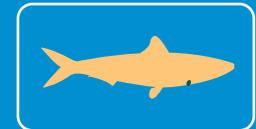
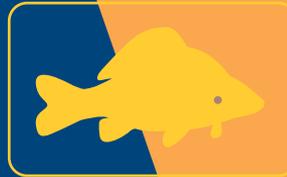
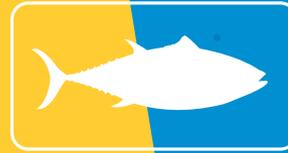


Impact of climate change on the coast of Lebanon

An awareness handbook



Impact of climate change on the coast of Lebanon

An awareness handbook

Manal Nader, Maria Bou Nassar, Shadi El Indary, Manale Abou Dagher

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Acronyms

CC	Climate Change
CZ	Coastal Zone
ICZM	Integrated Coastal Zone Management
IUCN	International Union for Conservation of Nature
MPA	Marine Protected Area
NIS	Non-Indigenous Species
SLR	Sea Level Rise
SST	Sea Surface Temperature

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Our gratitude goes to IUCN's Regional Office for West Asia, the Ministry of Environment of Lebanon, the GEF and UN Environment Programme for supporting this study and its publication. We would specifically like to express our sincere gratitude to Dr. Hany El Shaer (Regional Director for West Asia Office) and his team, Eng. Natalia Boulad (Programme Manager for the Protected Areas, World Heritage and Biodiversity Programme), Mr. Ziad Samaha (Programme Manager for the Marine and Coastal Zone Management Programme), and Eng. Hanna Haddad (Programme Assistant for the Protected Areas, World Heritage and Biodiversity Programme) for helping to successfully complete the text prior to publishing. In addition, we would like to thank the Ministry of Environment for adopting this guidebook, and especially Ms. Lara Samaha (Head of Ecosystems Department) for her constant support.

I. Climate change and the coastal zone in Lebanon

The sea provides us all with food and other resources that we need, regulates our climate and provides part of the oxygen we breathe. All our biodiversity, our economy, our food security and our society will be affected by any changes in our marine waters, more specifically by changes brought by Climate Change (CC). Adapting to CC is the major challenge facing our societies today since it will define the progress and evolution of human civilization for centuries to come.

The ocean plays a central role in regulating the Earth's climate. The latest IPCC Special Report on the Ocean and Cryosphere in a Changing Climate in 2019 revealed that oceans have thus far absorbed 93% of the extra energy from the greenhouse effect.

What is climate change?

The IUCN defines CC as a significant change in the average weather conditions or a change in the distribution of weather events. It is likely to happen over an extended period.

Naqura, South Lebanon



© JO.B

Chekka, North Lebanon



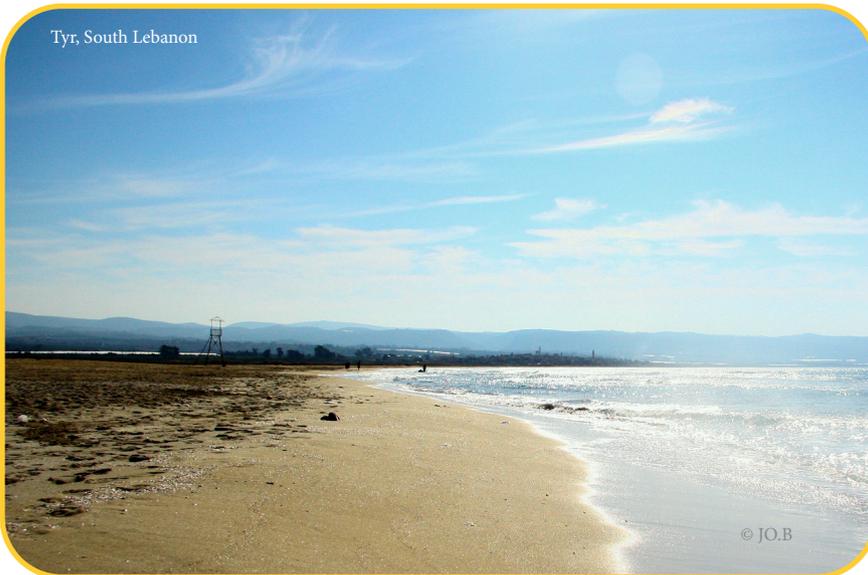
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A. What is the impact of climate change on coastal zones?

