affiliated to the National Council for Scientific Research (CNRS)

- Observatories for the environment and sustainable development
- Non-Governmental Organisations (NGOs)
- Monitoring programme(s), networks and other environmental monitoring initiatives
-

1.3.1 Ministry of Environment

MOE has a role in CZM, as they formulate strategies, policies, programs, and action plans for CZM. MOE is responsible for the development of relevant legislation, and participation in the preparation of international treaties and protocols. Moreover, they promote awareness and guidance on CZM issues at community level. MOE has also the task of:

- Creation and exploitation of public beaches
- The protection of the coastal zone
- Formulating the strategy, action plans, programs, and studies required for the integrated management of hazardous and non-hazardous solid waste, domestic and industrial wastewater, in addition to monitoring their implementation
- Regulating hunting and fishing activities in coordination with the MOA
- Controlling the use and disposal of chemicals
- Conducting inspection visits and stopping contraventions

1.3.2 Ministry of Public Works and Transport

The authority to implement the laws and regulations related to coastal control and to sanction violations was delegated to a special body attached to the Directorate General of Land and Maritime Transportation with regards to the inner areas of ports and harbors, in coordination with a similar body affiliated to the Directorate General of Internal Security Forces. The joint decision issued by the Minister of Public Works and Transportation and the Minister of Interior defined instructions to coordinate the duties of controlling and ending violations on the public maritime domain.

1.3.3 Ministry of Energy and Water

The MOEW's may have an indirect role in CZM due to legislation related to the execution of water projects and works, implementation of laws and regulations relating to water conservation and use, due to their authority over the public river domain that usually inputs in the Mediterranean Sea and their role in management of waste and storm waters.

1.3.4 Ministry of Public Health

In relation to ICZM, Ministry of Public Health may have an indirect role through the Inspection of water quality in public beaches and tourist resorts, conducting studies and suggesting protocols aiming at preserving the environment's safety from threats to public health, and approval of projects such as the establishment of slaughterhouses and construction of sewage networks

1.3.5 Ministry of Agriculture

In summary, MOA's mandate related to CZM can be through their role in agricultural planning, forest protection, reforestation activities and creation of natural reserves which can indirectly affect that land use change. In addition to this, MOA do research and manage of fishing sector in cooperation with the MOPWT

1.3.6 Ministry of Interior and Municipalities

Municipalities may have a role due to their authority in approving permit for any residential, touristic and industrial activities on coast, controlling violations of laws (including those related to sand extraction) and infringements on the public maritime domain or municipal domain, stopping contraventions, creating and managing public beaches, and cleaning up the shore

1.3.7 National Center for Marine Sciences (NCMS)

The NCMS is part of the Lebanese National Council for Scientific Research (CNRS). It was established in 1977. The decision to establish such a centre (1975) was the national response to the 1972 Stockholm Conference. Its mandate is to maintain permanent monitoring of the country's coastal zone and marine environment, in particular via a national observation network. This involves monitoring the quality of water and sediments and studying species and habitats.

The centre is a recognized institute within the Mediterranean network of marine centers and is integrated in a number of regional and international activities. Research activities at the center focus on three themes:

- Monitoring of the coastal zone by creating a national observation network, modeling the cycles of contaminants and using bioindicators.
- Evaluation of specific diversity by characterizing the living communities more particularly the migratory species and their habitats.
- Production and transfer of matter in the coastal and marine ecosystems.
- Fishery stock evaluation.

The NCMS has laboratories in Jounieh and Batroun, and a research vessel (CANA-CNRS) acquired as part of bilateral cooperation with Italy. The vessel is fitted out for sampling in the water column and in sediment, and for performing explorations (dives, remotely operated vehicles, multi-beam and dual-beam echosounders, side-scan sonar, sediment sounder, etc.). The Centre has just (2016) acquired a new vessel (CADMOS-CNRS, a 7m twin-engine catamaran).

1.3.8 National Remote sensing center (NCRS)

The NCRS was established in 1995 and became fully operational in 1997. This came as the culmination of a focused effort to catch up with recent advances in remote sensing and GIS technology. The Centre is linked to various regional and international organizations for implementation of collaborative programmes. The Center has proved to be an important tool for decision makers as it is supporting various activities that are essential to several ministries.

The RSC has to its credit various studies dealing with watershed and forestry management, urban settlements, archaeology and the environment, integrated coastal zone management, public participation, natural hazards, updated and new soil map of Lebanon. Furthermore, the Centre is securing highly needed upgraded information as well as cooperating with several development projects necessary for environmental monitoring and data acquisition in various sectors, and producing various thematic maps, training staff of various public agencies on requirements and applications of remote sensing and GIS.

1.3.9 National Centre for Geophysical Research (NCGR)

The geophysical Research Center CRG was established in 1975 and is the oldest among the four CNRS centers. Within the framework of a French-Lebanese partnership, the RN Le Suroît of the IFREMER fleet surveyed an area extending 100 km off the shores of Lebanon in order to complement the land studies about the exposure of the country to seismic risk. One of the main outcomes of this survey (code-named SHALIMAR for Seismic HAzard Liban MARin) was the new multi-beam bathymetric map of Lebanon.

Recognizing the necessity to connect offshore structures to the inland observed ones, it was possible to start to complete the bathymetric map within the Italian funded CANA-CNRS vessel, equipped with a costly multi-beam echo-sounder system with its sophisticated positioning system.

1.3.10 Observatories for the environment and sustainable development

In Lebanon, there have been two experiences of implementing an Environment and Development Observatory.

The first was part of the LIFE – Third Countries programme, which implemented the Lebanese Environment and Development Observatory (LEDO) hosted by the Ministry of Education. As part of this project, approximately 90 indicators were identified with a view to collecting and recording data on 14 environmental and development themes. In 2002, the project also published a report on the state of the environment in Lebanon. However, the LEDO ceased to function after the end of the project in 2002.

The second is the Tripoli Environment and Development Observatory (TEDO), created in 2000. TEDO was launched as part of a project more integrated into Lebanese institutions, following a project with the Al-Fayhaa Federation of Municipalities (Decision of the Council of Ministers dated 9/12/2004). This Observatory has full-time staff and equipment for monitoring the main environmental factors in Tripoli, El Mina and Beddawi. It should be noted that, for the time being, TEDO is focussed on monitoring air quality and solid waste.

1.3.11 Non-Governmental Organisations (NGOs)

Several NGOs are active in the environment sector in Lebanon; however, few are involved in regular environmental monitoring actions, because most NGOs perform one-off actions that cannot supply a series of data useful for environmental monitoring. The Society for the Protection of Nature in Lebanon (SPNL) is a Lebanese association that is particularly active in monitoring bird life. It is a partner of BirdLife International and aims to protect nature, birds and biodiversity in Lebanon and to promote sustainable use of resources. It provides most monitoring of bird life in Lebanon, working in partnership with government institutions, municipalities, other NGOs and the private sector. The local NGO “Bahr Loubnan” played a major role in removing oil and cleaning coastlines and the seabed following the 2006 oil spill.

1.3.12 Monitoring programme(s), networks and other environmental monitoring initiatives

The only multi-institution environmental monitoring programme that has been clearly defined and institutionalised in Lebanon is for monitoring air quality. This is an agreement grouping several institutions (Beirut Municipality, American University of Beirut, Saint Joseph University, and the CNRS). For the marine environment, the NCMS has provided monitoring for thirty years using a network of around thirty stations along the Lebanese coast, covering physical, chemical and bacteriological parameters.

Other monitoring initiatives have been one-off or limited in time; the table below lists those that may be useful for IMAP, either because they use human and equipment resources that may be useful to IMAP, or because they have produced baseline data that could serve as a reference or help in selection of sampling stations to be implemented under IMAP.

1.4 National CZM committee

No national committee for CZM has been established in Lebanon. However, Decree no. 2275/2009 has established the various departments and units of the MOE, granting each its own prerogatives. It is recommended to create CZM committees that may include the different institute and ministries that may have a role in the IMAP to review and study projects and legislations related coastal zones.

Chapter 2: Monitoring methods of the different indicators

This chapter presents a monitoring programme for each common Indicator considering the parameters or elements to monitor (e.g. species or chemicals or physical parameters), a methodology, monitoring sites and both frequency and time series of monitoring data

2.1 EO7 Hydrography

Hydrography is the science that measures and describes the physical features of the water bodies. It includes mapping out water depth, the shape of the seafloor and coastline, the location of possible obstructions and physical features of water bodies. In the national IMAP, the objective of this indicator is to map the areas where human activities may cause permanent alterations of hydrographical conditions (using i.e. existing EIA, SEA and Maritime Spatial Planning -MSP); and by modeling potential changes in the spatial extent of habitats affected by permanent alterations, using field data and validated model data.

Few studies has been made on the modelling of Lebanese coast (EL Jubeily et al., 2016; Fadel, 2015; Issa et al., 2016; Kabbara, 2005). Issa et al., 2016 worked on the prediction of surface velocity in the Eastern Levantine Mediterranean. The method relies on a variational assimilation approach where a velocity correction is continuously obtained by matching observed drifter positions with those predicted by a simple advection model. They found that with few drifters, the estimation of velocity was improved in two typical situations: an eddy between the Lebanese coast and Cyprus, and velocities along the Lebanese coast. El Jubeily et al., 2016 built and test a simulation model made explicitly for the wave climate near the Lebanese coast. The simulation model is dependent on wind input data based on meteorological databases of the Levant region. It aims to help understand wind generated waves and how they propagate as they move. In M3-HAB project, Fadel 2015 used Mike model to downscale the circulation form the Mediterranean Forecasting System (MFS) model available from Copernicus. The study used data collected from two main open sources: "http://www.myocean.eu.org/" and "http://www.emodnet-physics.eu/map/". These data are present as reanalysis data and also as forecast data from the Mediterranean Forecasting System (MFS) model. Kabbara 2005 presented a statistical analysis on wind and wave data measurements collected from the Lebanon Meteorological Network during a two-year period (2000-2003) to reveal the general characteristics of wind and wave climate on Lebanese coastal area.

Several separate studies on the biodiversity (Bitar et al., 2007; El Shaer et al., 2012; Kapiris and Al., 2014; Ministry of Environment, 2004; Zenetos and et al., 2015), fisheries (Lteif, 2015), turtles (Newbury et al., 2002; St. John et al., 2003), sea birds and phytoplankton community (El Hourany et al., 2017), that were never modelled or linked to hydrographic models.

A methodological approach of how to reflect the objectives of the Hydrography Common Indicator can be adapted for Lebanon, as seen in Figure 1.

The methodology to assess the indicator can be divided in three main steps:

- (1) Baseline hydrographical conditions characterisation (Monitoring and modelling of actual conditions without structure).
- (2) Assessment of hydrographical alterations induced by new structure (Comparing baseline conditions and with structure conditions, using modelling tools).
- (3) Assessment of habitats impacted directly by hydrographic alterations (By crossing hydrographical alterations and habitat maps).

