2023 Quality Status Report (QSR)
Content on IMAP Ecological Objectives (EO) 7 and 8

Contribution to the 2023 Med QSR for the cluster on Coast and Hydrography

PAP/RAC
Split, April 2023

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Contents

Introduction

This report contributes to the 2023 Mediterranean Quality Status Report (2023 MED QSR) based on region wide Ecological Objectives (EO) and Common Indicators (CI) that are the basis of the Integrated Monitoring and Assessment Programme (IMAP) (Decision IG. 22/7). This report contributes to the cluster on Coast and Hydrography that is composed on EO 7 and EO 8 with the following CIs:

EO 7 Hydrography;

a. CI 15: Location and extent of the habitats impacted directly by hydrographic alterations;

EO 8 Coastal ecosystems and landscapes;

b. CI 16: Length of coastline subject to physical disturbance due to the influence of human-made structures;
c. Candidate CI 25: Land cover change.

The CI 15 and 16 are assessed for the whole Mediterranean region while candidate CI 25 for the Adriatic sub-region only. Assessment of CIs is based on national reports (by reporting to IMAP Info system or in the frame of EcAp MED III and IMAP MPA projects), contributions from the scientific partners and compiled datasets from open-source data.

Ecological objective 7 - Hydrographic alterations

Common indicator 15 “Location and extent of the habitats potentially impacted by hydrographic alterations”

1. Key messages

1. All countries had difficulties with the monitoring of this indicator according to the Guidance factsheet and could not provide monitoring data therefore, the Good Environmental Status has not been assessed.
2. A baseline assessment has been made using data from the national reports prepared in the frame of EcAp MED III and IMAP MPA projects, including some other countries that used the same report format, and from the data provided by scientific partners, Mercator Ocean in particular.
3. Climate change seems to have far bigger impacts on the habitats and marine ecosystems in general than the impacts of hydrographic alterations caused by new structures.
4. Due to the difficulties that countries have with reporting on this indicator further simplification of the Guiding Factsheet is needed so to allow countries to report on the physical loss of habitats, i.e. the structures’ footprint.

2. Background information and methodology

1. The EO7 Common Indicator 15 reflects the location and extent of the habitats potentially impacted by hydrographic alterations due to new developments (QSR 2017, 2018), i.e. upcoming constructions. It concerns area/habitat and the proportion of the total area/habitat where alterations of hydrographical conditions are expected to occur. The GES is achieved when negative impacts due to a new structure are minimal with no influence on the larger scale coastal and marine system.

2. In relation to the 2017 Med QSR countries still have difficulties to provide monitoring data according to the Guidance Factsheet, although the methodology has been simplified. The information received by majority of the countries is of a descriptive nature, rather homogeneous, regardless of the same annotated questionnaire developed in the frame of the EcAp MED III and IMAP MPA projects. However, some scientific partners provided very relevant information of the hydrographic parameters based on satellite data and mainly related to climate change impacts. It seems that all these parameters that are increasing their values due to climate change have significant impacts on all other EOs and should be taken into account for an integrated assessment.

3. No monitoring data was reported so GES assessment could not be made according to the Guidance Factsheet (UNEP/MAP, 2019). Therefore, for this assessment other sources of information were used to provide a general overview of the hydrography in the Mediterranean, such as national reports prepared in the context of the EcAp MED III project, IMAP MPA project and by some other countries, and those provided by the scientific partners (i.e., Mercator Ocean) in particular on hydrographic parameters that are changing due to climate change.

3. Drivers, pressures, state, impact, response (DPSIR)

4. The Operational objective of the Common Indicator 15 is to minimize hydrographic alterations due to permanent constructions on the coast and watersheds, marine installations and seafloor anchored structures. Two of the drivers of such constructions in coastal and marine areas are population growth and tourism development, in particular coastal and nautical tourism which results in construction of associated infrastructure (i.e., construction of marinas). In addition, maritime transport, fisheries and aquaculture also lead to increases in construction of ports, marinas and other related objects on the very coastline. Demand for energy, electricity and minerals results in activities such as sand excavation, construction of desalinization plants and powerplants

cooling basins, constructions on the coast (LNG and oil terminals) and offshore structures (windfarms, oil and gas platforms). Finally, coastal protection works to stabilize the shoreline, highly in focus recently due to effects of climate change, also alter the natural dynamics of sediment and seawater flow (Table 1.1).

Table 1.1: The main drivers (human activities), pressures and impacts causing hydrographic alterations that can potentially impact habitats

DRIVERS	PRESSURES	IMPACTS
Population growth Demand for oil, gas, minerals and electricity Need for drinking water Beach nourishment, coastal erosion Increasing maritime transport Tourism development	Construction and/or extension of ports and marinas Windfarms, oil and gas installations Protection structures from erosion Construction of desalinization plants Anchoring structures	Fragmentation and habitat loss due to construction Changes of sediment transport Permanent changes of bathimetry (during construction and during maintenance works) Changes of hydrographic conditions in habitat's neighborhood Alterations of natural dynamics of water flow, waves, currents

5. All these above-mentioned drivers and pressures lead to changes in important hydrographic parameters such as:

- waves and currents (also reflected in changes in bottom shear stress, turbulence and alike).
- sediment transport and turbidity and induced changes in morphology of the coast.
- salinity and/or temperature (if the new structure involves water discharge, water extraction or changes in freshwater movements).

6. The impacts of such alterations can result in physical habitat loss induced by the structure itself (on the sea floor and in water column). In addition, permanent changes in bathymetry in dredged and disposal areas can happen during the construction of the structure (digging of basins) or for its normal use (channels dredging to maintain a certain depth). Impacts on erosion and sedimentation rates can lead to smothering of benthic organisms, and increases in turbidity. Increased turbidity means reduced transparency and consequent reduction in photosynthetic ability. For example, *Posidonia* is in particular sensitive to turbidity. Changes in temperature and salinity (related to the mentioned structures that involve discharge) can have effects on marine organisms' changes in physiology, shift or even disappearance of species). All the mentioned hydrographical changes and related impacts will be exacerbated by climate change.

4. GES assessment/alternative GES assessment

7. The proposed targets of the indicator are directed to the process of planning of new structures that should implement all possible mitigation measures in order to minimise the impact on coastal and marine ecosystem, the integrity of its services and cultural/historic assets. According to the methodology, the indicator requires reporting of physical loss of habitats induced by the structure itself; assessment of permanent changes to the seabed due to human activities (related to the construction and the use of the structure); and assessment of hydrographical changes induced by the structure in the surrounding area (i.e. a buffer zone proportional to the largest dimension of the structure, e.g. 5 times the cross-shore length of the structure) Here, a direct link is established with the EO1 Biodiversity, i.e., with impact on marine habitats, where a particular consideration

should be given to *Posidonia* (seagrass) meadows. The monitoring results should be represented by a map showing the intersection of spatial maps of the areas of hydrographical changes with spatial maps of habitats that are impacted by hydrographical changes. Thus, the spatial scale of the indicator is very local, it concerns a "micro-location" where the structures are or are planned to be constructed.

8. The main hydrographical conditions to be considered include changes in waves and currents, sediment transport processes, turbidity, salinity and temperature changes.

9. Due to difficulties that countries have to implement the requirements of the indicator, the approach was to collect at least general hydrographic data. General data on the hydrography baseline situation in the Mediterranean countries was presented in national reports based on the questionnaires that were collected through the EcAp Med III and IMAP MPA projects (Algeria, Egypt, Israel, Lebanon, Libya, Morocco and Tunisia) as well as some other countries that provided similar information (Bosnia and Herzegovina, Croatia, Cyprus, France, Greece, Malta, Montenegro, Slovenia, Spain and Turkey). The national reports provided information on the general characterization of the coastal area and marine environment, anthropogenic activities present in marine environment, hydrodynamic conditions and on planning of new installations in the coastal or marine environment. The variation of information provided through reports made it challenging to extract commonalities. The information on planning of future structures would be of particular importance as it would indicate the scope for monitoring in the future. However, such information was very difficult to obtain. Instead, some scientific partners provided valuable information, such as the Mercator Ocean, related to changing hydrographic conditions due to climate change.

10. It should be emphasized that none of the countries have reported monitoring results according to the requirements of the Guidance Factsheet (UNEP/MAP, 2019). This is the reason why GES assessment could not be made. Therefore, other sources, including the ones referred above have been utilised.

11. The baseline situation that could be extracted from the national reports is structured along the following main components:

12. <u>General characterization of the coastal area and marine environment</u>
The Mediterranean coast is classified mainly into three categories: rocky, sandy and artificial. The average representation of rocky coasts among the mentioned countries is about 45%, with the Republic of Croatia convincingly leading the way with about 90% of rocky coasts. The sandy coast makes up about 35% of the coast of the entire considered coastal zone, and the largest proportion of the sandy coast is recorded in Libya (65% of the coastal zone). In conclusion, artificial coasts occupy more than 20% of the coastal area, with the greatest representation of this type of coast recorded in Lebanon (more than 40%).

13. Large parts of the Mediterranean coastal zone are faced with geo-morphological instability. The coastal zones of southern Mediterranean countries are faced with erosion phenomena, which is primary determined by anthropogenic pressures (Bocci and Allegri, 2022). Erosion rates reported for the countries in the southern region range between -0.14 m/y (Morocco) up to -1.4 m/y (Lebanon). To counteract erosion, many protection structures have been constructed in the area. It seems in general that interventions with traditional protective structures lack a comprehensive view about geomorphology and coastal processes and therefore there is a risk of generating additional impacts on the marine and coastal environment. The realisation of nature-based sea defence structures is reported for Egypt, using soft, self-maintaining and reversible protection solutions.

14. As far as the hydrodynamic conditions the general conclusion is that the sea level is rising at the annual rate of 25 mm yr^{-1}, the mean wave height (MHW) is increasing at the annual level of 2.6 to 2.9 cm yr^{-1}, and that the surface water temperature is warming at the annual level of $0.13^{0}C\ yr^{-1}$.

15. Anthropogenic activities present in marine environment

Mediterranean coastal and marine areas are subject to multiple pressures, linked to both anthropogenic activities and climate change. Urban sprawl due to increases in coastal population and expansion of tourist areas is a common feature in several Mediterranean countries.