Main impacts of CC on coastal zones (CZ)

- Sea Level Rise (SLR) caused mainly by ice sheet melting and warming of marine water bodies.
- More intense storms.
- Higher Sea Surface Temperatures (SST).
- Increase in the number of Non-Indigenous Species (NIS) with those of invasive character being more worrying.
- Increase in water acidity and low oxygen levels in coastal waters.
- Abnormalities such as sediment flow and beach erosion/regression.
- More intense rain and coastal disasters (e.g., storm surges) that will accelerate erosion.
- Effects on biodiversity, mainly negatively, dependent on the ability of the species to adapt to new changes.
- Sometimes, effects on the economy might be positive as species will migrate and occupy new areas with several potentially becoming of economic value.

Tyr, South Lebanon



What is the coastal zone?

The CZ constitutes a dynamic area where marine waters meet land masses, and as such, is considered as a zone of transition. IUCN defines the Coast as "The strip of land that lies immediately after the sea on the dry land, covering the area that is directly affected by the ocean. It includes cliffs, coastal plains, steep marine terraces, swamps and lagoon systems".

What is the role of oceans and seas in mitigating climate change?

Oceans and seas regulate global climate by defining rainfall, droughts, and floods and store carbon where around 83% of the global carbon cycle is circulated through marine waters. Actually, in the last 200 years, oceans have absorbed 1/3 of the CO₂ and 90% of the extra heat produced by human activities.

To understand the consequences of CC on CZs, important effects need to be monitored such as SST, SLR, NIS, sea acidification, and deoxygenation amongst others, in addition to their impact on biodiversity, ecosystems, the economy and society as a whole.

SST

Warmer water causes changes in precipitation and air temperature and an increase in extreme weather events. Additionally, warmer water increases absorption of additional quantities of CO₂ by the sea that leads to more acidic waters, and changes water circulation, nutrients, and coastal productivity. All these will have major negative impacts on marine biodiversity.

SLR

Warm water takes up more space than cold water leading to a rise in sea levels. Additionally, more water is flowing into the oceans due to warmer overall temperature that melts landlocked ice sheets. The change in SLR will increase the danger of coastal flooding, particularly in low-lying areas near the coast. SLR will submerge coastal lands and will increase the risk of damage by storm surges. Coastal biodiversity, infrastructure, coastal agricultural lands, fresh water aquifers and coastal communities will be negatively impacted.

NIS

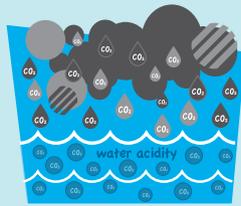
As sea waters get warmer, species are likely to migrate outside of their natural habitats into areas where temperatures are within their tolerance range. The spread and establishment of NIS will compete with native marine communities and affect the whole ecosystem. NIS will also affect fishermen, markets and consumers as they will have to get used to the fishing and consumption of new species.

The NIS Lionfish, *Pterois miles*



© (MCR-IOE-UOB)

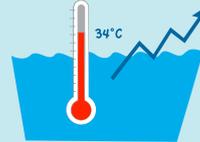
Impact of Climate Change on Coastal Zones



Sea acidification



SLR & erosion



Higher SST



Increase NIS



Intense coastal
storms & flooding

Sea acidification

Humans are producing large quantities of CO_2 that is released in the atmosphere. Oceans and seas absorb a large quantity of this CO_2 , making waters more acidic. Acidic water will harm marine life, fishing and tourism. This will destroy habitats, threaten food security and the income of people who rely on the marine sector.

Sea deoxygenation

The higher the temperature, the lower the oxygen (O_2) in water. The main causes of reduction of O_2 in marine waters are eutrophication from organic pollution and temperature rise of the ocean due to CC. Low oxygen levels will kill species, damage spawning grounds, harm coastal habitats (i.e. vermetid platforms) and reduce the survival rate and growth of different marine organisms.