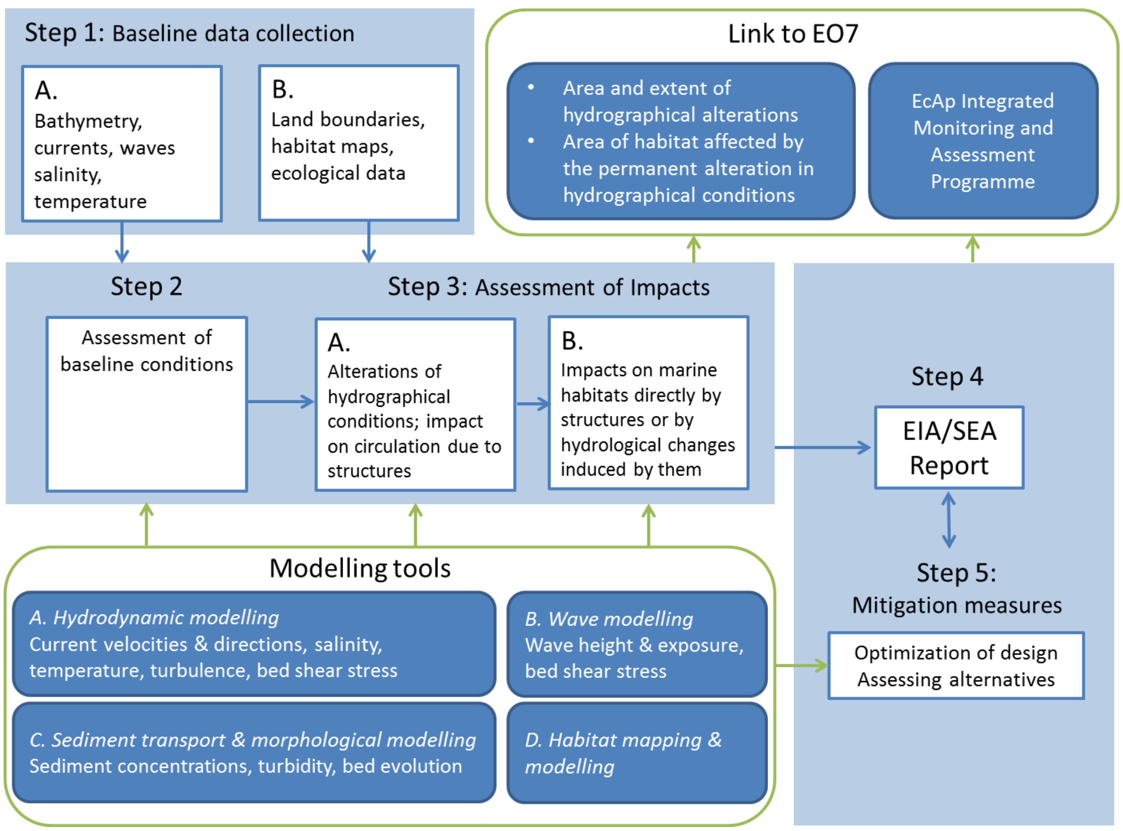

Figure 1 Methodological approach of how to integrate the EIA/SEA process with the implementation of EO7

<u>New structures to be considered under EO7 assessment:</u>

All permanent structures, for which an EIA and/or a planning/building permit is required, should be considered. As far as the type and dimension of structures to be taken into account: use the case by case approach depending on the nature of the coast, the function of the structure and the depth reached by the structure where appropriate threshold values are taken into account (such as absolute surface in m², range of depths where structure will be built (to avoid habitat "segmentation")).

Hydrographical conditions to be considered:

- At least, waves and currents changes (can be used to assess changes in bottom shear stress, turbulence, etc.).
- For sandy sites or sites with natural sediment dynamic, changes in sediment transport processes and turbidity and induced changes in morphology of the coast.
- If the new structure involves water discharge, water extraction or changes in fresh water movements: assessment of salinity and/or temperature changes.

Following the previous point, the base-line hydrodynamic conditions are defined by:

- Actual bathymetric data (with fine resolution to the coast or closed to the structure, less fine resolution off-shore) and knowledge of bottom nature (taken from habitat map EO1).
- Water level variations (tide, storm surge).
- Waves and currents characterisation in terms of direction, intensity, occurrence and period for waves (from long duration waves and currents data analysis and hydrodynamic modelling). Seasonal variability should be taken into account (mean/max/min values, quantile).
- For sandy sites or sites with sediment transit: quantitative assessment of sediment transport rate and turbidity, actual evolution tendencies (stability, erosion, accretion of the coast) and rate of change (ex: coast retreat of x meter/year).
- Temperature and salinity actual conditions if the new structure will involve water discharge, water extraction or changes in fresh water movements.

The knowledge of these base-line conditions with the new structure location and dimensions (footprint, height, shape …) will allow assessing the hydrographical conditions induced by the presence of the structure.

Then the comparison of hydrographical conditions without and with structure will allow assessing the significant changes, i.e. the alterations, induced by the structure.

The last step of the EO7 indicator calculation will consist in crossing hydrographical alterations and habitats maps. The link to EO1 is so essential, as map of benthic habitats in the zone of interest (broad habitat types and/or particular sensitive habitats) is required.

Monitoring sites and the use of risk based approach to select them

The monitoring of EO7 indicator can be achieved on 6 sites (Enfeh, Ras Chekaa, Raoucheh, Saida, Tyre and Nakoura) distributed over the Lebanese coast from North to South. Beside their geographical distribution, these site are witnessing development in touristic activities and differs in their biodiversity.

In those sites, Sediment dumping, hyper-sedimentation, organic pollution, land reclamation, littoral dynamic alterations (marinas, ports) are the main threats.

Due to human activities, the littoral rock is the most threatened marine habitat. The main anthropogenic impacts are tramplig, shell-fish and algae collection (normally for baits), hydrocarbon and sewage pollution, littoral disturbance (building, ports, and sediment filling).

The upper infralittoral rock is also threated by many anthropogenic impacts, such as sewage pollution (industrial and domestic), littoral development (building, ports), sediment filling and land reclamation.

Inventories of habitats and species are available thanks to a series of exploration campaigns performed in Lebanon in June 2012 and August-September 2013, covering the littoral and sublittoral surveys (0-47 m depth), on 6 sites of interest along the Lebanese coast.

A rapid assessment of the marine natural habitats along the coast of these six sites (Enfeh Peninsula, Ras Chekaa cliffs, Raoucheh, Saida,Tyre and Nakoura), allowed better assessment and characterization of the ecology of threatened habitats with recommendations for conservation measures.

These campaigns involved:
1) the exploration the suggested areas (between 0 and 50 meters down), locating and generally mapping the habitats;
2) elaboration of an updated inventory of the biodiversity of species and habitats, mainly targeting species with heritage value;
3) characterization of the habitats, mainly those that are to be protected, and define their conservation status.
These campaigns provided data about

- the composition of the Lebanon inshore megabenthos;
- The characterization of the seascapes and habitats;
- A hierarchical ecological approach for marine biodiversity conservation;
- Use of focal species in marine conservation and management;
- Properties of focal species under various ecological and anthropogenic conditions: Implications for marine conservation and management

These data will be of great help for EO7 indicator. This data is very useful for selecting reference sites and habitats. Habitat data collected during these exploration campaigns is available in GIS format.

An open-access 3D hydrographic model needs to be used for this indicator. TELEMAC-MASCARET is an example. It is an integrated suite of solvers for use in the field of free-surface flow. Having been used in the context of many studies throughout the world, it has become one of the major standards in its field. Other models like Delft 3D can be also considered for the modelling process requested for EO7 indicator.

As input data to the model, global marine data source at the scale of the Mediterranean Sea together with local data can be used, these include:

- EMODnet Central Portal (http://www.emodnet.eu/)
- Mediterranean Marine Data (http://www.mediterranean-marinedata.eu/)
- Copernicus, Marine environment monitoring service (http://marine.copernicus.eu/). Depending on the required scale and resolution, it is possible to extract local spatial and temporal distribution of parameters from regional models, such as the products and services for the Mediterranean Sea as part of the Copernicus Marine Environment Monitoring Service. These include temperature. Salinity, sea surface height, velocity, mixed layer thickness, wind, planktons, oxygen, nutrients, primary production, turbidity, transparency and sea surface waves.

The resolution of the bathymetric data will depend on the local topography. If topography is uniform, low resolution data from lower precision at EMODNET (http://portal.emodnet-bathymetry.eu/#) is sufficient; if very complex, high resolution bathymetric data can be requested from National Center for Geophysics who is updating the bathymetric map of the Lebanese coast with a high precision.

Wind data gives information on the dominant wind direction and magnitudes, providing important input data for hydrodynamics and wave modelling. Meteorological data (wind statistical data) collected by local meteorological stations close to the 6 sites, should be part of the baseline data collection.

Combination of monitoring methods, such as satellite products and autonomous devices can be used. Different grids are to be created (large, medium and small) and downscaling might be needed to obtain more details around harbors and groyne.

Habitat analysis and mapping generally relies on the use of GIS as a spatial analysis tool. GIS provides the ability to construct models of habitat that rely on existing or readily obtained information (e.g.surveys, bathymetric maps). As habitat maps from surveys are very costly and time consuming, full coverage habitat maps are produced from low resolution maps and models to 'predict' seafloor habitat types. Such models offer the possibility of optimizing monitoring and focusing field activities in much smaller areas. A number of marine habitat maps for the Mediterranean basin were produced in the Mediterranean Sensitive Habitats project (MEDISH; 2011-2013) through the compilation of historical and current data on the locations and the status of sea grass beds, coralligenous and mäerl beds, the identification and mapping of suitable areas for Posidonia, coralligenous and mäerl communities by developing habitat distribution models at different spatial scales. Marine habitat maps for Western Mediterranean can also be found in EMODnet Seabed Habitats. Maps of expected seabed-habitat types can be generated by combining a series of proxy measurements such as water depth, sediment type and light levels amongst others, using statistical analysis and GIS modelling.

Different monitoring timescales needs to be conducted to correctly assess changes in time on habitats induced by constructions:

- Before construction, initial state assessment (baseline conditions):

Monitoring should provide the initial distribution (area, location, eventually density…) of the habitats of interest located in and around the future impacted area and the initial hydrodynamics conditions surrounding the future construction.

- o During construction: monitoring should ensure that impacts due to works are limited in space and in time.
- o After construction, short term changes (0 to 5 years after): at least yearly up to 5 years. During this period, strong changes should happen on hydrographical, morphological and habitats conditions. The monitoring frequency should be high enough to assess these changes. It should be annual (at the same period of year) and provide, each year, the distribution of the habitats of interest around the construction and the changes in hydrodynamic conditions (assessed by comparing present and initial conditions).
- o After construction (5 to 10 years after): at least binnemium to 10 years. Same as before with a lower monitoring frequency as the changes should be lower.
- o Long term changes (10 to15 years after construction) Same as before with a lower monitoring frequency as the changes should be lower.