16. Artificialization of the coastline, and particularly maritime constructions, with realisation of new ports and port enlargements, new marinas, structures for erosion protection, desalination plants, infrastructures for exploration and production of offshore energy resources, recurrent maintenance dredging and beach nourishment, represent growing pressures on Mediterranean coastal and marine environment in the last decades, especially in the South and East Mediterranean countries. These infrastructures have resulted in disturbance, damage and destruction of natural habitats, in addition to impacts related to sedimentation, chemical, acoustic and light pollution. The main causes are the construction of dams for agricultural and hydroelectric purposes and river channel modifications over the last two centuries that have affected the rivers, commonly generating drastic reductions in sediment inputs necessary for maintaining dynamic beach and dune systems. The most dramatic changes have been reported in the area of Nile delta, the fluvial sediment supply of which is considered to have been totally curtailed upstream of dams (Bocci and Allegri, 2022; according to Anthony, 2014).

17. Dredging and dumping are also practised mainly in South and East Mediterranean countries with increasing trends, due to the ever-increasing demand for material for coastal infrastructures and beach nourishment, as well as increasing dredging need in ports, demanding ever deeper navigation channels to allow entrance to ever larger vessels (Bocci and Allegri, 2022).

18. Planning of new installations in coastal or marine environment

Planning the construction of new installations in coastal or marine environments is reported from almost all countries. It will mainly manifest through the expansion and upgrading of ports and marinas, new tourist facilities, and, in particular, aquaculture infrastructures in South and East Mediterranean countries.

19. The contribution of Mercator Ocean (Preliminary report, 2022) and the latest Copernicus Marine Service (CMEMS) products, provide an insight into the available spatial data for monitoring hydrographic alterations (waves, sea water velocity, temperature and salinity, turbidity and suspended matter) in the Mediterranean Sea. Data comes from satellite observations and from models.

20. The Operational Mercator global ocean analysis and forecast system at 1/12 degree (6 km at midlatitudes) is providing 10 days of 3D global ocean forecasts updated daily. The time series start from 1st January 2016 and are aggregated in time in order to reach a two full years' time series sliding window. This product includes daily and monthly mean files of temperature, salinity, currents, sea level, mixed layer depth and ice parameters from the surface to the bottom over the global ocean. It also includes hourly mean surface fields for sea level height, temperature and currents.

21. An important source of information on alterations of hydrographic conditions can also be the data prepared within the Environmental Impact Assessment and Strategic Environmental Assessment (EIA/SEA) reports for the installation of various structures in the marine environment. However, such data either does not exist or is not publicly available. Also, such reports would use different modelling methods and input variables. For example, the list of EIA reports for Croatia is available on the official website of the Ministry of Economy and Sustainable Development, but these EIAs do not contain a geospatial component, which prevents their spatial comparison and overlap with other data layers (such as hydrographical alterations and habitat data).

22. A partial and incomplete database of human structures in the Mediterranean Sea is to some extent available through EMODnet Human Activities database portal (e.g., telecommunication cables - schematic routes, dredging sites, oil and gas boreholes and installations' sites, pipelines routes, dredge spoil dumping sites, dumped munitions areas).

23. Hydrographic alterations caused by climate change

The consequences of climate change in the Mediterranean are especially manifested through hydrographic alterations of the Mediterranean Sea, which is explained in detail in the last Copernicus Ocean State Report – 6^{th} issue (2022) and the MedECC 2020 First Mediterranean Assessment Report (MAR1, MedECC 2020).

24. Taking advantage of the freely available high-resolution satellite-derived sea surface temperature dataset from the Copernicus Marine Environment Monitoring Service, that covers the longest period, it could be observed that the **surface temperatures** in the Western Mediterranean Sea have been rising over the last 39 years with an average rate of 0.036°C yr^{-1} (Krauzig et al., 2022; according to Pisano et al. 2020).

25. Over the last three decades, **marine heatwaves** (MHWs) in the Mediterranean Sea have caused mass-mortality events in various marine species, and critical losses for seafood industries. Three different sea surface temperature products (Copernicus Marine datasets) show that the maximum intensity, frequency and duration of MHWs have all increased on average over the Mediterranean Sea since 1993.

26. Based on the satellite observations over the 1993–2019 period, the number of MHWs showed an inhomogeneous spatial distribution in the entire Mediterranean Sea, with a lower number of events per year in the south-eastern Mediterranean Sea and slightly more events in the western Mediterranean Sea, especially in the north-western area, as well as the Adriatic Sea (Dayan et al., 2022). On average, the number of MHWs substantially increased across the entire Mediterranean Sea by approximately 1 event per decade. The number of MHWs increased significantly in distinct ways in the four sub-regions (Figure 1.1.). Satellite observations show that the number of MHWs has increased the most in the Adriatic Sea (1.61 ± 0.17 per decade), followed by the Aegean Sea (1.30 ± 0.23 per decade), the western Mediterranean Sea (1.13 ± 0.12 per decade) and finally the eastern Mediterranean Sea (1.01 ± 0.14 per decade). Satellite observations reveal that the duration of moderate and strong MHWs increased the most in the Adriatic Sea (23.01 days ± 2.67 and 3.22 ± 0.53 days per decade, respectively), while the duration of severe and extreme MHWs increased the most in the Aegean Sea (0.59 ± 0.18 days per decade) and the western Mediterranean Sea (0.53 ± 0.15 days per decade).

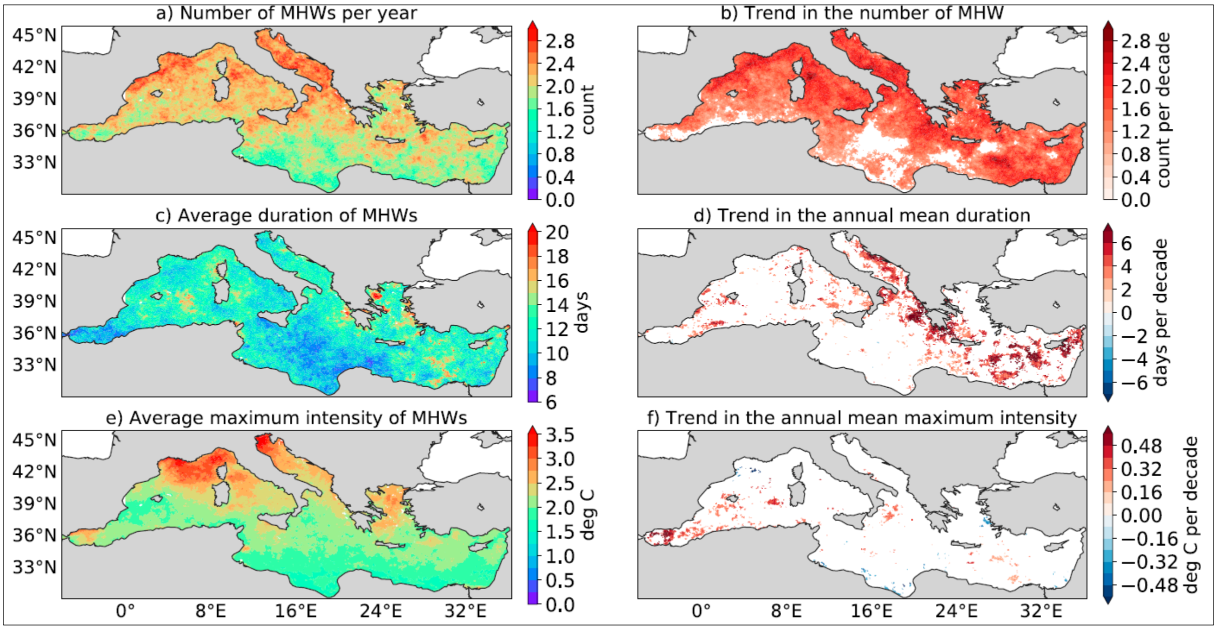


Figure 1.1: Spatial distribution of the marine heatwave (MHW) metrics from satellite-derived SST record over the period 1993–2019Source: Dayan et al., 2022

27. In the future, MHWs may undermine many benefits and services that Mediterranean ecosystems normally provide, such as food, maintenance of biodiversity, and regulation of air quality (Dayan et al., 2022, Martín-López et al. 2016). MHWs are predicted to become more intense and more frequent under anthropogenic warming, embodying a growing threat to both marine ecosystems and human society (Dayan et al., 2022).

28. The annual 99th percentile of **significant wave height** (SWH) – a measure of extremes – has increased almost everywhere in the basin during the last 28 years at a maximum rate of 0.026 m yr^{-1}. The most significant upward trends were found in the south-eastern Levantine and eastern Alboran Seas (Figure 1.2.), followed by the Adriatic Sea and contained areas of the Tyrrhenian (Zacharioudaki et al., 2022).

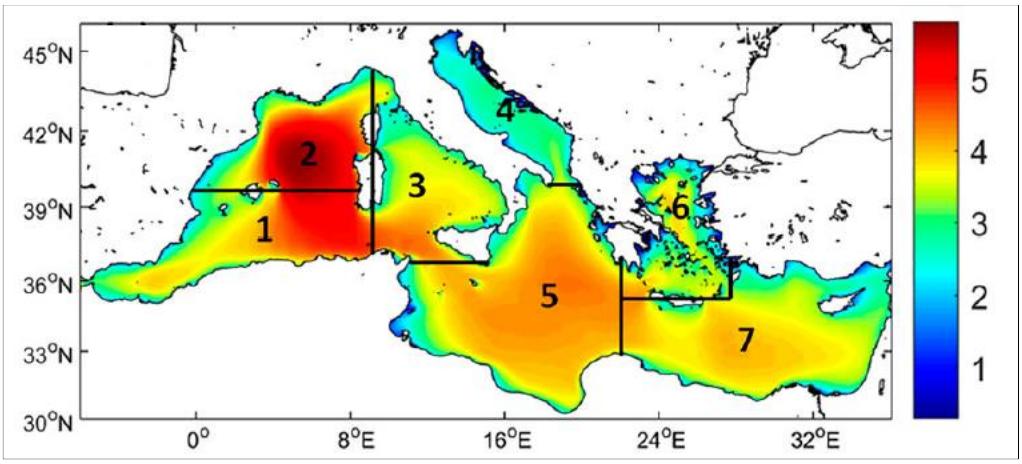


Figure 1.2.: Long-term 99th percentile of SWH in meters (1993–2020)
Source: Zacharioudaki et al., 2022

29. The **water mass temperature and salinity** changes of the water outflowing from the Mediterranean Sea through the Strait of Gibraltar are 0.077°C decade^{-1} and 0.063 psu (practical salinity unit) decade-1, respectively, compared to 2004 (MedECC, 2020).