White Cliff, Naqura



© J.O.B

B. Does CC affect us on the Lebanese CZ?

Our CZ has come under extreme pressures from human activities with the most flagrant being artificialization of the shoreline. Latest calculations using Geographic Information System (GIS) technology showed that the Lebanese coastline extends over 370 km (instead of 225 km) from Arida in the North to Ras Al-Naqoura in the South due to all the sea-filling activities that took place in the past 50 years. This reinforces the fact that the majority of the Lebanese population lives on the coast and that much investment in infrastructure has been made in this area with both being negatively affected by CC. CC will lead to flooding of these areas that is amplified by SLR, to extreme storm events, to decrease of food sources that people depend on due to destruction of habitats and to changes in the chemical and physical characteristics of marine waters, to negative impacts on coastal tourism, to beaches being eroded, and to coastal agriculture disappearing. Surely, all the investment in coastal infrastructure and the economies that depend on them are at risk of excessive damage.

II. Climate change and the physical environment

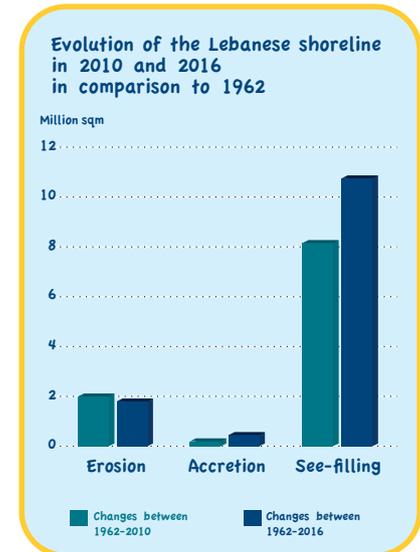
A. What constitutes our coastal physical environment?

The Lebanese coastline includes three bays, 12 headlands and several river deltas, where 80% of the shoreline is rocky and 20% is sandy. Rocky shores are associated with habitats called vermetid platforms, listed of conservation interest by the UNEP/MAP-SPA/RAC in 2002. Other habitats along the coast include rocky off-shore islands (i.e. Palm Island Nature Reserve), sandstone and limestone cliffs (i.e. Jbeil, Ras Al Shakaa and Ras El Bayada), coastal sand dunes (i.e. Chekka, Tyre Coast Nature Reserve), and coastal caves (i.e. Beirut, Amchit, Ras Al Shakaa, etc.), in addition to sandy, rocky and pebble beaches.



Evolution of the Lebanese coastal zone

A study conducted by the Marine and Coastal Resources Program, Institute of the Environment - University of Balamand comparing historical aerial photographs of 1962 and satellite images of 2010 and 2016 showed that sand and pebble beaches have retreated due to extensive erosion while more than 10 km² (8,288,918 m² in 2010 and 10,823,462 m² in 2016) of land was added along the Lebanese shores by sea-filling. These changes are attributed mainly to illegal activities like sand extraction and chaotic coastal development, mostly due to the lack of enforcement applicable laws especially during and after the civil war (1975-1992) and beyond. Furthermore, the CZ and beaches of Lebanon are usually sediment starved, a situation made worse by the building of dams along rivers and valleys, and to the diversion of the majority of coastal rivers towards potable water and irrigation. Extensive disturbance in the sediment supply to beaches is leading to further erosion and disruption to food webs. These impacts are expected to intensify due to CC.



B. What does CC do to our physical environment?

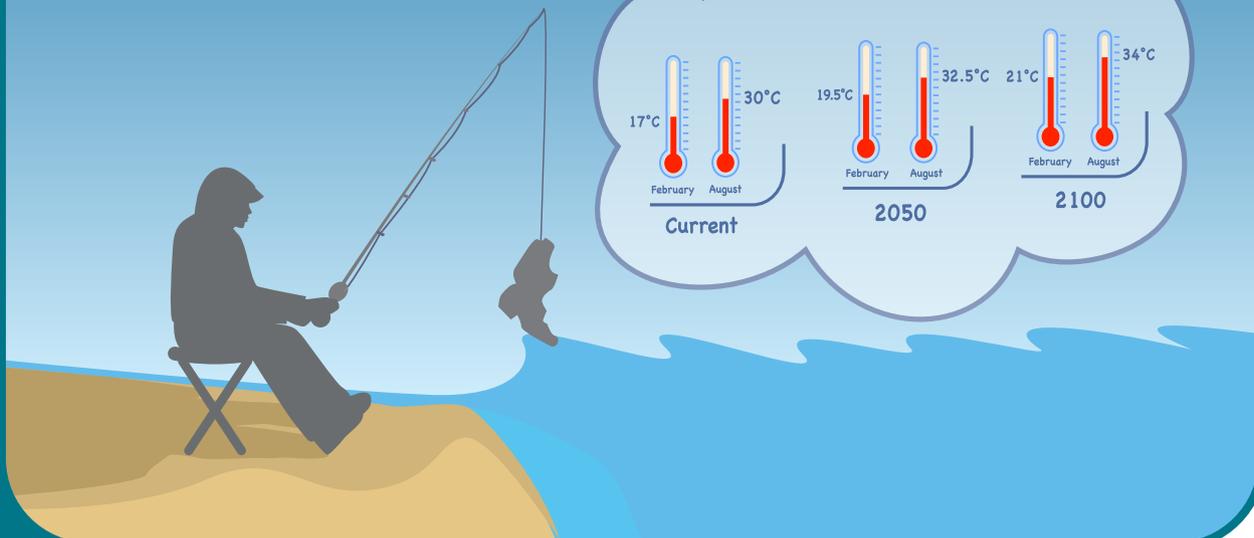
1. What do we know?