Many parameters exhibit pronounced seasonal cycling (e.g., wind, waves, temperature, stratification). As changes to the seasonal cycles may be of relevance to ecology, typical winter and summer baseline conditions may be considered. The selection of the model time step should also take into account the natural time scales of the processes/phenomena that are captured by the model. The monitoring frequencies to be used in these different phases should depend on the habitats considered (link to EO1→ adequate frequency/habitat) and on the intensity of changes in hydrographical, morphological or habitats conditions occurring on the site (case by case).

Modelling results are subject to a number of uncertainties arising from the inherent limitation of the model to accurately represent certain processes, the spatial and temporal resolution of some processes and the accuracy limitation of computers. The accuracy of the modelling analysis will be in line with the quantity and quality of data available used to calibrate and verify the model performance. Currently, there is lack of guidelines for methodologies, standardization and analytical techniques in addressing EO7. Modelling is mostly valuable when the impacts on the receptors can be quantified and categorised as significant or not significant. In order to assess the significance of an impact on a sensitive receptor, the sensitive threshold must be first quantified. Moreover, new data can be collected and supplied from NCMS to validate the model output.

The outputs to be reported are (map and GIS data):

- The area and location where the future structure will be built;
- The area and location where alterations in hydrographical conditions are expected to occur and those areas where alterations are actually occurring;
- The area and location of the habitats of interest potentially impacted by these alterations;
- The area and location of these habitats of interest previously identified for the whole analysis unit (to assess the proportion of total habitats that are altered).

The outputs of this indicator should be in km^2 of impacted habitat or as proportion (%) of the total area/habitat impacted

2.2 EO8 Land use change

Land use change is defined as the change of purpose to which land is profited by humans. Change in land use like conversion from any form (forest, agricultural lands, urban areas, etc.) to another can impact coastal zones. Urbanization for example, or land take, is the most dramatic change that is usually irreversibility. This change can result in fragmentation and habitat loss due to C sequestration, regulation of water cycle, or biomass production. For that, identifying and understanding the processes of land use change is especially relevant for critical and vulnerable areas such as coastal zones, where several competitive uses are pressing. Land use change is monitored in an aim to 1) avoid construction within the setback zone, 2) Change of coastal land use structure, dominance of urban land use reversed, and 3) Keep, and increase, where needed, landscape diversity.

The first land cover / land use map of Lebanon according to CORINE nomenclature was produced in 1998, using 2 satellite images (Landsat multispectral of 30m resolution and IRS panchromatic of 5m resolution) on a scale of 1:20 000. The project was finalized with the collaboration of: Ministry of environment (MOE), Ministry of agriculture (MOA), National council for scientific research (CNRS) - Remote sensing center (CNT), Council of development and reconstruction (CDR), center of studies and research on the contemporary of Middle East.
An update for the CORINE LUC map was produced in 2003, by visual interpretation of IKONOS satellite images of 1 m resolution on a scale 1:50,000. The results obtained from 1998 and 2003 were used for a change detection application for Lebanon, and the following results were established (Tables 1 and 2):

Table 1 Change detection between 1998 & 2003 based on level 1&2 of CORINE nomenclature

<table>
<tr><th>Level 1</th><th>Level 2</th><th colspan="2">% of the total surface(339.9 km²)</th><th colspan="2">% of the total surface (336.9 km²)</th></tr>
<tr><td rowspan="4">Artificial areas</td><td>Urban fabric</td><td>22.18</td><td rowspan="4">32.74</td><td>21.7</td><td rowspan="4">32</td></tr>
<tr><td>Industrial, commercial and transport units</td><td>5.76</td><td>6.1</td></tr>
<tr><td>Mine, dump and construction sites</td><td>4.4</td><td>3.7</td></tr>
<tr><td>Artificial non-agricultural vegetated areas</td><td>0.4</td><td>0.5</td></tr>
<tr><td rowspan="3">agricultural areas</td><td>Arable land</td><td>6.03</td><td rowspan="3">40.13</td><td>6.9</td><td rowspan="3">40.5</td></tr>
<tr><td>Permanent crops</td><td>26</td><td>25.7</td></tr>
<tr><td>Pastures</td><td>8.1</td><td>7.9</td></tr>
<tr><td>Forest and semi-natural areas</td><td>Forest</td><td>6.36</td><td>24.64</td><td>6.8</td><td>25.2</td></tr>
</table>

	Shrubs and or herbaceous vegetation associations	15.57		16.2	
	Open spaces with little or no vegetation	2.71		2.2	

Table 2 Change detection between 1998 & 2003 based on level 4 of CORINE nomenclature

Level 4	Surface 1998 (km²)	Surface 2003 (km²)	Difference
Areas of urban centers	14.22	14.54	0.317
Leisure areas	2.76	3.01	0.248
Greenhouses	5.68	8.19	2.514
Vineyards	0.10	0.00	-0.100
Mixed dense forest	1.61	1.77	0.164
Bare rocks	3.85	2.83	-1.021
Urban extension over agriculture	7.40	3.85	-3.556

The inner Bekaa and Hermel valleys and Anti-Lebanon Range suffered the largest deforestation rate between 1963 and 1998 (58%), followed by the Northern coastal region (10%) and the Southern coastal region (4%). On the other hand, forest cover increased in the Mount Lebanon region for the last decades (25%) as forests naturally expanded due to the abandonment of agricultural land, rural land-use practices (including grazing), war or displacement of people.

According to data from the FAO Global Forest Resources Assessment (FRA), 2010 [FAO-MOA, 2010], forests [i.e. land with tree crown cover (or equivalent stocking level) of more than 10% and area of more than 0.5 ha; the trees should be able to reach a minimum height of 5 m at maturity in situ] cover 13.2% of the total land area of Lebanon (136,900 ha). An additional 10.2% of land classified as “other wooded land” (OWL) [i.e. land either with a tree crown cover (or equivalent stocking level) of 5-10% of trees able to reach a height of 5 m at maturity in situ; or a crown cover (or equivalent stocking level) of more than 10% of trees not able to reach a height of 5 m at maturity in situ (e.g. dwarf or stunted trees) and shrub or bush cover] makes a total of 242 900 ha (23.4% of the Lebanese land area) of forests, woodlands and scrub. This makes Lebanon to be one of the most forested countries by total percentage in the Middle East.

RSC have been monitoring land use change using different methods, since several years (Darwish et al., 2004; Faour, 2015; Masri et al., 2002). Recently they prepared Land Cover/Use for Lebanon at a scale of 1:20000 according to level four of CORINE Classification System, using GeoEye 2013 Satellite imageries. So, the most recent version of CORINE LUC map is produced in 2016 by National council for scientific research (CNRS), and it is mapped on a scale of 1:20000, based on CORINE 4th level nomenclature.

Figure 2 presents Level one maps of the LU/LC national products produced by:

- 1998, Landsat images of 30 m resolution and IRS panchromatic images of 5 m
- 2005, IKONOS satellite images of 1 m resolution
- 2013, Geoeye VHR images of 0.5 m

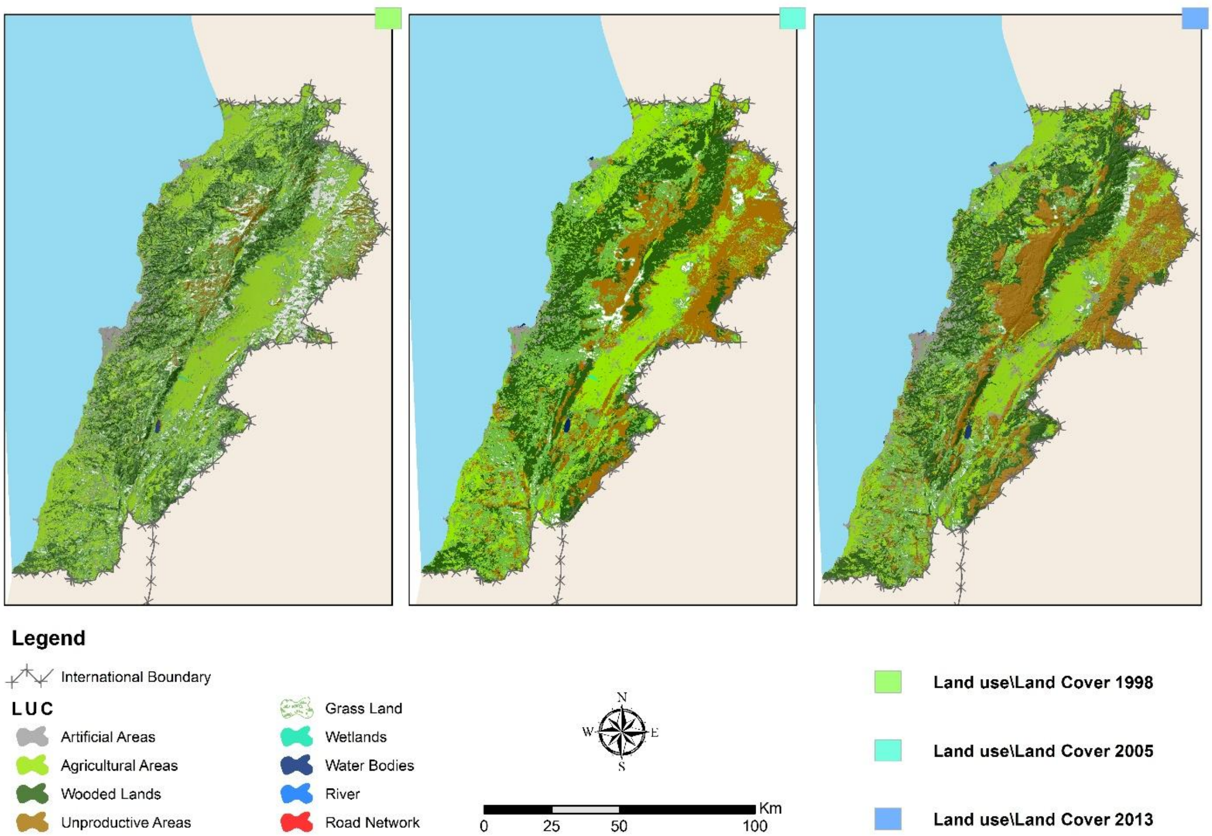

Figure 2 Available LU/LC national products for Lebanon.