30. Mediterranean Sea water **surface pH** has decreased by -0.08 units since the beginning of the 19th century, similar to the global ocean, with deep waters exhibiting a larger anthropogenic change in pH than the typical global ocean deep waters because ventilation is faster (MedECC, 2020). Nutrient enrichment causes eutrophication and may provoke harmful and toxic algal blooms, trends which will likely increase. Harmful algal blooms may cause negative impacts on ecosystems (red-tide, mucilage production, anoxia) and may present serious economic threats for fisheries, aquaculture and tourism (MedECC, 2020).

31. As a result of increasingly pronounced hydrographic alterations, the marine habitats in the Mediterranean Sea are increasingly endangered, and some of them are threatened with complete extinction. It stands out in particular for the Adriatic Sea where current climatological and oceanographic research (Bonacci and Vrsalović, 2022; Mihanović et al., 2021; Pastor et al., 2018; Šepić et al., 2021; Vilibić et al., 2013; Vilibić et al., 2019; Vilibić et al., 2022) indicates that the Adriatic Sea is already experiencing significant changes in hydrographic alterations, and their intensity will become more and more pronounced, while the occurrence of climatological extremes could increase.

5. Key findings

32. The main findings related to assessment of this indicator can be summarised as follows:

1. GES has not been assessed for EO7 CI 15 because countries had difficulties to monitor this indicator according to the Guidance Factsheet and therefore, monitoring data was not provided.
2. There are insufficient surveys and monitoring data provided by the countries according to the Guidance Factsheet. This is mainly related to the complex and demanding methodology, as well as institutional and scientific capacities. Assessments that estimate the extent of hydrographic alterations (knowing conditions before and after construction) and its intersection with marine habitats were not provided. Also, related studies such as EIA and SEA reports are either publicly inaccessible or conducted by various different methods. The use of numerical models in EIA to assess hydrographic alterations is costly and time-consuming and requires technical expertise and knowledge as well as statistically significant sets of hydrographic parameters;
3. The link to EO1 is essential for this indicator. Maps of benthic habitats in the zone of interest (broad habitat types and/or particularly sensitive habitats) are required. Therefore, identifying the priority benthic habitats for consideration in EO7, together with assessment of impacts, including cumulative impacts is a cross-cutting issue of priority for EO1 and EO7. Efforts need to be given to detect the cause-consequence relationship between hydrographic alterations due to new structures and habitat deterioration (i.e., scientific gaps and uncertainties exist);
4. Spatial resolution and temporal scope (historic data) of openly available spatial data on hydrographic alterations (i.e., CMEMS products) are not sufficient. Due to the scale of the locations where structures are constructed or planned are rather local (micro-location).
5. Although there are certain systematic databases of spatial data (e.g., EMODnet, CMEMS), the availability and spatial resolution of certain spatial data varies significantly at the level of countries (for example, Malta and Slovenia have bathymetric data measured by LIDAR technology, while some countries do not have these at all).

6. Measures and actions to achieve GES

33. The assessment according to the Factsheet and based on data provided by the Contracting Parties was not possible. Therefore, the following measures and activities are proposed to enable future CI 15 assessments:

1. Establishment of the national IMAP, monitoring programme that will systematically collect statistically significant data of the hydrographic parameters is required – first, to allow modelling of hydrographic alterations of the planned structures at the very local scale in the EIA/SEA and second, to provide subsequent monitoring data once the structures have been built. A close cooperation has to be established with the authorities that are responsible for planning of such structures including those

responsible for EIA. In parallel, mapping of habitats in a surrounding area that could possibly be impacted by such hydrographic alterations should be prepared (link to EO 1).

2. Creation of a digital spatial database of all data from EIA/SEA including spatial coverage and location of the intervention, existing and planned structures and marine habitats. The Copernicus Marine services, the EMODnet service and the spatial planning information system of individual countries (via WMS or WFS layers) (Baučić et al., 2022b) should be used, thus providing all necessary data for the CI 15 assessments and monitoring;
3. As the rational possibility a revision of the existing indicator Factsheet should be considered that will simplify the method to allow countries to report on the physical loss of habitats, i.e. the structures' footprint only.
4. Considerations should also be given to the possibility of proposing a set of climate change related indicators in the frame of IMAP. This could include monitoring of hydrographic parameters (e.g., salinity, temperature, waves and currents) that are changing rapidly due to climate change. The use of hydrographic parameters reported within EO 5 on eutrophication should be taken into account with the use of remote sensing and other available sources for climate change in order to determine the hydrographic alterations in the Mediterranean region. Such alterations may have much stronger impacts on marine habitats and ecosystems than those monitored by the CI 15 itself.

Ecological objective 8 – Coastal ecosystems and landscapes

Common indicator 16 “Length of coastline subject to physical disturbance due to the influence of human-made structures”

1. Key messages

1. Monitoring data was provided for 57% of the total Mediterranean coastline (31 283 km), out of which 26 658 km (85.2%) of coast is natural and 4 625 km (14.8%) is artificial. This provides a good overview of the baseline situation.
2. The majority of human-made structures belong to ports and marinas.
3. Changes in the percentage or total length of coastline subject to physical disturbance due to the influence of human-made structures could only be assessed for three countries.
4. GES could not be assessed because only the first set of monitoring data was provided (except for the three countries that provided two sets of data).

2. Background information and methodology

34. The assessment of this indicator in the 2017 Med QSR was rather subjective as no monitoring data was available at the time. The current assessment is based on the data provided by the majority of the countries and gives a good insight into the baseline status. It will be with the second set of monitoring data when changes could be assessed with regard to GES that is country-specific. A Guiding document has been prepared that includes a list of criteria which may be used by the countries when defining their GES (PAP/RAXC, 2021). It was successfully tested in Morocco (PAP/RAC, 2022).

35. The relationship with other EOs is important with relation to land sea interactions and communication between the terrestrial and marine habitats. Within the Ecological Objective 8 (EO8) there is no possibility for integration between the two indicators, i.e., land cover and the coastline, because there is no firm correlation.

36. EO 8 is focusing on the terrestrial part of the coastal areas where human activities are continuously altering coastal ecosystems and landscapes. The objective of EO 8 is to ensure that the natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved. The monitoring under EO 8 addresses coastal artificialisation: construction of buildings and infrastructure along the coastline (such as defence structures, ports and marinas, etc.) and land cover change in accordance with the Guidance factsheet (UNEP/MAP, 2019). Two CIs are established for monitoring coastal artificialisation:

1. Common indicator 16 (CI 16): Length of coastline subject to physical disturbance due to the influence of human-made structures; and
2. Candidate common indicator 25 (CCI 25): Land cover change.

37. For CI 16 data is aggregated from the national reports (seventeen out of twenty Mediterranean countries reported), while for CCI 25 the assessment was made for the Adriatic sub-region only, mainly based on open-source data.

38. The assessment of CI 16 is done for 31 283 km out of 54 992 km of total Mediterranean coastline (or 57 %) as provided by the national reports referring to various years for baseline data (2006 - 2022). Nonetheless, the aggregated baseline data shows that 15 % of the assessed coast is artificial or 8% of the total Mediterranean coastline.

39. Two sets of monitoring data were elaborated only for three countries for periods of 6 and 10 years, to observe the change. Change of artificial coast fluctuates around zero (+0.4, -1.1 and 0,1 %) when expressed as a

proportion of reference coastline length. In absolute value there is an increase of artificial coastline of 50 km in these three countries.

40. The majority of countries (17), i.e., 57% of the total coastline of the Mediterranean, provided at least one set of monitoring data. Three countries also provided the second set of monitoring data. A good overview of the baseline situation is presented, i.e., the ratio between the natural coastline and the coastline influenced by human-made structures. Changes can be assessed only with the second set of data, according to the country-specific GES that has still to be defined. As far as the length of the artificial structures the countries have used different methods. This resulted in significant differences in the lengths of the coastline and lengths of the artificial structures.

3. Drivers, pressures, state, impact, response (DPSIR)

41. Mediterranean coastal areas are particularity threatened by coastal development that modifies the coastline through the construction of buildings and infrastructure needed to sustain residential, commercial, transport and tourist activities (Table 2.1). The land, intertidal zone and near-shore estuarine and marine waters are increasingly altered by the loss and fragmentation of natural habitats and by the proliferation of a variety of built structures, such as ports, marinas, breakwaters, seawalls, jetties and pilings. These coastal human-made infrastructures cause irreversible damage to landscapes, losses in habitat and biodiversity, and strong influence on the configuration of the shoreline. Indeed, physical disturbance due to the development of artificial structures in the coastal fringe can disrupt the sediment transport, reduce the ability of the shoreline to respond to natural forcing factors, and fragment the coastal space. The modification of emerged beach and elimination of dune systems contribute to coastal erosion phenomena by lessening the beach resilience to sea storms. Coastal defence infrastructures have been implemented to solve the problem together with beach nourishment but preserving the natural shoreline system with adequate sediment transport from river has proved to be the best solution.

42. Monitoring the length of coastline subject to physical disturbance due to the influence of human-made structures and its trend is of paramount importance to preserve habitat, biodiversity and prevent coastal erosion phenomena, as well as for its importance in land-sea interactions. Until now there has not been systematic monitoring in the Mediterranean regarding this, in particular neither quantitatively based monitoring nor any major attempt to homogenously characterize coastal ecosystems on a wider Mediterranean basis.