- SST is expected to reach a minimum of 19.5°C in February and a maximum of 32.5°C in August in 2050 and a minimum of 21°C in February and a maximum of 34°C in August in 2100 in comparison to the current averages of 17°C in February and 30°C in August.
- SLR will amplify the impact of coastal erosion and beach retreat by increasing the risk of coastal floods to coastal areas and the degradation of the few remaining natural coastal habitats. Sea level is expected to increase between 7-12 cm by the year 2050 with larger SLR occurring along the Eastern and Southern Mediterranean coasts and therefore the Lebanese coast.
- Sandy and pebbles beaches, and their ecosystems are extremely susceptible to erosion. Sand and gravel are lost not only due to SLR, but also due to stronger waves generated by storms intensified by CC.



© (MCR-IOE-UOB)

SST is expected to rise in comparison to current averages



2. What do we still need to know?

Marine meteorological data sets, series or otherwise, are missing at local and national levels adding to the difficulty of developing prediction scenarios, and in turn introducing adaptation and mitigation plans. Therefore, multi-year daily time-series of meteorological and oceanographic variables are needed to effectively predict CC impacts on the CZ.

Detailed geological and geomorphological maps in Lebanon necessitate major updates especially that they are extremely important for understanding CC impact on the CZ and for mitigating its effects. Currently, there is no monitoring, long-term or otherwise of the land movement of the different regions of the Lebanese CZ to understand and project the impact of SLR. Sea level change reflects changing levels of both land and sea. It is the balance between these two that produce observed changes in sea levels.



III. Climate change and the Lebanese marine biodiversity

Lebanese waters constitute less than one percent of the world's oceans surface but hold an impressive six percent of global marine species and more than 20 marine habitats.

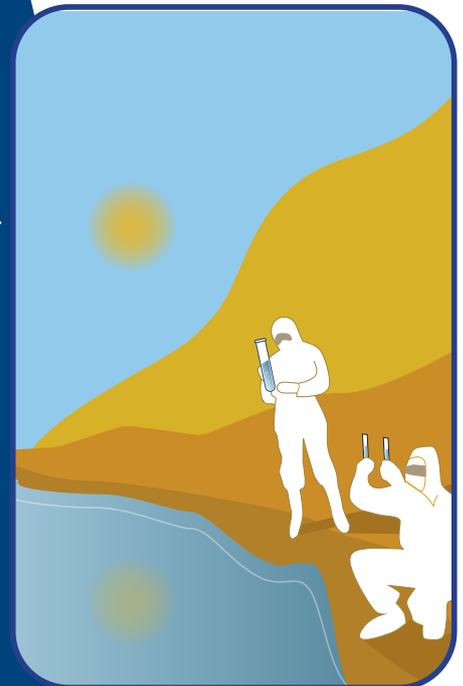
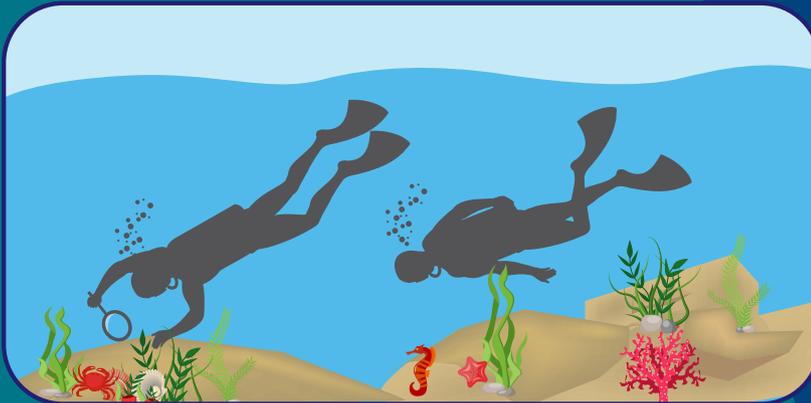
A. What does CC do to our biodiversity?