Additional spatial data sources on Current natural areas, Natural Domain of National Interest, Protected Natural Reserves and Grottos, The Coastline, fragile assets and others have been published by Council for Development and Reconstruction (CDR) who has also produced an open access maps with their shapefiles data as follows:

- **Data**
  - **Administrative**
    - **Lambert** (e.g. Caza limits)
  - **Environment**
    - **Climate**
      - **Lambert** (e.g. Rainfall)
    - **Geology**

        - **Lambert** (e.g. Geology map)
    - **Hydrogeology**
        - **Lambert** (e.g. Hydrogeology map)
    - **Soil**
        - **Lambert** (e.g. Soil map)
    - **Topography**
        - **Lambert** (e.g. Contour lines)
- **Infrastructure**
    - **Electrical**
        - **Lambert** (e.g. Power plants)
    - **Industry**
        - **Lambert** (e.g. Industries locations)
    - **Quarries**
        - **Lambert** (e.g. Potential quarries sites)
    - **Sewer**
        - **Lambert** (e.g. Wastewater treatment plants)
    - **Telephone**
        - **Lambert** (e.g. Fixed phone network)
    - **Water**
        - **Lambert** (e.g. Irrigation perimeters)
- **Keymaps**
    - **Lambert** (e.g. 1:20,000 topo. keymaps)
- **Landcover**
    - **Lambert** (e.g. Landuse 1998)
- **Landscape**
    - **Lambert** (e.g. Natural reserves)
- **Morph**
    - **Lambert** (e.g. Morphological zones)
- **Natural Risk**
    - **Coastal Flood**
    - **Desertification**
    - **Earthquake**
    - **Erosion Risk**
    - **Flood**
    - **Forest Fire**
    - **Mass Movement**
- **Patrimonial** (e.g. Location of protected patrimonial sites)
- **Pollution**
    - **Industrial**
        - **Lambert** (e.g. Air polluting industries)
- **Raster**
    - **Topo_20k**
        - **Lambert** (1:20,000 Topographic maps of Lebanon)
- **Schemes**
    - **Lambert** (e.g. Decreeted Master Plans)
- **Socio_economic** (e.g. Enterprises)
- **Technological Risks**

- **Lambert** (e.g. Location of industries with technological risks)

These data can be requested for free and are known as SDATL data. Some of the maps that can be of interest for the ICZM is presented in the Annex section.

The general methodology that can be approached to monitor land use change is presented in Figure 3. Geoeye, year 2018 images, of 0.5 m resolution with radiometric and geometric corrections will be used. A process visual interpretation and classification using a GIS software will be used to determine the change in the different classes.

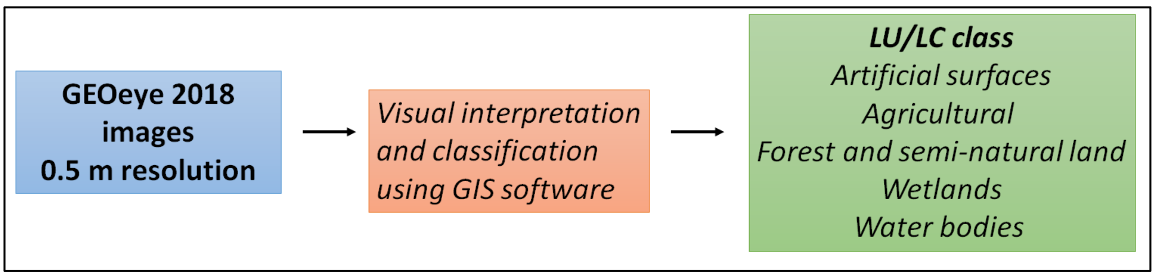

Figure 3 General methodology to monitor Land use change

The Lebanese coastal zone, in its scientific meaning, comprises almost one third of the territory, including the west side of Mount-Lebanon between 0 and 800 meters in altitude, as well as vast zones of North and South Lebanon. It can be also considered as a corridor of 10 km wide along the coastline.
As mentioned above, the Land used/ Land cover of this coastal zone has been monitored using very high resolution images (0.5 to 5 m resolution) taken in 1998, 2005 and 2013.

The following indicator units are indicated below can be extracted from the previous LU/LC national maps for the coastal zone:

- km^2 of built-up area in coastal zone
- % of built-up area in coastal zone
- % of other land use classes in coastal zone
- % of built up area within coastal strips of different width compared to wider coastal units
- % of other land use classes within coastal strips of different width) compared to wider coastal units

For the coming monitoring the following units will be relevant:

- % of increase of built-up area, or land
- % of change of other land use classes

A very high resolution images of 0.5 m resolution will be used making locational and classification in accuracy low. Also, ground differential GPS will be performed for any feature that may not be clear on images and to validate the performed classification.

The temporal scale should be 5 years, in order to be effective on the counteracting negative effects and taking early actions on problematic areas. As an output of the assessment of this indicator, the following should be provided:

- A digital map with the land cover classes for the coastal area based on the classification provided in Figure 3. If more detailed classification is available, then it could be provided making the clear link with Figure 3. The following specifications should be respected:
    - Format: raster GeoTIFF (Geographic Tagged Image File Format) 1 km x 1km
    - Metadata (Title of the map, Geographic reference, temporal reference (year)and the responsible organisation)
- A spreadsheet with the calculated indicators as described in the methodology.
- When starting with the second monitoring, additional maps will be provided indicating areas of land take (new urbanisation).

The statistics of artificial area, land take, changes of forest and semi-natural areas, and in wetlands can be computed as presented in Figure 4. Land take, changes of forest and semi-natural areas, and in wetlands will start to be computed on the second monitoring since the first monitoring focus only on the baseline (state at t_0).

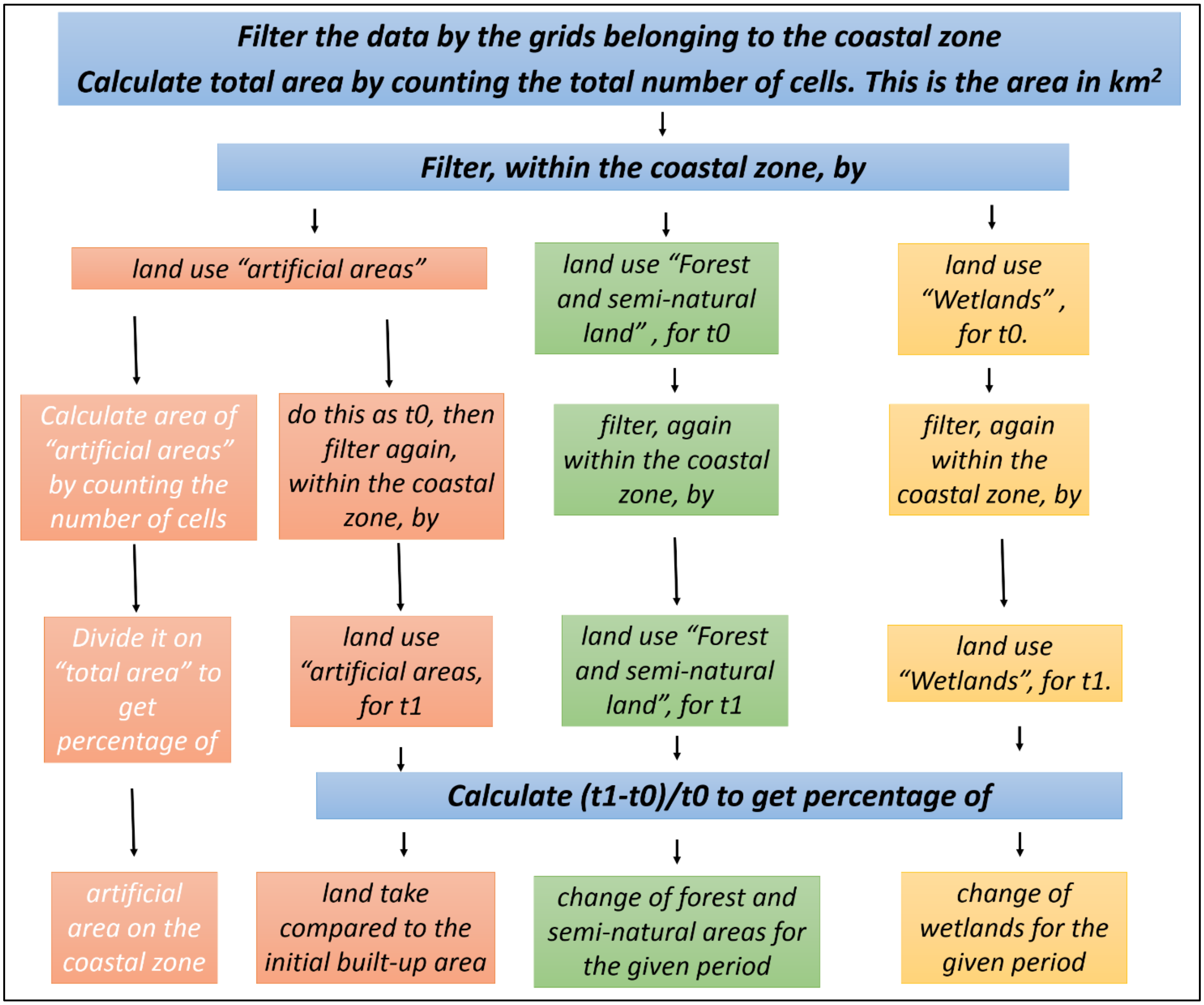

Figure 4 Statistical analysis of different variables

The above mentioned analysis can be complemented with the following ones that provide additional insight on the land use indicator.

- Optional analytical units
    1. Setback zone (if defined in the country). Given the relevance of this part of the coastal area, as referred on the ICZM protocol, the indicators on % of built-up and land take can be analysed for this specific zone.
    2. Elevation breakdown within the coastal area. Distance to the coast and elevation are elements that configure different habitat distribution and patterns. With available local knowledge 3 to 5 elevations classes could be considered to be analysed independently within the coastal area in order to better link the pressure

of land take to specific habitats. An example follows: < 50 m asl, 50 – 300 m, >300 m.

- Additional parameters
    1. What has been lost by urbanisation?

        1. Filter the data by the grids belonging to the coastal zone.
        2. Calculate total area by counting the total number of cells. This is the area in km^2.
        3. Develop a pivot table with land cover classes at t_0, on rows, and land cover classes at t_1 on columns. Cells in this matrix will contain the area that has changed from certain land cover class at $t_0$to a new class in t_1.
        4. Select the column for "Built-up areas".
        5. Values on the rows indicate the different land cover classes at t_0 that have been converted into built-up area.

Values from 5 can be divided by the corresponding area of the same class at t_0. This will provide the percentage of certain land cover class that has been converted into built-up

2.3 EO8 Coastal ecosystems and landscapes

Coastal manmade infrastructures result in irreversible damage to landscapes, losses in habitat and biodiversity, disrupt the sediment transport, reduce the ability of the shoreline to respond to natural forcing factors, contribute to coastal erosion phenomena and influence on the configuration of the shoreline. EO8 Coastal ecosystems and landscapes indicator aims to quantify the rate and the spatial distribution of the Mediterranean coastline artificialitsation and to provide a better understanding of the impact of those structures to the shoreline dynamics to minimize it later on.