Table 2.1: The main drivers (human activities), pressures and impacts affecting coastline subject to physical disturbance due to the influence of human-made structures

DRIVERS	PRESSURES	IMPACTS
Population growth Tourism development Maritime transport and other types of (inland) transportation Fisheries and aquaculture Demand for oil, gas, electricity, and minerals Need for protection of coastal assets	Construction of buildings and infrastructure needed to sustain residential, commercial, transport and tourist activities Construction of ports, harbours and marinas Coastal protection works (dykes, groynes, seawalls, breakwaters, piers, pilings, jetties etc.) Construction of LNG and oil terminals on the coastline	Impacts on landscape Habitat loss and fragmentation (terrestrial and marine habitats, especially in inter-tidal zones and near-shore) Loss and fragmentation of entire coastal ecosystems (dunes, wetlands, beaches) Permanent changes in configuration of coastline and bathymetry (in disposal areas). Impacts on erosion and sedimentation rates – disruption of sediment transport

		Increased turbidity and related reduction transparency and photosynthetic ability

4. GES assessment/alternative GES assessment

43. Construction of various structures along the coastlines such as ports, marinas, break walls or jetties causes irreversible damage to landscapes, losses in habitat and biodiversity and permanently changes the shoreline configuration, thus disturbing the natural dynamic of coastal zones. Even though coastline structures are sometimes introduced to reduce erosion. Thus, it is of high importance to monitor the length of coastline subject to physical disturbance by human-made structures. The monitoring aim of the CI 16 is twofold: (i) to quantify the rate and the spatial distribution of the Mediterranean coastline artificialisation and (ii) to provide a better understanding of the impact of those structures to the shoreline dynamics.

44. CI 16 monitoring entails an inventory of the length and location of human made coastline (hard coastal defence structures, ports, marinas) while soft techniques e.g., beach nourishment are not considered as artificial coastline. Monitoring data of the CI 16 are presented as:

- km of artificial coastline and % of total length of coastline;
- percentage (%) of natural coastline in the total coastline length.

45. Following the CI 16 methodology, the Contracting Parties prepared the national reports of the CI 16 assessments. The first sets of monitoring data are provided for seventeen out of twenty Mediterranean countries. By summarising the national data, a good overview of the baseline status of CI 16 is obtained for the Mediterranean level, i.e., ratio between the natural and artificial coastline. CI 16 is calculated for two periods for Italy, Spain and Malta thus first results showing trends are available, too. The Good Environmental Status (GES) for CI 16 serves to minimise physical disturbance to coastal areas induced by human activities, i.e., whether the coastline has been further developed and country's specific targets have been achieved. The definition of GES is country-specific and has not yet been defined. Therefore, the assessment will only be possible once country-specific GES are defined, and once the second set of monitoring data is provided by all countries.

46. Mediterranean countries selected reference coastlines that satisfy the required level of details. Mapping was performed with a minimum length of 10 m for natural coastline segments. Artificial coastline is further classified into six classes (breakwaters, seawall/revetments/sea dike, groins, jetties, river mouth structures, port and marinas). The first sets of data have different reference years, within 2018 – 2022 period, except for the three countries that provided the second set of data within this period. Digital data constitutes a GIS database for the Mediterranean region. The main data sources used for the CI 16 assessments were national official data, aerial orthophotos and satellite images.

47. Even though CI 16 data from national reports could be summarised to assess CI 16 on the Mediterranean level, different CI 16 national datasets cannot be compared. This is due to the fact that the national assessments were made for different reference years and with different mapping techniques and scales, caused by differences between national data sets and geographic specifics but also by different interpretation of instructions given by the methodology.

48. GES assessment based on CI 16 requires that country-specific GES, operational objectives and proposed targets should be defined for each Contracting Party. The Guidance factsheet defines GES in a general manner, as "Physical disturbance to coastal areas induced by human activities should be minimised". At this moment, seventeen Mediterranean countries have baseline data for CI 16 enabling countries to specify their GES in a more objective manner. Future sets of monitoring data will allow assessments of coastline status: whether the coastline is within GES or not and thus, operational measures should be applied. Based on the CI 16 monitoring

data, updated/new targets for GES could be specified, too. GES definition is country specific and should consider geographic, socio-economic and cultural context. International and national policies and directives should be considered too, but also characteristics of the human-man structures that can be nature based. The Guiding document (PAP/RAC, 2021) is available to assist countries to define GES.

49. CI 16 baseline data provided by countries are presented at the Mediterranean scale, summarized for the Med region (Table 2.2) and illustrated by graph (Figure 2.1) and in an overview map (Figure2.2). Natural coast occupies 26 658 km or 49% while artificial coastline 4 625 km or 8%, while 23 709 km or 43% (coastline of Cyprus, Greece, Syria and parts of Croatia) could not be assessed. Level of coastlines' details corresponds to scales of 1:2000 and thus lengths are longer than most published ones of smaller scales (due to well-known dependency of length calculations on the map scale).

Table 2.2: CI 16 baseline data for the Mediterranean Sea

	Natural coast	Artificial coast	No monitoring data *	Total length
Mediterranean Sea	26 658 km	4 625 km	23 709 km	54 992 km
	49 %	8 %	43 %	100%

*unassessed coastline length is estimated based on Open Street Data (2022) that corresponds to national coastline data with the level of details (spatial scale)

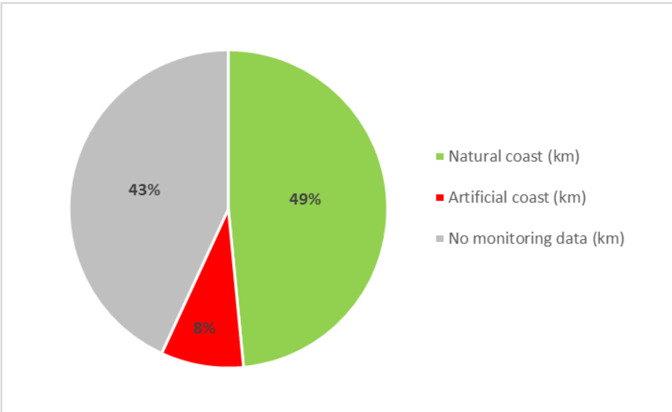


Figure 2.1: Chart with calculated percentage of CI 16 on the Mediterranean scale

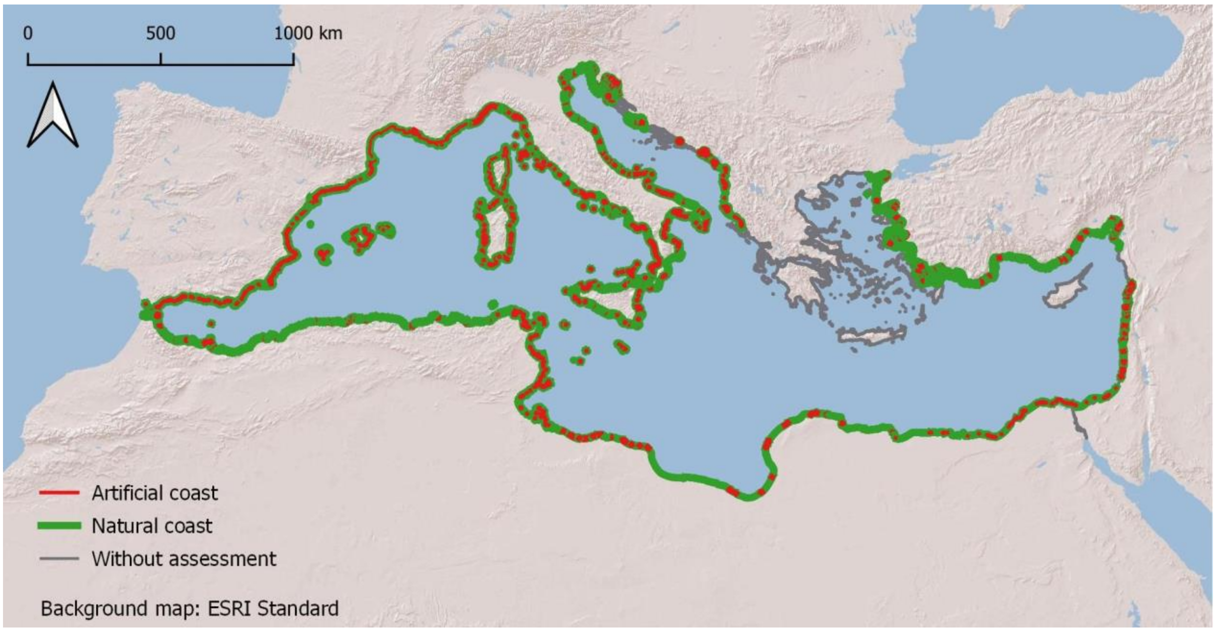


Figure 2.2: Overview map of the baseline situation for CI 16

50. Detailed baseline data at the country level is illustrated by two graphs (Figures 2.3 and 2.4)[1]. As data has various reference years, scales, mapping methods and data sources one should take these into consideration before interpreting the values, particularly if comparing data among the countries. However, in terms of proportion of artificial coastline, Slovenia stands out with 75% and Lebanon with 64%, while Libya has only 4% of artificial coastline.

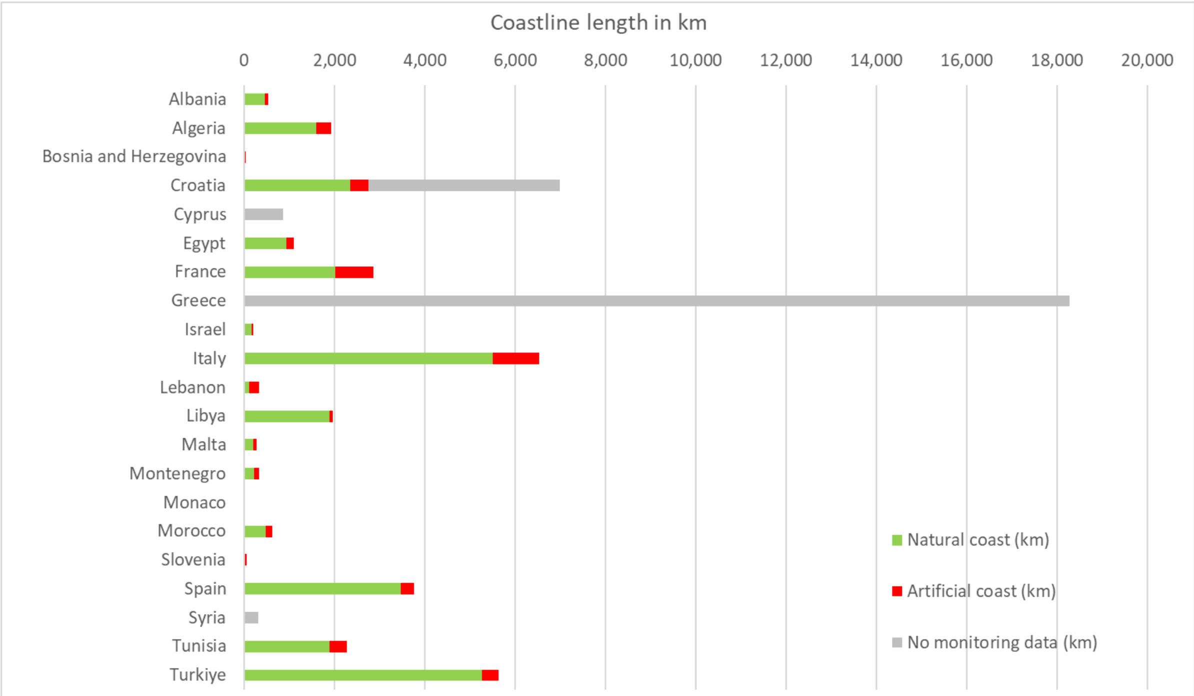


Figure 2.3: Length of natural and artificial coastline per countries in km

[1] The countries that have uploaded the data to the INFO/MAP System, i.e. validated the results through an elaborated and agreed procedure of data submission are: Algeria, Bosnia and Herzegovina, France, Italy, Libya, Malta, Montenegro, Morocco, Slovenia and Spain (status as of 2 February 2022).