1. What do we know?

Sea warming has already altered community composition and interactions between species. For example, CC and temperature increase of seawater facilitate the spread and establishment of NIS. To date, hundreds of NIS species have become a familiar sight, at least in the East Levantine corner of the Mediterranean, with 215 marine NIS identified in our waters.

2. What do we still need to know?

Not all marine habitats in Lebanon are well defined or mapped. Mapping habitats in Lebanese coastal waters and monitoring changes in species composition is essential to understand the impact of CC on marine biodiversity and to introduce adaptation measures.





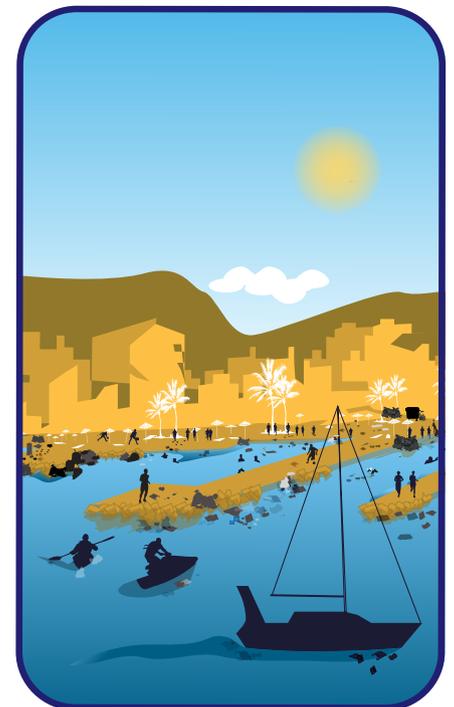
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IV. Climate change and human activities

A. What are the human activities on our coast?

The coastline hosts 70% of the Lebanese population where the most important economic sectors are located. Coastal sectors that will be mostly impacted by CC are agriculture, tourism, fisheries and residential areas, especially those infringing on the maritime public domain.

- Agriculture represents 60% of our coastal areas and are mainly concentrated in Akkar, Abou Ali valley in the North, Damour, and the Southern Plain (mainly in Saida and Tyre) in the South.
- In Lebanon, 51% of industries occupy 10% of the coast in the areas surrounding the cities of Beirut, Tripoli, Chekka, Sibline, Choueifat, and Zouk.
- Tourism is considered to be one of the most important sectors with 71% of Lebanon's total hotels and resorts located on the CZ, mainly in Beirut and Jounieh and is a main generator of jobs.
- Fishing in Lebanon is a family-based activity and fishermen in general are artisanal or traditional in nature with fishing vessels operating from 44 fishing harbours and landing sites. A fisher earns about 25% less than the minimum wage of the country.



B. What does CC do to our coastal communities?

1. What do we know?

- SLR intensifies erosion, narrows the beach and allows seawater to reach agricultural lands.
- With intensification of storms, waves may flood agricultural lands and sea spray will travel further inland salinizing fertile soils.
- Coastal flooding leads to increased seawater intrusion into coastal aquifers negatively affecting drinking and irrigation water supplies.