Figure 7 presents the monitoring methods for the calculation of Coastal ecosystems and landscapes indicator for Lebanon. Digitalization of several type of Geoeye 2013 Satellite imagerie data will allow the determination of:

(i) the length and location of manmade coastline (hard coastal defence structures, ports, marinas). Soft techniques e.g. beach nourishment are not included.

(ii) land claim, i.e. the surface area reclaimed from the 1980's onward (ha); and

(iii) the impervious surface in the coastal fringe (100m from the coastline).

The length of artificial coastline should be calculated in km as the sum of segments on reference coastline identified as the intersection of polylines representing manmade structures with reference coastline ignoring polylines representing manmade structures with no intersection with reference coastline. The minimum distance between coastal defence structures should be set to 10 m in order to classify such segments as natural, i.e. if the distance between two adjacent coastal defence structures is less than 10 m, all the segment including both coastal defence structures is classified as artificial.

Remote sensing center performed several studies that both directly and indirectly related to coastal ecosystems and landscapes (Faour et al., 2013; Faour and Rizk, 2014). They did a study to monitor the changes in the Lebanese Shoreline between 1962 and 2003. They processed aerial photographs and satellite images taken between 1962 and 2003 in addition to the topographic map of 1963 to assess the changes occurring throughout the Lebanese seashore. The used methodology was based on geometric corrections of aerial photographs and satellite images in order to digitize the Lebanese shoreline by photo-interpretation. The study illustrated there are changes in the seashore throughout the last 40 years. This methodology showed important variations along the coastline over the last forty years: 41 % of the shoreline is artificially made and 45 % of the sandy beaches are being degraded.

RSC have also worked on accelerated Sea Level Rise (SLR). They addressed the risk assessment of physical and economic impacts under different SLR scenarios and the analysis of the effects due to SLR (i.e. extended coastal inundation, coastal erosion on populations, land use, etc.). A degree of vulnerability analysis based on different criteria has been also carried out to better locate which sectors are more vulnerable to the possible sea level rise (SLR). Relative rate of erosion and advancement of the Coastline was estimated from the displacement of the coast between two dates, which reflects the dynamics of the coast. They calculated the distance between the two coastal lines in 2013 compared to 2005. They digitized the coastline using the technique of photo-interpretation on images taken from the Google Earth. Consequently, the distance between the 2005 and 2013 coastline was calculated using the tools present in the Arc GIS (version 10.3).

At the moment, no official reference coastline has been agreed on for Lebanon. There is no responsibility on any of centre and national observatories presented in section (1.3) to produce and update the national reference coastline with proper resolution for the implementation of EO8. However, RSC at the CNRS has conducted a study that was published in 2008 in which it delineated the shoreline using raster images (aerial photographs or satellite images, Table 3) for the years 1962, 1983, 1991, 1998, 2001 and 2003.

The photographs and topographic maps that were used are listed in Table 3. These were digitized and enlarged to a scale of 1/5000. The digitizing was made by photo-interpretation of the visible bands since this method is the most reliable when laying out a shoreline. After laying out the coastlines, a quantification of the changes was to be done to measure the process of moving forward (advance) or backward (retreat) of the line in question Figure 5.

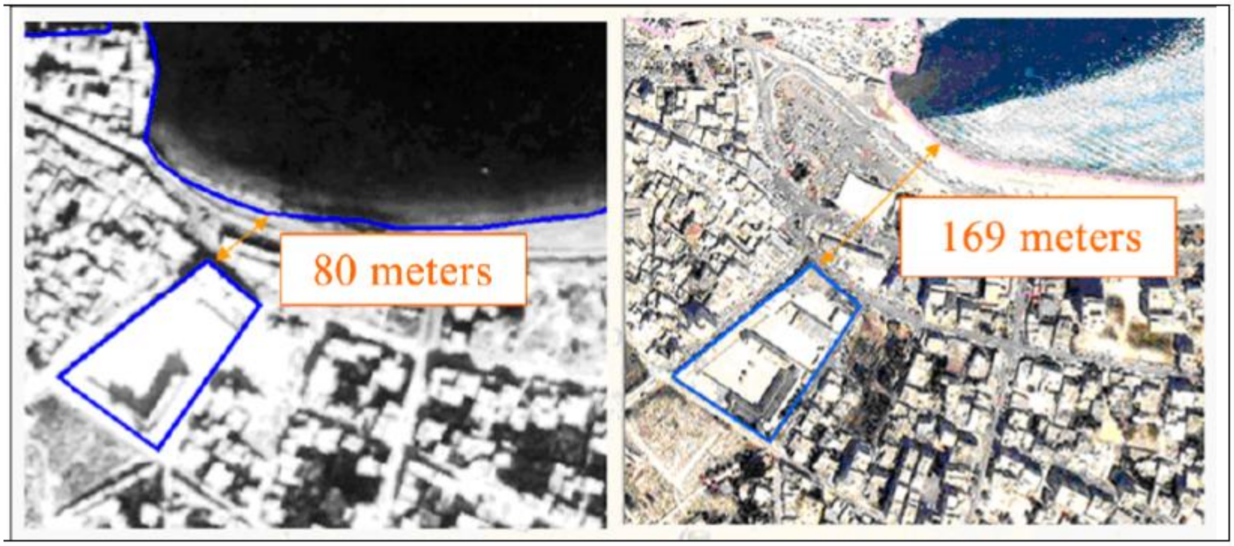

Figure 5 Change in coastal line shown by Faour and Rizk 2008

Table 3 Data used in the study conducted by Faour and Rizk 2008

Data		Acquisition date	Scale	Resolution (m)	Origin / partner
Raster	Aerial Photographs	1956	1 / 7 000 1 / 8 000 1 / 10 000	1	House of Orient and the Mediterranean
		1962	1 / 8 000 1 / 25 000	2	
		1968	1 / 25 000	1	
		1975	1 / 25 000	1	DAGG
		1983	1 / 5000	1	CNRSL Remote sensing center
		1991	1 / 10 000	1	
	Topographic Maps	1963	1/ 20 000	-	DAGG
	Satellite Image CORONA	1967	-	2,5	CNRSL Remote sensing center
		1971	-		
	Russian Topographic maps	1987	1 / 50 000	-	
	Russian satellite Images KVR1000	1994	-	2	
	Satellite Images Landsat TM combined to IRS-1C	1998	-	5	CNRSL Remote sensing center
	Satellite Images IKONOS	2001	-	1	
	Satellite Images SPOT 5	2003	-	2.5	
	Satellite Images IKONOS	2003	-	1	

RSC also have a 40 cm resolution GeoEye satellite imageries for year 2013.

Figure 6 Example of area under construction development such from Geoeye 2013 Satellite imagerie available at RSC.

The fixed reference official coastline as defined by responsible Contracting Party (RSC) should be considered. The optimal resolution should be 5 m or 1: 2000 spatial scale. As monitoring should be done every 6 years, RSC should fix a reference year in the time interval 2000-2012 in order to eliminate the bias due to old or past manmade infrastructures.

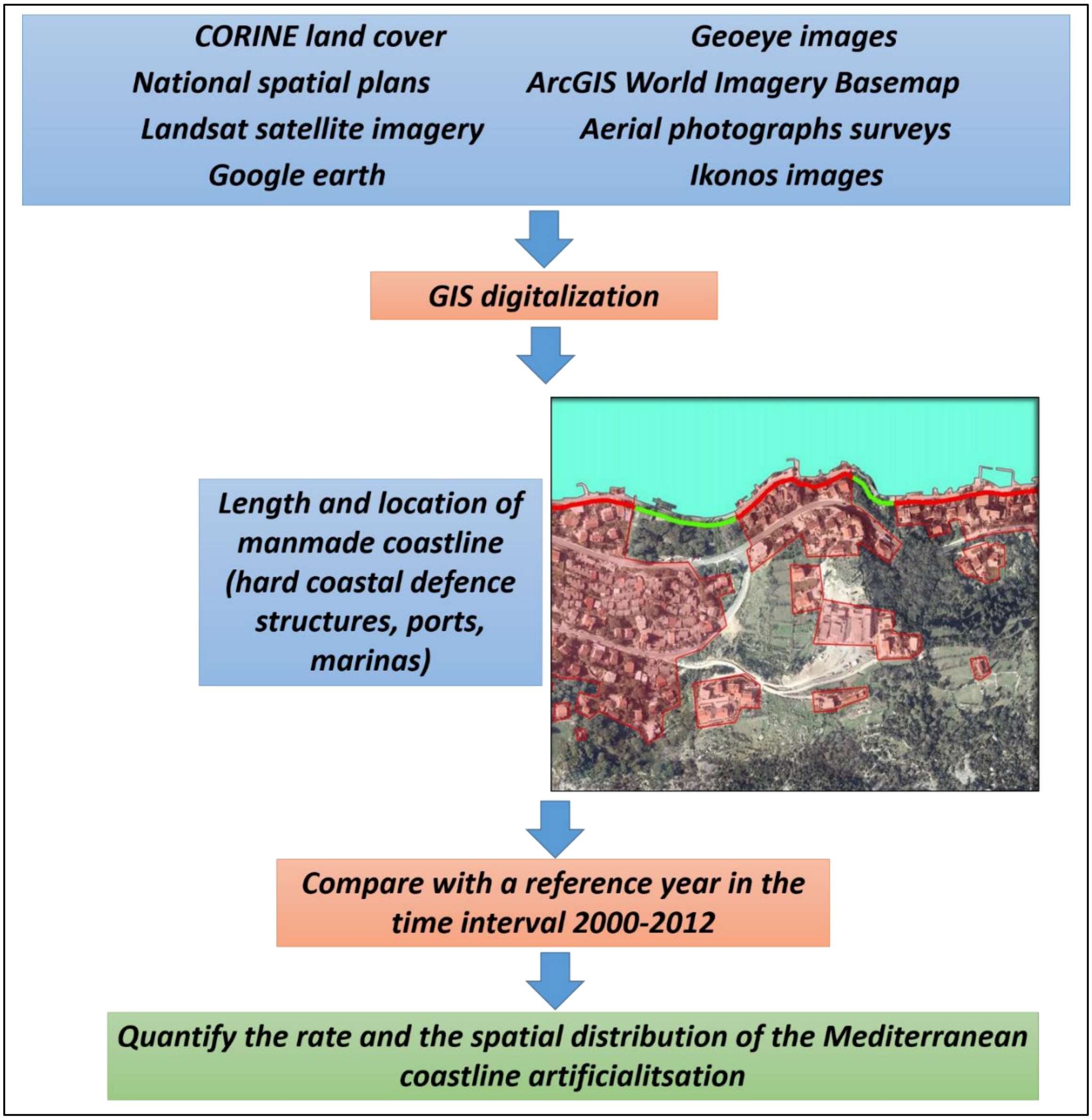

Figure 7 Methodology for Coastal ecosystems and landscapes indicator calculation

The total length of coastline influenced by manmade structures, the share of this coastline in total country's coastal length, etc. should be provided on a map showing the coastline subject to physical disturbance due to manmade structures (artificial segments) in red line and the rest (natural segments) in green line as in Figure 7. The assessment output should be reported as a common shape file format with GRS as WGS84. Shape file with other GRS will also be accepted if provided with a complete .prj file that allows GRS transformations by standard GIS tools.