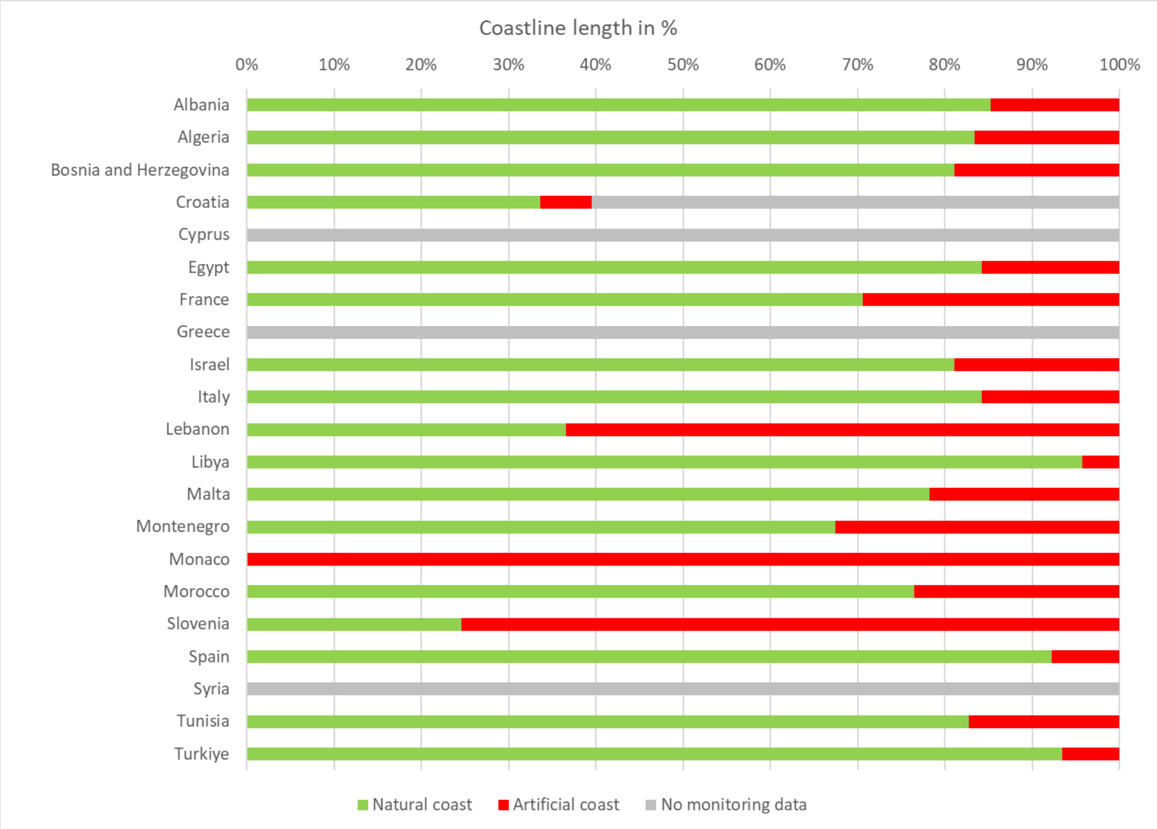


Figure 2.4: Share of natural and artificial coastline per countries in percentage

51. Artificial coastline infrastructure is further mapped showing all details of the structures and described as Breakwaters, Seawaters/Revetments/Sea dike, Groins, Jetties, River mouth structures and Port and marinas. Lengths and artificial structures' proportion of total artificial coastline are aggregated at the Mediterranean level (Table 2.3). Artificial structure of Ports and marinas dominates with 49% or 3 955 km.

Table 2.3: Artificial structures in km and in % of total artificial coastline

	Breakwaters	Seawalls/Revetments/Sea dike	Groins	Jetties	River mouth structures	Port and marinas	Unclassified	Total
Mediterranean coast	918 km	1 625 km	392 km	567 km	193 km	3 955 km	457 km	8 107 km
	11%	20%	5%	7%	2%	49%	6%	

Note: There are significant differences between countries on the interpretation of the methodology when measuring the length of the artificial structures. Some countries have followed the methodology provided in the Guiding Factsheet and reported the projection of the artificial structure to the coastline. But others (such as Italy, Spain, Egypt) reported the total length of the structures. See Figure 2.5 below.

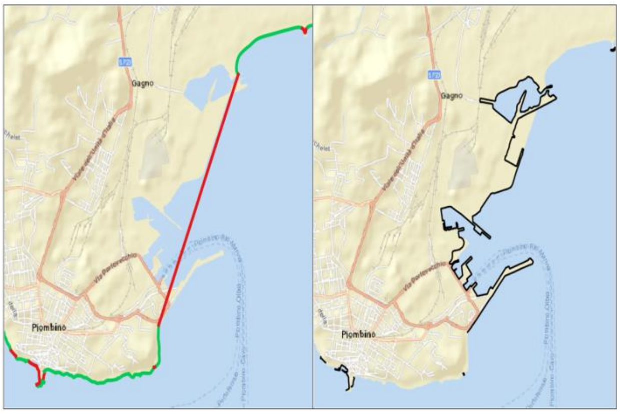


Figure 2.5: Different methods used for monitoring the length of the artificial structures.

52. Only three countries provided two sets of monitoring data for CI 16. Therefore, the assessment of changes in the coastline is given for Italy, Malta and Spain (Table 2.4). Change of artificial coast fluctuates around zero when expressed in percentage of reference coastline length. In absolute value there is an increase of artificial coastline of 50 km in these three countries.

Table 2.4: Artificial coastline change in km and in % of total coastline

Italy	Malta	Spain
Trend 2006-2012	Trend 2012-2018	Trend 2011-2022
+23.51 km +0.36%	+1.71 km -1.14% *	+2.43 km +0.06%

*Difference due to different data sources (maps with different resolution and different levels of detail).

5. Key findings

53. Aggregation of national assessments for CI 16 parameters for the Mediterranean reported here provides the first set of monitoring data. CI 16 assessments are provided for 57% of the Mediterranean coastline or 31 283 km out of which 14.8% or 4,625 km revealed as artificial coast. The proportion (percentage) of artificial coast vary a lot among countries: from 4% to 75% which clearly demonstrates the necessity for country specific GES definitions in terms of percentages or thresholds. Looking at the length of artificial structures, their length is 8 109 km of which 49% have maritime use as ports and marinas (as structures are mapped with all details, they have much longer length then artificial coast itself. See Figure 2.5 above). Looking at the trend, even for only three countries, there is a slight increase of artificial coast in percentage terms. Still, in a monitoring period of 6 or 10 years, it amounted to a total of 50 km.

54. It should be emphasised that there are well-known difficulties in unambiguously defining the coastline and its length. A coastline is a geographical feature that can change significantly over time, and its length significantly depends on the level of detail with which the coastline is depicted. Additionally, the national assessments were made for different reference years and with different mapping techniques, caused by different national data sets and geographic specifics, but also by different interpretation of instructions given in the Guidance factsheet (UNEP/MAP, 2019) and related Data Dictionaries and Data Standard (UNEP/MAP, 2019a). Thus, countries' data cannot be completely compared. However, applying the same criteria as provided at the regional level to ensure synchronization of national efforts to set GES and threshold, and therefore, to prevent biased treatment of countries within regional assessment. will allow a more objective assessment of trends once the second monitoring datasets are provided for the next QSR. The GES in the Guidance Factsheet is defined in a descriptive manner as minimised physical disturbance (negative impacts) to coastal areas induced by human activities.

Future sets of monitoring data will allow more objective assessments of coastline status: whether it has been further artificialised or it has stayed within GES. This need for a systematic monitoring in Mediterranean regarding the physical disturbance of coastline due to the influence of human-made structures was also a major conclusion in the 2017 QSR.

6. Measures and actions to achieve GES

55. While analysing and aggregating the CI 16 data received from the countries, several challenges in mapping and interpretation of CI 16 results were observed.

56. First, technical issues that have to be considered in future monitoring and assessments of CI 16 are as follows:

1. Monitoring of the coastline (second and following assessments) should use the same level of details and spatial resolution as the initial assessment (baseline data). Otherwise, monitoring results could be compromised by the fact that coastline length increases by using larger scales, more so on more indented coasts.
2. The calculation of the length of the coastline varies also due to deformations caused by the choice of the cartographic projection (i.e., calculated in plane by using one of the cartographic projection or by using the ellipsoid). It is recommended to use the ellipsoid lengths calculated on WGS84 as required by the Guidance Factsheet and related Data Dictionaries and Data standards.
3. Methods of mapping coastline vary between the national reports which results in semantic differences of assessed CI 16, in particular with regard to mapping of the length of artificial structures. This should be taken into account while interpreting aggregate data for the Mediterranean. Classification of artificial structures should be unambiguous, regardless of the monitoring period, country or the method used (visual inspection of aerial images or field survey). A manual that will elaborate on various situations should be prepared so that interpretation is unambiguous, i.e., harmonised.