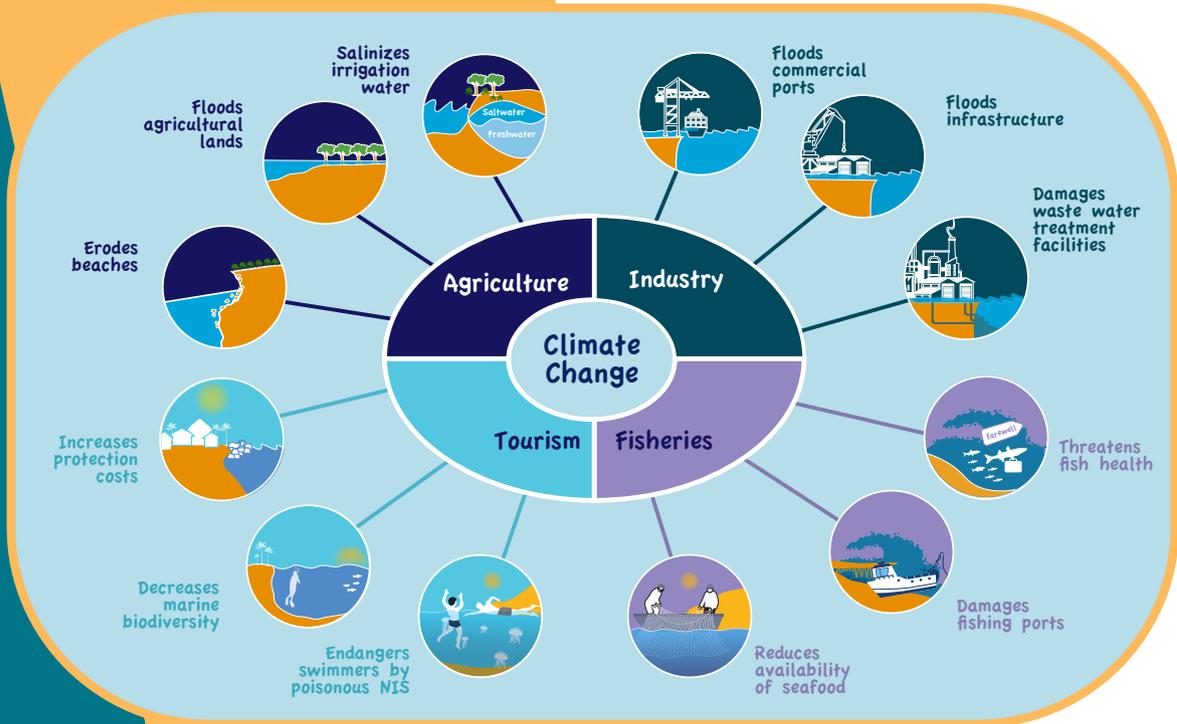
At the level of industry:

- SLR threatens flooding commercial ports and may interrupt the movement of goods and hamper other economic sectors, mainly industries.
- Industries located on the CZ, especially their waste treatment facilities, land transportation networks and other vital infrastructure are greatly vulnerable to SLR and coastal flooding.
- Wastewater treatment facilities and the coastal landfills located on the CZ are at the risk of coastal floods that are aggravated by SLR potentially polluting the marine environment.

At the level of tourism:

- SLR increases beach erosion adding financial costs to protect beach resorts which, in turn, negatively impacts the tourism sector.
- Tourism is impacted by the loss of certain habitats attractive to tourists. Attractiveness will drop due to a decrease in species richness and diversity, regression of beaches and inundation of cultural heritage sites.
- Several toxic NIS species whose numbers and abundance may increase due to CC are considered a new threat for swimmers and divers in shallow waters as they contain toxins in their spines that can cause severe pain like the sea urchin *Diadema setosum* (قنفذ البحر كويل الأشواك), the Striped catfish *Plotosus lineatus* (سلور مرجاني) and the lionfish *Pterois miles* (سمكة الاسد).





At the level of fisheries:

- Storms and damages to fishing ports will lead to interrupting the movement of fishing activities and creates additional cost for maintenance of harbours or mitigation of possible damage to the fishing fleet.
- Food security, fisheries and shoreline protection will be threatened due to changes in species growth and reproduction, as well as alterations in ecosystems due to sea acidification, sea deoxygenation and NIS.
- Reduction in O₂ in sea water will impact the economy and communities relying on ecosystem services from wetlands and estuaries, amongst others.
- Certain commercial fish species are establishing themselves in new territories driving away local species, or show shift in their depth of distribution, both affecting the fisheries sector.
- NIS is changing commercial species composition where fishermen will have to introduce new fishing gear, adapt to new fishing techniques and try to establish a market for NIS of commercial value.
- Small scale fishers may face reduction in their main marine resources and therefore will have to adapt and increase their resilience to the new circumstances.