Validation of the total length of coastline influenced by manmade structures needs to be done to validate the methodology adapted. On-Site Visit of the Zones Showing a Remarkable Change along the Lebanese littoral using a GPS.

Chapter 3: Potential institutions to monitor the different indicators

This chapter suggests the potential future providers of EO7 and EO8 indicators and their data sharing and access principles.

3.1 Potential providers of the different indicators

3.1.1 EO7 Hydrography

The hydrography indicator, need data and expertise from different institutions/organizations. Remote Sensing Centre (RSC) can handle this indicator due to its expertise in mapping and integrated coastal zone management but only in collaboration with:

- NCMS that has data about water quality, biodiversity and habitats
- National Center for Geophysics is updating the bathymetric map of the Lebanese coast that can be also found with lower precision at EMODNET (http://portal.emodnet-bathymetry.eu/#)
- National or International habitats and modelling experts.

The National Centre for Remote Sensing (NCRS) has a scientific full time staff consisting of 7 researchers and 2 research assistants in addition to 4 administrative full time staff. The center has 2 cars used for field campaigns and Land use Land cover verification purpose.

As a governmental institute the NCRS has an allocated budget to pay the salaries of the permanent scientific staff and to run the research centers. Additional financial resources include small grant research projects (less than 20k USD per research project) , bilateral projects with France (CEDRE) and Italy (JRP) with funds less than 20k USD as well, partial funds from CDR to update the landcover/land use map each 5 years, and international projects funded by (FAO, World bank, EU, Italian cooperation, etc.). Most important was the CAPWATER project that was funded by the World Bank and allowed the research center to buy costly equipments like the field-spec spectroradiometer.

On the other hand, The NCMS, a research center also related to CNRS, has laboratories in Jounieh and Batroun, and a 27 m research vessel (CANA-CNRS) acquired as part of bilateral cooperation with Italy. The vessel is fitted out for sampling in the water column and in sediment, and for performing explorations (dives, remotely operated vehicles, multi-beam and dual-beam echosounders, side-scan sonar, sediment sounder, etc.). The Centre has just (2016) acquired a new vessel (CADMOS-CNRS, a 7m twin-engine catamaran).

With regard to human resources, the Centre's permanent staff is made up of 9 scientists and 3 administrators. This staff is supported by contract researchers and PhD students. The scientific disciplines covered include hydrobiology, planktonology, oceanography, coastal hydrodynamics, chemistry, biology, cetology, microbiology, etc.

Since 1980, the National network for observing the Lebanese coastal waters has provided permanent monitoring of physical, chemical, bacteriological and biological parameters. Currently, the network covers 30 stations which are checked monthly (twice-monthly in summer).

The data series gathered are stored in Excel files, and are currently only available from the NCMS which provides information based on this data to various ministries as requested

It should be noted that several Lebanese universities have laboratories and equipment for environmental monitoring. However, the opinion of most of those encountered was that despite the availability of equipment and scientists, IMAP implementation in Lebanon will require assistance for practical organisation of field monitoring campaigns, and for acquiring reagents for analyses and any satellite images that would be needed.

Maps creation and GIS data can be handled by the NCRS. The modelling part can be achieved either by a help from a national or international hydrographic modelling expert or by a reinforcing the expertise of a researcher from NCRS or NCMS. NCMS will need to do two annual campaigns in both Winter and Summer season to provide field data on biodiversity and physical variables that will help validate the model and assess the habitats impacted directly by hydrographic alterations.

For successful continuous monitoring of EO7 indicator, NCMS and NCRS will need some support as summarized in table 4.

Table 4 Support needed by NCMS and NCRS for the implementation of EO7 indicator

Institute	**Financial needs**	**Costs in USD**
NCMS	Field campaigns funding	30,000
	Training on hydrography modelling or expert salary	10,000
NCRS	Mapping expert salary	5,000
	GPS trackers/ surveying cameras	10,000
	Geoportal	10,000
Total		65,000

Final objective of

minimizing the impact on coastal and marine ecosystem in promoting ecosystem health can be more effective after discussion with the different experts of biodiversity that would or have been active in this project, under the umbrella of the Ministry of Environment.

3.1.2 EO8 indicators

As shown in section 3.1.2 and 3.1.3, the main research institution that can provide data about Length of coastline subject to physical disturbance due to the influence of man-made structures and the Land cover/Land use indicators is the Remote Sensing Centre (RSC) that is part of the Lebanese CNRS. RSC uses analysis of satellite imagery and GISs to produce reports and maps on the country's land resources. RSC is securing highly needed upgraded information like Land use map and Coastal ecosystems and landscapes as well as cooperating with several development projects necessary for environmental monitoring and data acquisition in various sectors, and producing various thematic maps, training staff of various public agencies on requirements and applications of remote sensing and GIS. Researchers at the RSC have been monitoring land use change using different methods, since several years. There recent work on this topic included the preparation of a Land Cover/Use for Lebanon at a scale of 1:20000 according to level four of CORINE Classification System, using very high resolution GeoEye 2013 Satellite imageries on the national scale. The RSC can commit to the production of the Land cover/Land use indicators on the 10 km width (to the inside) along the Lebanese coast 220 km, in an 18 months period after the acquisition of the very high resolution images. For that, RSC needs the following financial resources:

Financial resources	**~ Cost in USD**
VHR images (about 15 USD per 1 km^2)	30,000
Research assistants (Digitizing)	30,000
Field verification	1,000
Management and coordination	5,000
Geoportal	10,000
Softwares and hardwares	10,000
Total	**86,000**

RSC will handle EO8 indicators through the suitable available data imagery (very high resolution IKONOS 1m resolution 2005 images and 40 cm GeoEye 2013 Satellite imageries) to monitor the Land use change and evolution of artificial coastline using ArcGIS interface each 5 to 6 years with no major gaps. The Centre can made a researcher available together partial time GIS analyst to handle the task of monitoring of EO8 indicator on length of coastline. Meanwhile, a reference coastline was produced by the RSC in 2008 from previous satellite images, this coastline is not agreed on as an official one. A new reference coastline with higher resolution can be produced if requested.

3.2 Data sharing and access principles for the different indicators

Several initiatives have been performed in Lebanon to implement IT systems and databases. Those that cover themes of interest for IMAP are described below.

The Ministry of Environment has developed a Geographical Information System (GIS) used to gather various kinds of environmental information and data. This GIS is implemented and managed by the IT department of the Service of Planning and Programming. This department is responsible for introducing IT systems and implementing the databases needed for the activities of the Directorate General of Environment. It has IT equipment and software available, in particular for GIS design and management. It also has the necessary skills, but its team needs strengthening in numbers to be able to cover all the tasks that would be generated by IMAP.

As part of the National Physical Master Plan of the Lebanese territory (SDATL), a georeferenced database was implemented in 2004 to store and manage data and for making queries. Several sectors of government have contributed by providing data (topography maps (1960-63), land-use map (2002), cadastral data (1996 and 2002), road network (2002), etc.).

Lebanon is contributing its data on the marine environment to the SeaDataNet network (Pan-European infrastructure for ocean and marine data management). This data covers:

- Current meter observations in the Mediterranean Sea off the coast of Lebanon during 1981-1983
- Distribution of zooplankton in the Lebanese coastal area
- Meiofauna along the Lebanese coast
- Monitoring Program for Lebanese Coastal Water
- Physio-chemical and biological characteristics of the marine environment around Batroun, North Lebanon (Eastern Mediterranean)
- Variability of phytoplankton and microzooplankton populations in the Lebanese coastal waters

Most environmental data available in Lebanon is produced by projects, often funded by international organisations and other donors. Data from these projects is stored in databases and IT systems that are not harmonised or interconnected. An analysis of the availability of environmental data in Lebanon was performed as part of the ENPI-SEIS2 project, showing that various environmental data is available. However, the lack of a suitable system for information exchange leads to doubling up in the gathering and production of data.

NCRS shares and provides researchers from universities and stakeholders with several types of shapefiles and maps for free. The center has also implemented an open-access geoportal system to share data online. It consists of Map Viewer system for viewing and downloading geographical data and maps of wildfires, flood hazards, erosion, landcover, solar map, snow cover, etc. These maps can be found on: http://rsensing.cnrs.edu.lb. The center is willing to improve and enhance this geoportal by adding additional tools that can be of use for different stakeholders and the public community. NCRS already some land cover data. When done, NCRS

[2] Towards a Shared Environmental System "SEIS"

can share the reference national coastline and changes in Landuse/Landcover that has been involved on it each 5 to 6 years.
Concerning EO7 indicator, NCRS can also share maps and GIS data through their geoportal, *of:*

- The area and location where the future structure will be built;
- The area and location where alterations in hydrographical conditions are expected to occur and those areas where alterations are actually occurring;
- The area and location of the habitats of interest potentially impacted by these alterations;
- The area and location of these habitats of interest previously identified for the whole analysis unit (to assess the proportion of total habitats that are altered).

Conclusion

There exist some gaps in the Legislations level in Lebanon especially that several ministers can have direct or indirect influence on the coast. There are no unified fines, penalties and criminal sanctions related to a unified list of environmental infractions and crimes. Monitoring programs for EO7 and EO8 were presented in chapter 2. Both indicators of EO8 can be easily monitored and assessed on a regular basis as recommended by NCRS. However, some difficulties may be faced with the EO7 that requires input data from several institutions and expertise in modelling and habitats as well.

References

Bitar, G., Ocana, O., Espla, A.R., 2007. Contribution of the Red Sea alien species to structuring some benthic biocenosis in the Lebanon Coast (Eastern Mediterranean). Rapp. Comm. int. Mer Médit. 38.

Darwish, T., Faour, G., Khawlie, M., 2004. Assessing soil degradation by landuse-cover change in coastal Lebanon. Leban. Sci. J. 51, 45–59.DAR-IAURIF 2005. National physical master plan of the Lebanese territory.

El Hourany, R., Fadel, A., Gemayel, E., Abboud-Abi Saab, M., Faour, G., 2017. Spatio-temporal variability of the phytoplankton biomass in the Levantine basin between 2002 and 2015 using MODIS products. Oceanologia 59, 153–165. doi:http://doi.org/10.1016/j.oceano.2016.12.002

EL Jubeily, M., Atallah, S., El Refai, F., Greige, F., 2016. Wave Climate Simulation and Assessment for the Lebanese Coastal Zone. American University of Beirut.

El Shaer, H., Samaha, L., Jaradi, G., 2012. Supporting the management of important marine habitats and species in Lebanon.

Fadel, A., 2015. Downscaling using MIKE 3: application on Lebanese coast. Beirut, Lebanon.