57. Second, measures and actions to achieve GES include:

1. The country-specific GES should be defined based on the first set of monitoring data in order to allow assessment of changes for the next QSR. Country specificities could significantly affect the assessment, i.e., interpretation of calculated CI 16. Therefore, issues such as the following need to be taken into account. For example, a country with a significant length of coastline on uninhabited islands, islets and rocks and with a small proportion of artificial coast can be interpreted as a very good condition, while in fact there is a lot of construction on the mainland part of the coast. Another issue is the total length of the coastline per country. If a country has a short coastline than it is expected that the proportion of the artificial coastline will be larger to provide facilities for all human coastal and maritime activities. When defining GES thresholds, these should be considered; i.e., different thresholds could be defined for different parts of coastline. For the definition of country specific GES, the list of assessment criteria and the Guiding document prepared by PAP/RAC can be utilised (PAP/RAC, 2021), including the results of testing the Guiding document in Morocco (PAP/RAC, 2022).

58. Also, measures and actions to achieve GES should be specified and may, in general, include the following three types:

- Particular management actions needed in order to move towards GES;
- Measures aimed at obtaining new knowledge for assessing and achieving GES (e.g., scientific research, application of innovative solutions at pilot locations);
- Measures with the aim of disseminating knowledge to all stakeholders and involving them in defining measures and actions for achieving GES.

59. Particular management actions regarding coastline artificialisation could include:

- Analysis of existing artificial coastlines and their categorization into those that are necessary, those that can be reduced and those that can be returned to nature (e.g., abandoned jetties, etc.).
- When planning new artificial structures on the coastline, first analyse whether human needs can be achieved through better management of existing artificial structures and their functional transformations.
- Along existing artificial coastlines: improve monitoring of environmental impacts and implement measures to reduce negative impacts (such as pollution, habitat fragmentation, noise, light pollution, water cycle).
- For new artificial coastlines, examine the use of nature-based solutions and ensure financial or other benefits for their implementation.
- Encouraging the use of coastline in a way that consumes spatial/natural resources as little as possible: e.g., restricting land-take for the second homes.
- Protect, restore, conserve and enhance threatened and degraded coastal habitats.

60. Results of above measures and actions could be measured by km of reversed coastline (from artificial to natural), km of recovered coastal habitats, % of nature-based solutions used in e.g., coastal protection, number of innovative projects tested (e.g., beach nourishments without impacts on coastal habitats), number of people involved in GES awareness, number of people actively working on the measures, etc.

Candidate Common Indicator 25 “Land cover change”

1. Key messages

61. The assessment of CCI 25 in the Adriatic sub-region (coastal zone of 10 km width) shows that:

1. In 2018 the built-up areas occupy 8.77% (2 500 km^2) of the Adriatic coastal zone. The largest land cover change from 2012 is the increase of the built-up area by 27 km^2 representing a land take trend of 1% in six years.
2. In the 2012-2018 period the land cover changed from forest and semi-natural land (24 km^2), water bodies (3 km^2) and agricultural land (2 km^2) to built-up (27 km^2) and wetlands (2 km^2).
3. In 2018 the narrowest coastal strip of 300 m has the highest share of built-up area (18%), more than twice as much as in the coastal zone of 10 km width. The increase in the narrowest coastal strip between 2012-2018 is 4.4 km^2 while in the 300 m-1km coastal strip the increase is 3.5km^2, mainly at the expense of the decrease of forests and semi-natural land, as well as water bodies and wetlands.
4. There are no countries with a decrease of the built-up areas in the reporting period.
5. Protected areas covered 20% in 2012, reaching 37% in 2018.
6. The low elevation coastal zone (up to 5 m above sea level) occupies 17% (4 955 km^2) of the coastal zone (10 km width), of which the built-up areas is 10% (484 km^2).

2. Background information and methodology

62. Good environmental status for CCI 25 is specified in the Guidance Factsheet (UNEP/MAP, 2019) as “Linear coastal development minimised, with perpendicular development being in balance with integrity and diversity of coastal ecosystems and landscapes. Mixed land-use structure achieved in predominantly human-made coastal landscapes”.

63. The assessment of the CCI 25 Land cover change was prepared for the Adriatic sub-region. It serves as an example on how the assessment of this indicator could be prepared for the entire Mediterranean coastal region once data is available for the next QSR and once the CCI 25 is designated as a mandatory IMAP Common indicator.

64. CCI 25 monitoring entails an inventory of the land cover change in the coastal zone (10 km belt from the coastline, following the practice of the European Environment Agency). The coastal zone is further divided into reporting units by coastal strips (<300 m, 300 m-1 km, 1-10 km from the coastline), Low Elevation Coastal Zone (LECZ) and coastal administrative units. CCI 25 units for the first monitoring (i.e., establishing the baseline) are the following:

- km^2 of built-up area in coastal zone;
- % of built-up area in coastal zone;
- % of other land cover classes in coastal zone;
- % of built-up area within coastal strips of different width compared to wider coastal units;
- % of other land cover classes within coastal strips of different width compared to wider coastal units;
- km^2 of protected areas within coastal strips of different width;
- km^2 of LECZ in coastal zone;
- km^2 of built-up area within LECZ in coastal zone;
- % of built-up area within LECZ in coastal zone;
- % of other land cover classes within LECZ in coastal zone;
- Km^2 of protected areas within LECZ in coastal zone.

65. For the second monitoring (i.e., assessment of change) the following units are relevant:

- % of increase of built-up area, or land take;
- % of change of other land cover classes;
- % of change of protected areas;
- % of increase of built-up area, or land take within LECZ;

- % of change of other land cover classes within LECZ;
- % of change of protected areas within LECZ.

66. The Candidate CI 25 has been assessed for the Adriatic sub-region of the Mediterranean based on open-source data from the Copernicus Land Monitoring – Coastal zones service, OpenStreetMap, World Database on Protected Areas, and Forest and Buildings removed Copernicus DEM (FABDEM) global elevation map for 2012 and 2018. All data retrieved per countries from the open-sources are available at the following link: https://gradsthr-my.sharepoint.com/:f:/g/personal/fgilic_gradst_hr/EvYZM0_maehAp7TqhRFWj54BV8-qtEfS6kcGfHON4PVBog_(Password: IMAP#2023). Coastal urbanisation or land take is almost an irreversible process. Therefore, the CCI 25 indicator provides, among other indications, an inventory of the urbanisation pressures on coastal ecosystems but also reveals changes between land cover classes. With an additional assessment of these processes within the Low Elevation Coastal Zone (LECZ), i.e., the zone below the elevation of 5 m above sea level, important findings related to adaptation to climate change are provided. The calculation of data and analysis has been prepared by PAP/RAC by using the above-mentioned sources, therefore countries have not provided their own assessments. The draft report (Baučić M. et al 2022 b) was discussed with the Adriatic countries at the meeting in Tunis on 10 November 2022. Upgraded with the LECZ it represents the main input to this QSR.

67. Due to the candidate status of indicator 25 on land cover change it was not included in the 2017 Med QSR. So, it is now for the first time that this indicator is presented; however, it still at the sub-regional scale (Adriatic Sea) where data was available from the open sources.

68. EO8 integration between CI 16 and CCI 25
For the purpose of integration of CIs within EO8 the question of correlation between the CI 16 on coastline and CCI 25 on coastal land cover has been studied, particularly between the land used by human activities and related artificial coastline. Typical situations that can be observed along the Adriatic coast vary from situations with strong correlation (in front of settlement there is the artificial coast) to situations of no correlation (natural beaches in front of a settlement). It can be concluded that there is no firm correlation between land cover and the type of the coastline.

3. Drivers, pressures, state, impact, response (DPSIR)

69. Coastal zones, arguably the most appealing assets of the Adriatic, are exposed to significant pressures from urban development, land-based and marine pollution, fishing, aquaculture, tourism, damming, extraction of materials, and marine biological invasions (Table 3.1). Climate change, and especially sea level rise, is expected to significantly increase pressures on coastal zones. In particular, many coastal systems will experience increased inundations and storm flooding, accelerated coastal erosion, saltwater intrusion in groundwater, displacement of coastal lowlands and wetlands, encroachment of tidal waters into estuaries and river systems. More frequent and severe weather and climatic events will further enhance these phenomena, while in the longer term, changes in wind and wave patterns could interfere with sediment transport leading to greater erosion or accretion.

70. Identifying and understanding the processes of land cover change (i.e., how land cover has been changed by humans and the processes that result in landscape transformation) is especially relevant for critical and vulnerable areas such as coastal zones, where several competitive uses are pressing. In this context urbanisation, or land take, is the most dramatic change given the (almost) irreversibility of the process. The associated impacts could be listed as follows:

- Habitat loss with the associated impact on related ecosystem functions like C sequestration, regulation of water cycle, or biomass production.
- Fragmentation. The division of natural habitats in smaller parcels contributes to the isolation of number of species and also compromises its viability.

71. Adriatic coastal areas are threatened by coastal development that modifies the coastline through the construction of buildings and infrastructure needed to sustain residential, tourism, commercial, and transport activities. Coastal human-made infrastructures cause irreversible damage to landscapes; habitats and biodiversity; and shoreline configuration by disrupting the sediment transport. The Adriatic is a tourism destination in terms of both international and domestic tourism: tourism revenues, which are considered as a proxy for tourism activity, grew in the last years before the COVID-19 pandemic in all Adriatic countries. Coastal urban expansion (indicatively new buildings/hotels, marinas by the coast) to accommodate higher flows of residents and tourists, affects habitats in both land and coastal ecosystems and, therefore, biodiversity (UNEP/MAP, 2022). Coastal tourism represents many of the problems associated with uncontrolled human activities such as linear and coastal urbanization, consuming the precious but very limited resource of coastal areas while compromising ecosystem integrity; and land degradation, biodiversity losses and a decrease of the aesthetic value of landscapes. Since impacts are dependent on the scale and pace of changes it is important to consider these aspects when monitoring land cover changes

72. The size of the agricultural sector in the Adriatic countries is strongly related with the impact in the ecosystem of each identified activity. It appears that the Adriatic economies have a moderate to strong developed primary sector. As per Eurostat's data, the primary sector of Albania represents around 21.6% of the national GDP, followed by Montenegro (9.9%), Croatia (3.9%) and Italy (2.2%). Agriculture and the river alterations do also affect the natural habitats in several ways. Infrastructure development (such as dams and dikes), use of water channels for irrigation (or pipes) are among the core drivers of habitats' deterioration and of relevant ecosystem services. This affects not only landward-inward ecosystems but coastal areas and aquatic ecosystems as well. Conversion from forest to agricultural use results in habitat loss, habitat fragmentation and, consequently, loss of biodiversity. There is also a decrease on the degree of soil coverage by vegetation which in turn determines the risk of erosion. Also, this type of change results in a net loss of soil carbon.