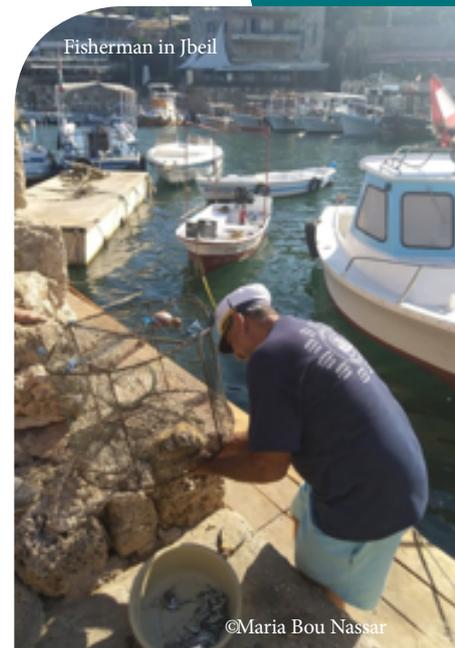
2. What do we still need to know?

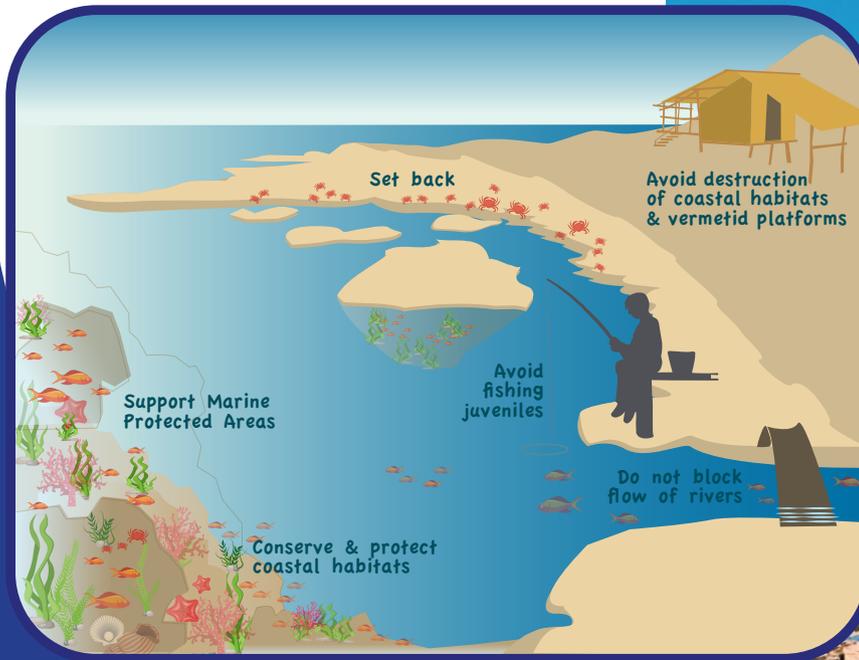
Information should be collected on the socioeconomic status of the CZ at national level. Current studies do not focus on the CZ but are more general or localized for certain areas.

The impact of CC on commercially valuable marine products must be assessed to determine the resilience of the local communities to changes in marketed and non-marketed goods and services.

V. What can we do about it? (Individual actions do count)

- Do not build/infringe on the maritime public domain.
- If you live next to the shoreline, establish your own setback to allow the shoreline to act as the first line of defence against hazards born at sea.
- Avoid fishing during the reproductive season.
- Avoid using fishing gear that catches juveniles.
- Avoid any activity that will lead to the destruction of coastal habitats, more specifically vermetid platforms. For example:
 - Avoid extreme stepping and walking on the platforms.
 - Avoid harvesting marine algae for fishing and other practices.
 - Avoid dumping pollutants on the CZ in general and on the platforms in particular.
 - Help restore damaged vermetid platforms by supporting conservation action and scientific research.
 - Actively support the establishment of new locally managed marine areas, Himas and Marine Protected Areas (MPA).
 - Actively conserve and protect your local coastal habitats.
- Speak up and support/join public and/or private organizations working on reducing and/or adapting to the impacts of CC.
- Reduce to the maximum the use of fossil fuels.
- Avoid activities that could block sediment flow from rivers that nourish beaches therefore avoiding habitat loss and beach erosion.
- Respect regulations related to sediment disposal.
- Create an economy for NIS in terms of fishing and consumption.
- Assure the sustainability of coastal and marine resources through good practices in fisheries, agriculture, industry and tourism sectors.