Faour, G., 2015. Evaluating urban expansion using remotely-sensed data in Lebanon. Leban. Sci. J. 16, 23–32.

Faour, G., Fayad, A., Mhawej, M., 2013. GIS-Based Approach to the Assessment of Coastal Vulnerability to Sea Level Rise : Case Study on the Eastern Mediterranean. J. Surv. Mapp. Eng. 1, 41–48.

Faour, G., Rizk, E.A., 2014. Changes in the Lebanese Shoreline between 1962 and 2003. GEO Obs. 17, 95–110.

Issa, L., Brajard, J., Fakhri, M., Hayes, D., Mortier, L., Poulain, P.-M., 2016. Modelling surface currents in the Eastern Levantine Mediterranean using surface drifters and satellite altimetry. Ocean Model. 104, 1–14. doi:10.1016/j.ocemod.2016.05.006

Kabbara, N., 2005. Wind and wave data analysis for the Lebanese coastal area – preliminary results. Leban. Sci. J. 6, 45–56.

Kapiris, K., Al., E., 2014. New Mediterranean Marine biodiversity records (April, 2014). Mediterr. Mar. Sci. 15, 198–212. doi:10.12681/mms.737

Lteif, M., 2015. Biology , distribution and diversity of cartilaginous fish species along the Lebanese coast , eastern Mediterranean. Universite de Perpignan.

Masri, T., Khawlie, M., Faour, G., 2002. Land cover change over the last 40 years in Lebanon. Leban. Sci. J. 3, 17–28.

Ministry of Environment, 2004. Final report biodiversity assessment and monitoring in the protected areas / lebanon leb / 95 / g31.

MRCZM-IOE-UOB, 2014. Identification of Legal, Policy and Institutional Gaps and Policy Reforms Drafted for Marine and Coastal Biodiversity Protection.

Newbury, N., Khalil, M., Venizelos, L., 2002. Population status and conservation of marine turtles at El-Mansouri, Lebanon. Zool. Middle East 27, 47–60. doi:10.1080/09397140.2002.10637940

St. John, F., Khalil, M., Venizelos, L., 2003. Marine Turtle Nesting in South Lebanon 2003.

Zenetos, A., et al., 2015. New Mediterranean Biodiversity Records (April 2015). Mediterr. Mar. Sci. 16, 266–284.

Annex

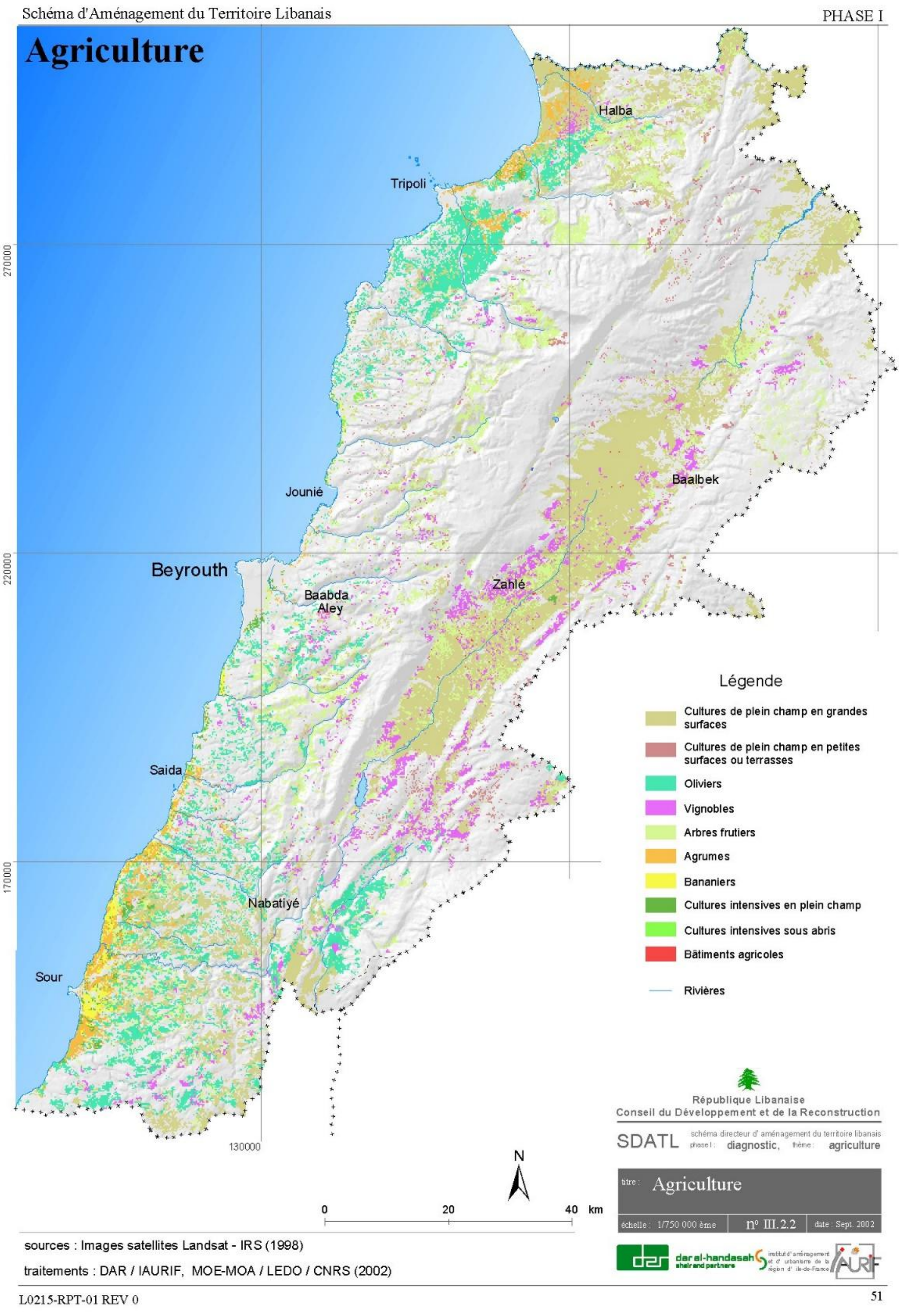

Figure 8 Agricultural map of Lebanon performed using IRS high resolution 1998 images

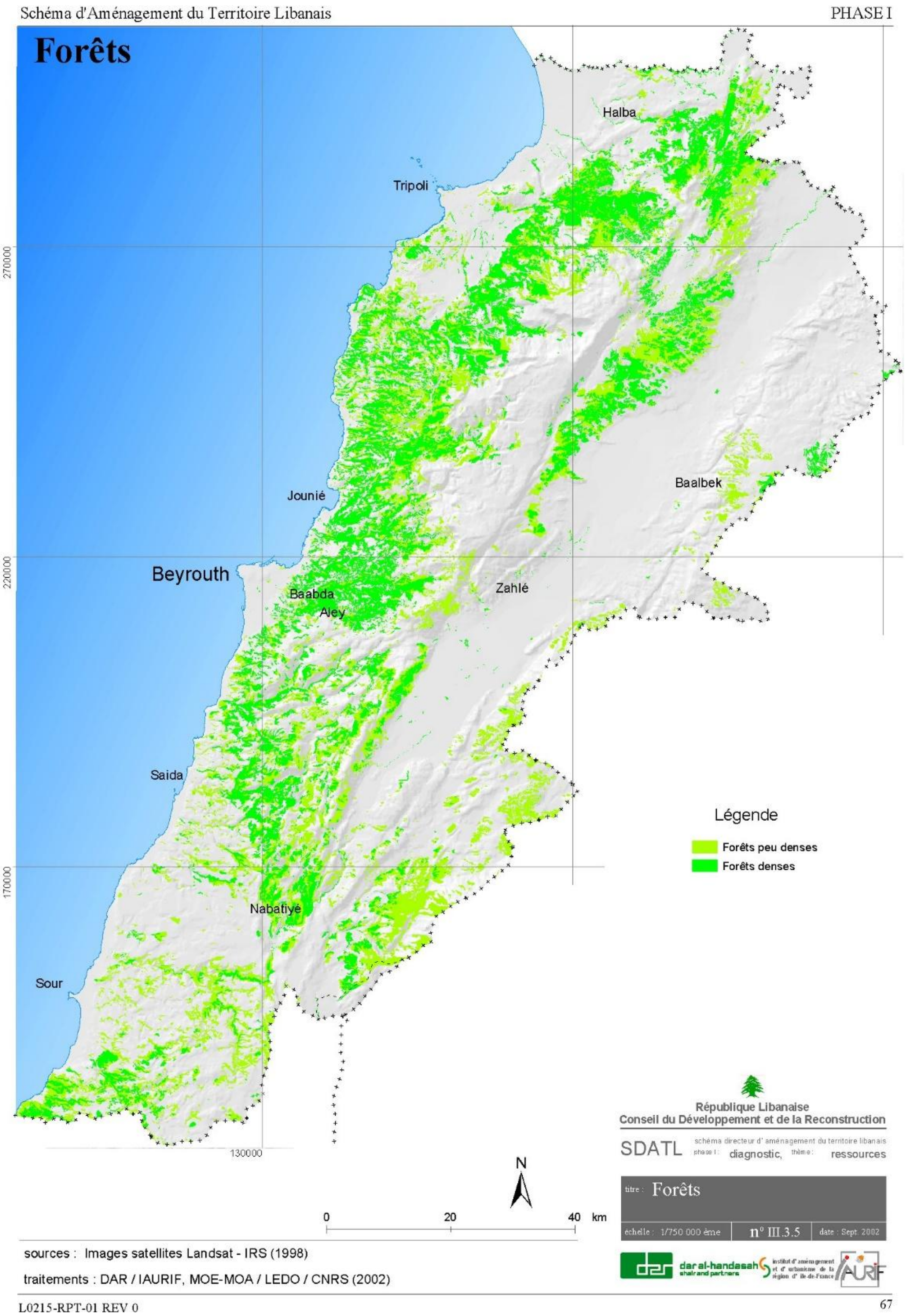

Figure 9 Dense forests (dark green) and lightly dense forests (light green) performed using IRS high resolution 1998 im