73. Again, the magnitude of this indicator is related to the size of the agricultural sector in the Adriatic countries. Climate change is expected to accelerate habitats' deterioration as temperature increase (and all linked extreme weather events) affects ecosystems and species directly. Land alterations in the agricultural sector derive from several activities (movement of soil for cultivation purposes and irrigation, development of infrastructure such as agricultural roads), tillage and use of heavy machinery. Several of the above geomorphological changes are affecting the characteristics of the habitats and lead to biodiversity loss in the land ecosystems (UNEP/MAP, 2022).

74. The Industrial sector differs significantly among the Adriatic countries as does the level of efficiency in the several production processes noted. The Industry of several Adriatic countries relies on mining processes and extraction of natural resources (such as metals and timber). Mining activity has a significant environmental impact since the extraction of resources leads to changes in the landscape. Other manufacturing processes, such as those of plastics and chemicals require large areas where the production units are installed and operated. Based on the above, land occupation and loss of land appears to be a possible State impacting the habitats characteristics, especially in those countries where mining and activities of similar impact is intense (UNEP/MAP, 2022).

75. Conversion from agriculture to semi-natural areas strongly depends on the conditions at the time of abandonment. If conditions are favourable, land abandonment can lead to a recovery of natural vegetation. However, in case of unfavourable conditions like low vegetation coverage and/or steep slope, agricultural abandonment could lead to further land degradation.

76. Conversion from agricultural land to forest (forestation) involves tree plantation and has a positive impact on land stability by increasing the vegetation cover of the soil and the increase of carbon sequestration. In terms of biodiversity, it strongly depends on the species used for plantation. Native species definitely increase diversity and connectivity.

Table 3.1: the main drivers (human activities), pressures and impacts affecting land-use

Economic **Driver**	**Pressure**	**Impact** (ecosystem)
Population growth and tourism development	Urban development	Fragmentation of ecosystems/habitats, physical loss of habitats, Loss of coastline, diminished integrity of coastal landscapes and ecosystems, Land-sea interface deteriorated, Soil, habitats and coastal forests Loss, Physical loss
Agriculture (crop)	Hydrological alterations	Habitats deterioration
	Geomorphological changes	Loss of biodiversity, Species threatened, Natural resources affected Landscape visual impairment
	Land use	Loss of biodiversity/ Population (species) decreases/unification of landscape patterns
	Wetlands use	Flooding vulnerability
Industry	Land use	Habitats deterioration Landscape/ecosystem fragmentation
	Landfills	Habitats loss
	Land artificialisation	Loss of biodiversity/ Population (species) decreases
Infrastructure, energy facilities, ports and maritime works and structures	Transport (roads, highways)	Habitats deterioration/loss Fragmentation of ecosystems/habitats, diminished integrity of coastal landscapes and ecosystems
	Land artificialization	Ecological fragmentation of the territory and forestry loss

4. GES assessment / alternative GES assessment

77. The main objective of monitoring the processes related to land cover change is to maintain the natural dynamics of coastal areas and to preserve coastal ecosystems and landscapes. Urbanisation or land take is an almost irreversible process that alters integrity of coastal ecosystems and landscapes. To this end, the CCI 25 indicator provides, among other indications, an inventory of the urbanisation pressures on coastal ecosystems. Balanced allocation of uses, preserving open coastal space, securing setback zones, avoiding urban sprawl by limiting linear extension of urban development and securing ecosystem health, are the most important objectives of the ICZM Protocol. In the context of climate change, the pressures on the coastal ecosystems are becoming more complex particularly in low-lying coastal areas that are under increased risks of coastal flooding and related indirect impacts such as pollution of coastal waters, erosion and salinization. Therefore, the CCI 25 reports also on urbanisation processes in low-lying coastal areas that are under major impacts of climate change. The Low Elevation Coastal Zone (LECZ) is added as an analytical unit representing an area contiguous to the coast, within the coastal zone and below elevation threshold of 5 m above sea level. In this way the information generated with this indicator will allow multiple analyses and synergies, such as about the evolution of coastal zones, mainly within the most impacted areas by climate change. In practice the CCI 25 parameters can identify: (i) where urbanisation pressures are higher (by extent of change and by pace of the process); (ii) spatial trends (along the coast and landwards and in low-lying coastal terrain); and (iii) areas for priority action.

78. The CCI 25 parameters are calculated based on open-source data: Copernicus Land Monitoring – Coastal zones service, OpenStreetMap, World Database on Protected Areas and FABDEM global elevation map. The use of that data is validated in (Baučić et al 2022a) as fitting the CCI 25 requirements from the Guidance factsheet (UNEP/MAP, 2019). The initial monitoring year is 2012 (baseline), and the second one is 2018 thus showing land cover changes within 6 years. As new global land cover data are emerging monthly - having better and better spatial, thematic and temporal resolution, land cover monitoring is becoming feasible globally.

79. At this moment, assessment of change can only be made by referring to the rather general GES defined in the Guidance Factsheet. This would mean that a positive change is the case when land cover class changes from built-up to semi-natural or there is an increase in protected areas, and as negative the increase of built-up areas. However, assessment of GES specified in the Guidance Factsheet "Linear coastal development minimised, with perpendicular development being in balance with integrity and diversity of coastal ecosystems and landscapes. Mixed land-use structure achieved in predominantly human-made coastal landscapes" is defined rather subjectively at the moment. Therefore, as a first step, guidelines could be prepared to allow more objective assessment of land cover changes. In this way, the focus of GES assessment could be for specific areas with significant increases of built-up areas (fragmentation of habitats, mono-cultural production of crops, loss of green corridors, soil artificialization, reduction of hedges, trees etc).

80. The first step of the assessment of CCI 25 parameters for the Adriatic Sea sub-region was the preparation of the baseline data for the year 2012 that encompass the coastal zone of 10 km width. The coastal zone in the Adriatic sub-region covers 28 491 km^2. Forest and semi-natural land dominate in the coastal zone with 51% (14 664 km^2) followed by agriculture with 34% (9 575 km^2). The built-up areas occupied 9% (2 500 km^2) of the coastal zone in 2012.

81. The next step was the preparation of CCI 25 parameters for 2018 and for the same coastal zone of 10 km width. This was followed by the comparison of land cover classes between 2012 and 2018 that revealed land cover changes. In the coastal zone of the Adriatic sub-region (0-10 km), the largest change is the increase of the built-up area by 27 km^2 and in the decrease of the forest and semi-natural land by 24 km^2. In absolute values, the largest increase of built-up area occurred in Italy (10.5 km^2), and without change (0 km^2) in Slovenia. There are no countries with decreases of built-up areas. In relative values, the largest increase of built-up areas comparing with year 2012 occurred in Bosnia and Herzegovina (6%) and Montenegro (4%). An overview map (Figure 3.1) shows land cover changes (red colour) and coastal zone of the Adriatic sub-region (light blue).

82. Table 3.2 provides data in km^2 and in % where negative values mean decrease and positive values mean increase in surface. The built-up areas have increased by 1.19 % in the coastal strip 0-300m. Looking at the percentage of built-up relative to the area of the coastal strip (Table 3.3), the narrowest coastal strip is again under the highest pressure.

Table 3.2: Land cover change from year 2012 to 2018 in km^2 and percentage for coastal strips

	Change in km^2				Change in percentage (2018 - 2012)/2012			
	Coastal strips			Coastal zone	Coastal strips			Coastal zone
2012-2018	**0-300 m**	**300 m -1 km**	**1-10 km**	**0 m -10 km**	**0-300 m**	**300 m - 1km**	**1-10 km**	**0m -10km**
Built-up areas	4.37	3.49	18.92	26.79	1.19%	0.78%	1.12%	1.07%
Agricultural land	0.10	0.50	-2.09	-1.50	0.07%	0.09%	-0.02%	-0.02%
Forest and semi-natural land	-2.15	-3.94	-18.01	-24.10	-0.15%	-0.20%	-0.16%	-0.16%

	Change in km^2				Change in percentage (2018 - 2012)/2012			
	Coastal strips			Coastal zone	Coastal strips			Coastal zone
2012-2018	**0-300 m**	**300 m -1 km**	**1-10 km**	**0 m -10 km**	**0-300 m**	**300 m - 1km**	**1-10 km**	**0m -10km**
Water bodies	-2.17	0.05	-0.85	-2.98	-2.86%	0.04%	-0.07%	-0.22%
Wetlands	-0.15	-0.09	2.03	1.79	-0.45%	-0.13%	0.63%	0.42%

Table 3.3: Landcover change from year 2012 to 2018 in km^2 and percentage for coastal strips

		Percentage of built-up area in coastal strip relative to total area of coastal strip		
2012-2018	**Coastal strips**	**2012**	**2018**	**2018-2012**
	0-300 m	18.12%	18.33%	0.21%
	300 m-1 km	13.95%	14.06%	0.11%
	1-10 km	7.24%	7.32%	0.08%
Total Coastal zone	0-10 km	8.77%	8.87%	0.09%