Protocol on integrated coastal zone management

In 2001, the development of The Protocol on Integrated Coastal Zone Management (ICZM) was launched under the Barcelona Convention for the Protection of the Mediterranean Sea against pollution in order to guarantee the sustainable management of coastal natural resources. The ICZM Protocol was signed in Madrid on January 21, 2008. It allows Mediterranean countries to better manage and protect their CZs as well as to deal with the emerging coastal environmental challenges. The Protocol entered into force on March 24, 2011 and the Lebanese Government ratified it on September 18, 2014 according to Decree n°639 and entered into force on August 31, 2017.

VI. What should be done at national level?

- Increase awareness at all levels on the Paris Agreement Under the United Nations Framework Convention on Climate Change (COP 21).
- Relieve pressure on the CZ by adopting the ICZM Draft Law and the ICZM Strategy (developed by MoE based on the ICZM Protocol).
- Create a platform for scientific information and documents that can be accessed by all stakeholders.
- Adopt the Ecosystem-Based Adaptation approach to promote more resilient coastal areas through the protection of ecosystems.
- Establish the MPA network proposed by "Lebanon's Marine Protected Area Strategy" developed by the MoE and IUCN (<https://www.iucn.org/content/lebanons-marine-protected-areas-strategy>).
- Integrate CC and its effects in urban planning and introduce sustainable and eco-friendly measures through soft engineering techniques in order to mitigate the damage of CC against coastal hazards.
- Take management measures to protect vulnerable species and habitats.
- Implement an institutional mechanism to protect and manage important sites as well as historical/natural assets along the coasts vulnerable to CC.
- Coordinate between technical agencies, institutions and authorities for effective exchange of technical information and proper management.
- Enact specific laws related to CC, and complete the passing of already drafted laws.

What should be done at national level



**Conserving
marine ecosystems**



**Connecting people
& institutions**



**Enactment &
application of laws**

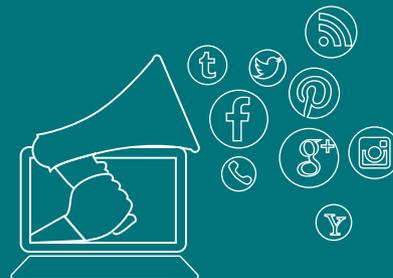
- Strictly enforce laws on violation of the maritime public domain, sea-filling activities, prohibition of public access to the shoreline amongst many others.
- Identify and map pathways of introduction/proliferation of NIS to allow for better management and monitoring.
- Create a market for NIS of commercial value in cooperation with the private sector.
- Enact conservation programs for key species affected by NIS and CC.
- Start the implementation of the "National Action Plan on species introductions and invasive species in Lebanon" produced by the SPA/RAC and MOE.
- Lobby for a convention/agreement with the Egyptian authorities to control/eliminate the introduction of Lessepsian species through the Suez Canal.
- Adopt the Integrated River Basin Management approach in new policies and in all policies that encompass land-based sources of pollution flowing into rivers and reaching the CZ.
- Model the impact of dams on CZs before construction.
- Increase the number and spatial distribution of marine monitoring stations on CZs to measure physical, chemical and biological parameters important for CC and share collected data.
- Enact laws and decrees through the implementation of existing norms to minimize agricultural and industrial runoff and municipal solid and liquid



Research & development



Market diversification



Awareness raising

Conclusion

In addition to the extreme stressors from human activities, and as for all coastlines around the world, the Lebanese CZ will suffer the impact of CC on biodiversity and community well-being. Impacts are anticipated from SST, SLR, NIS, sea acidification and sea deoxygenation. SST is expected to increase 2°C to 3°C in 2050 and 3°C to 5°C in 2100 while sea level is expected to rise between 7-12 cm by the year 2050 leading to flooding of coastal lands, especially during storms. NIS will increase in numbers and will overtake habitats of indigenous species affecting their survival and resilience and in turn the fisheries sector and food security. Adding sea acidification and deoxygenation, the whole equilibrium of the coastal marine ecosystem will be affected and food webs will be altered. Since the sea plays a major role in combating CC, protection of coastal and marine ecosystems is essential to allow marine organisms and human coastal communities alike to adapt to, and mitigate the impacts of CC.









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