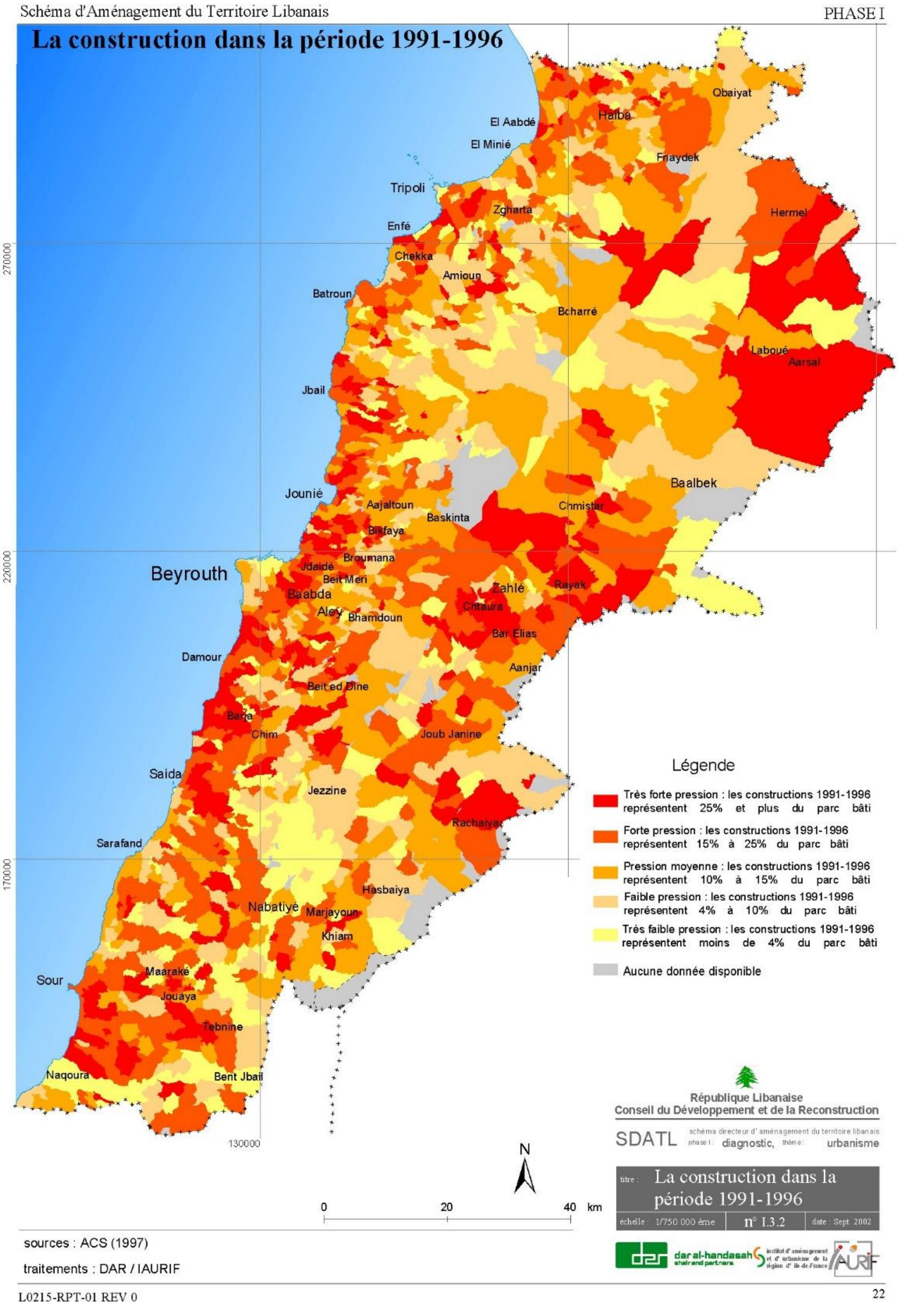

Figure 10 Different levels of contructions over Lebanon between 1991 and 1996

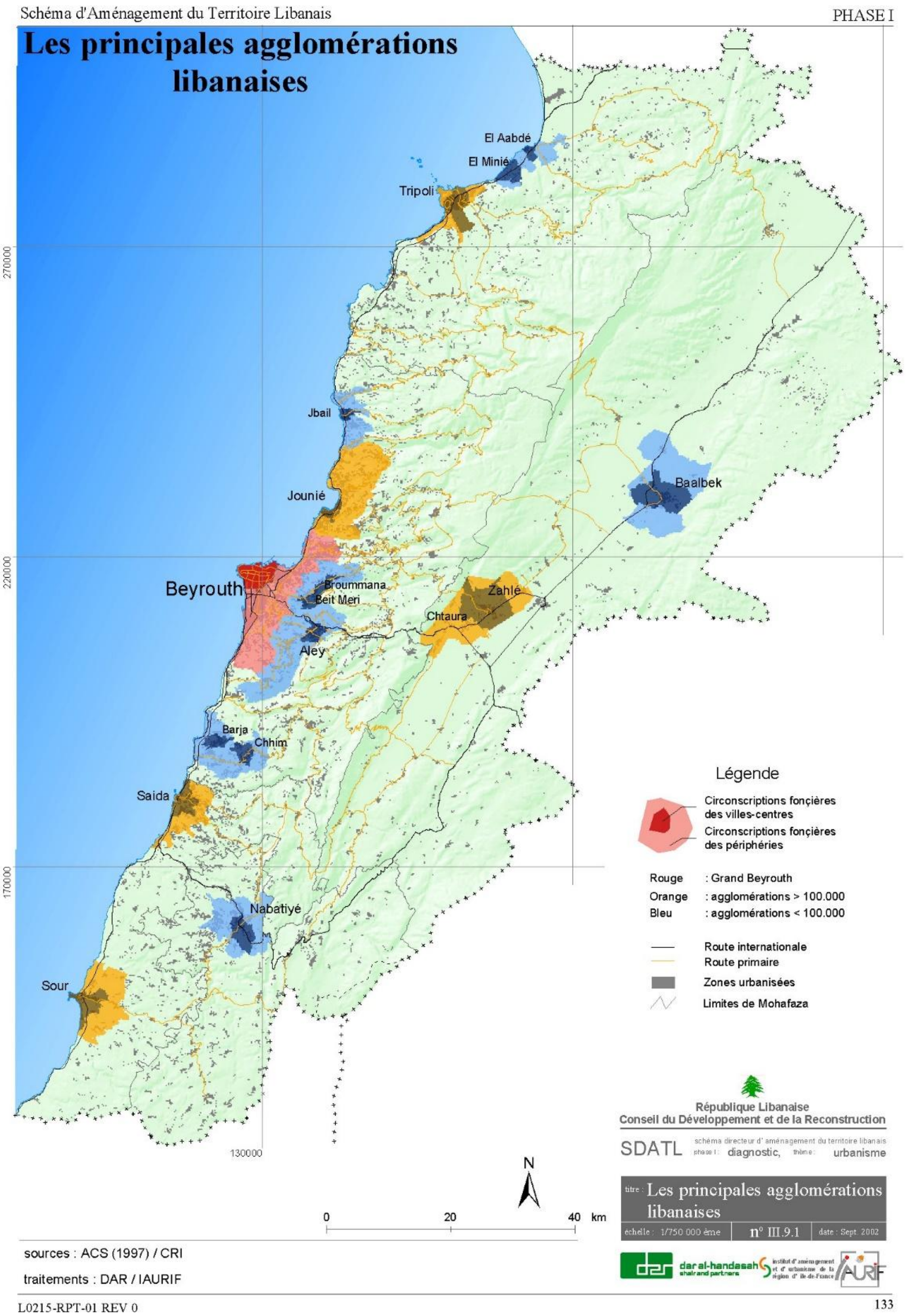

Figure 11 Different degrees of agglomeration over Lebanon until 1996

Figure 12 Distribution of water treatment plants throughout Lebanon.

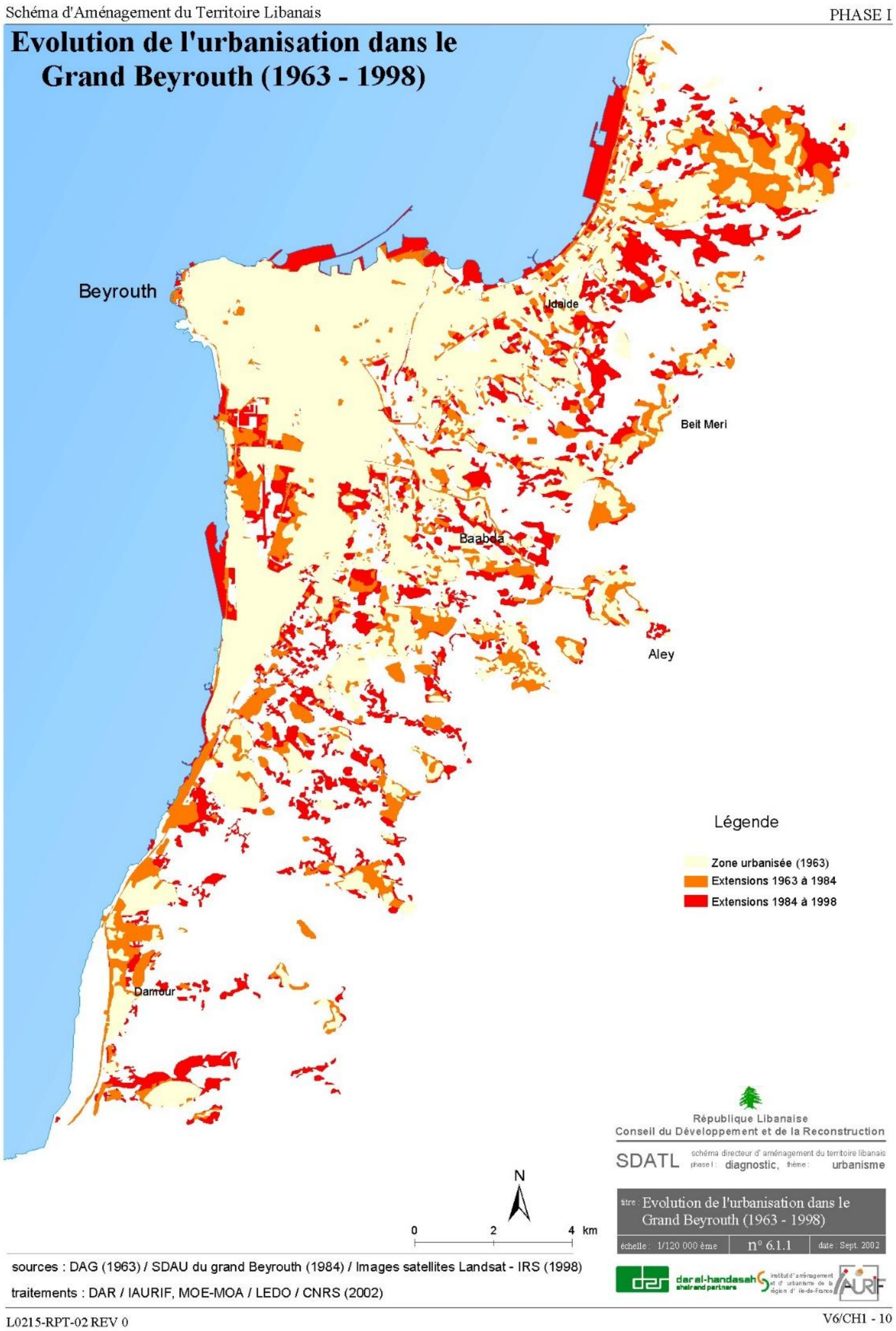

Figure 13 Evolution of urbanization in the Greater Beirut area between 1963 and 1998