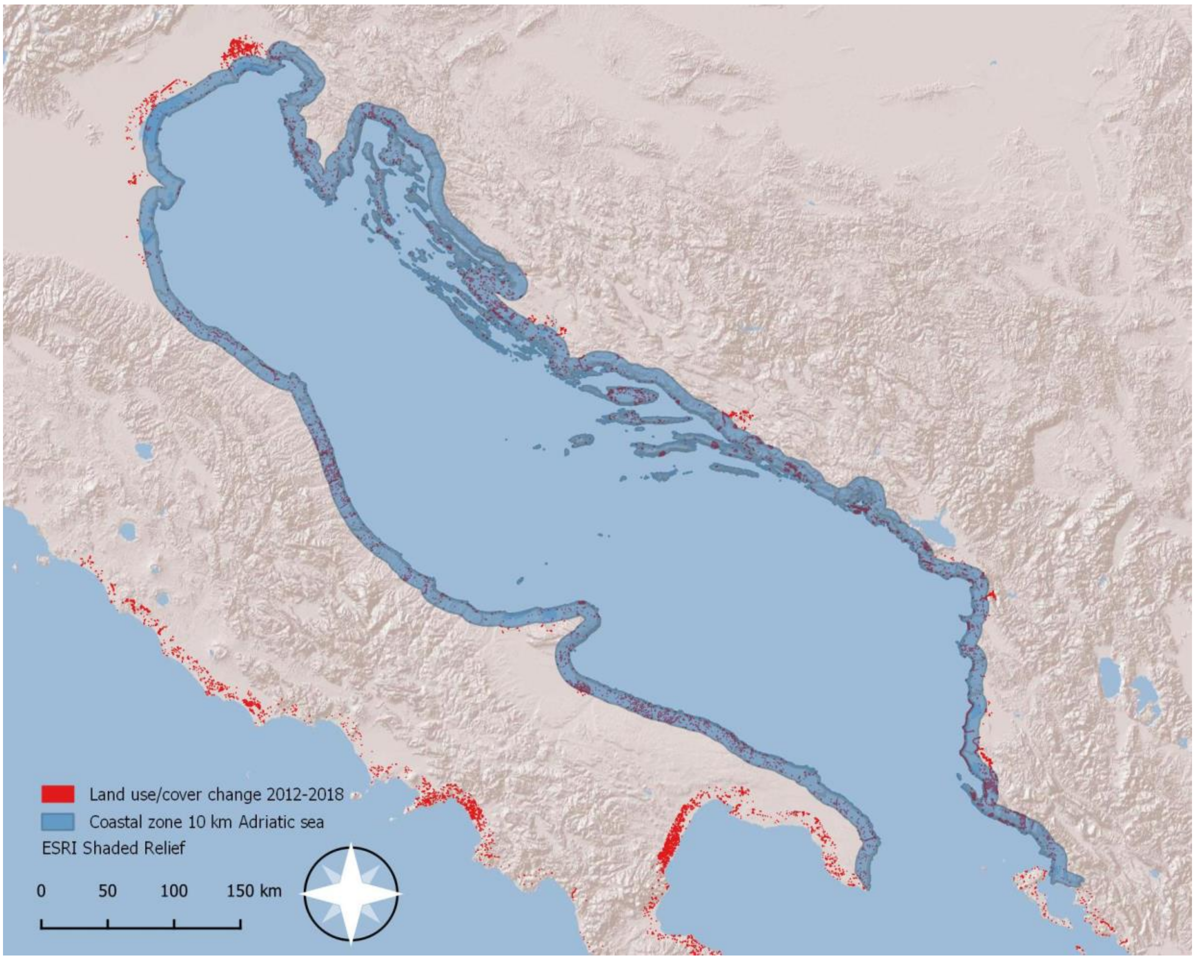


Figure 3.1: Adriatic sub-region Land cover change 2012 to 2018 for coastal zone (0 – 10 km)

83. Figure 3.2. illustrates land cover change in km^2 on country level for coastal zone (0 – 10 km). In Croatia, there is an increase of agricultural land for 10 km^2 and decrease of forests and semi-natural areas for 16 km^2 in the coastal zone. A more detailed (zoom-in) is illustrated as an example in Figure 3.3.

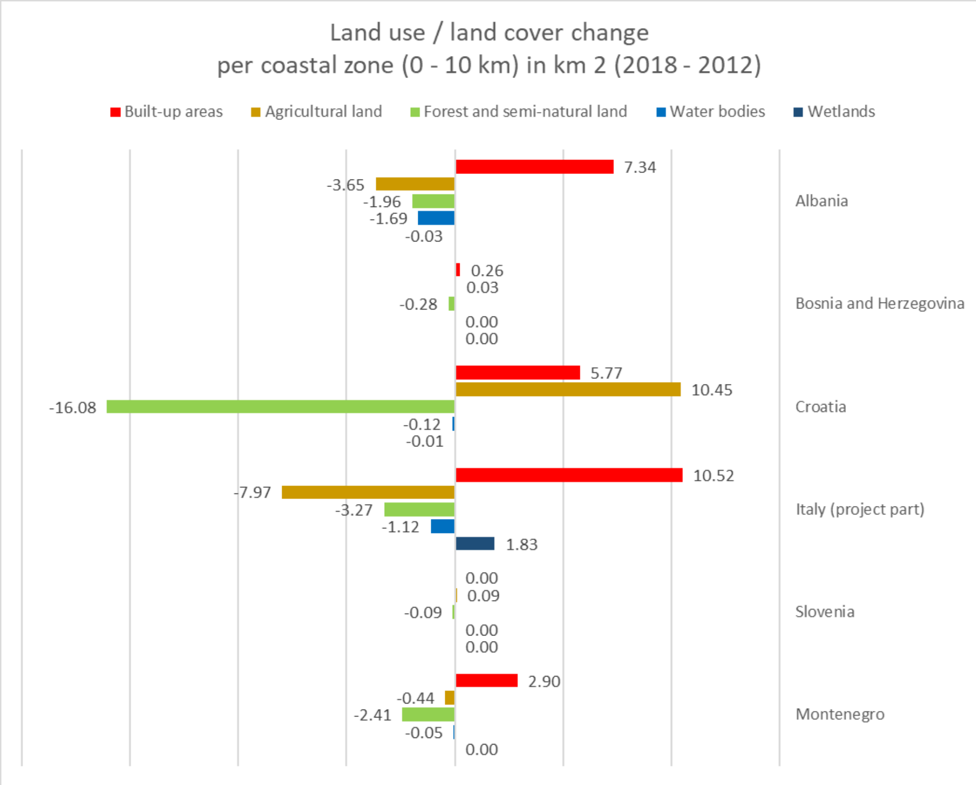
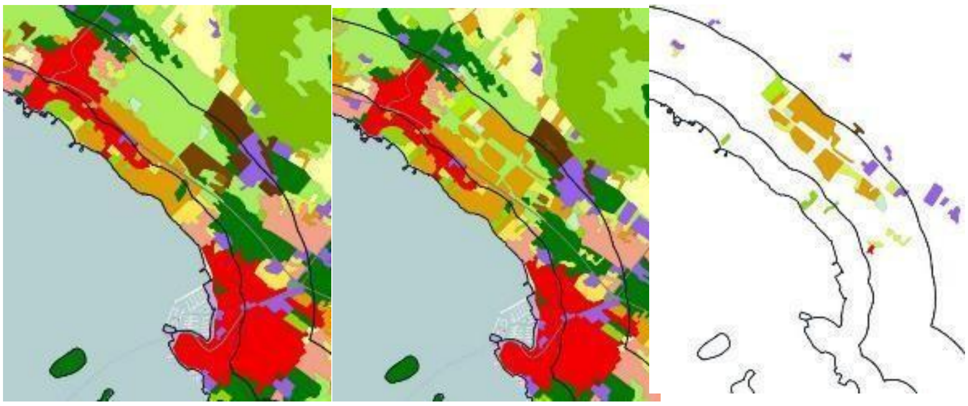


Figure 3.2: Land cover change in km^2 from year 2012 to 2018 on country level for coastal zone (0 – 10 km)



a) 2012 b) 2018 c) Change 2012 -2018

Figure 3.3: Change in land cover classes (area of Biograd na moru in Croatia)

84. Figure 3.4. illustrates land-take in km^2 (increase of built-up areas) from year 2012 to 2018 per coastal strips on country level. Looking at the distribution of land-take among the coastal strips, in Croatia, followed by Albania the narrower coastal strip (by absolute area the smallest among other coastal strips), has the largest amount of land-take. This clearly identifies that urban sprawl is located at the nearest vicinity to the coastline e.g., 0-300 m and that the Article 8 of the ICZM Protocol on the setback zone should be better respected. In Albania, Italy and Montenegro, the coastal strips 1-10 km have the largest land-take meaning that majority of urban areas have not been constructed in the narrow strip along the coastline.

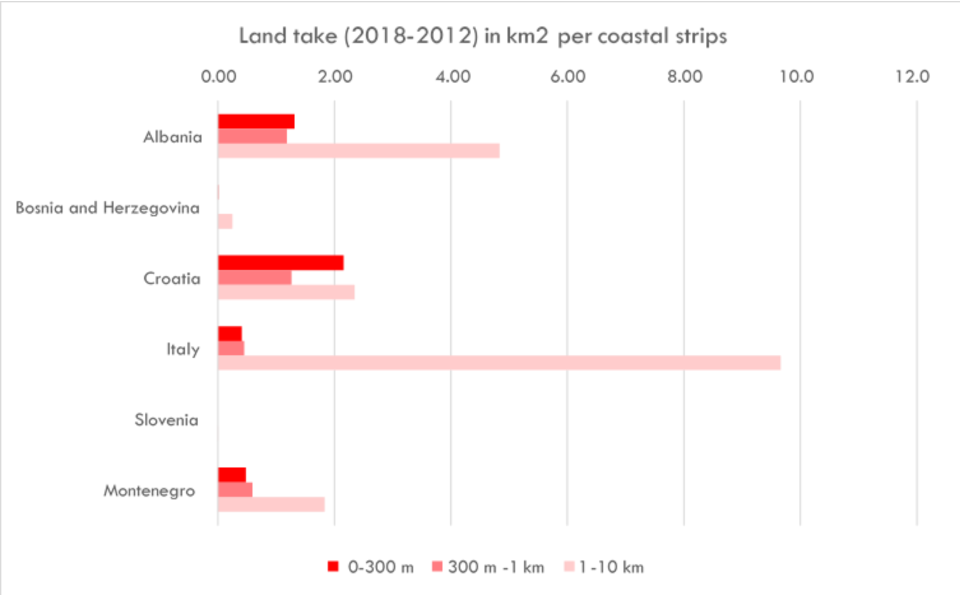


Figure 3.4: Land take (increase of built-up areas) from year 2012 to 2018 per coastal strip

85. A parameter on terrestrial protected areas has been assessed for the same period as well. The baseline situation was first carried out for the Adriatic sub-region for 2012. It shows that in the coastal zone of 10 km width there were 5 772 km^2 of protected area or 20% of the total area. Percentages of protected areas in all coastal strips are around 20% Croatia has the largest protected area in the narrowest coastal strip of 300m (252 km^2), more than all the other countries combined. Regarding the widest coastal strip 1-10 km, the most areas are located in Italy (2 122 km^2). The country with the largest share of protected areas relative to country's size is Slovenia (63% in coastal strip 1-10 km). Also, protected areas in Albania in the 300m – 1km coastal strip take almost half of the area.

86. The same calculation was carried out for 2018 and with comparison to 2012 it shows an increase of protected areas for 4 734 km^2 which is almost double (Figure 3.5).

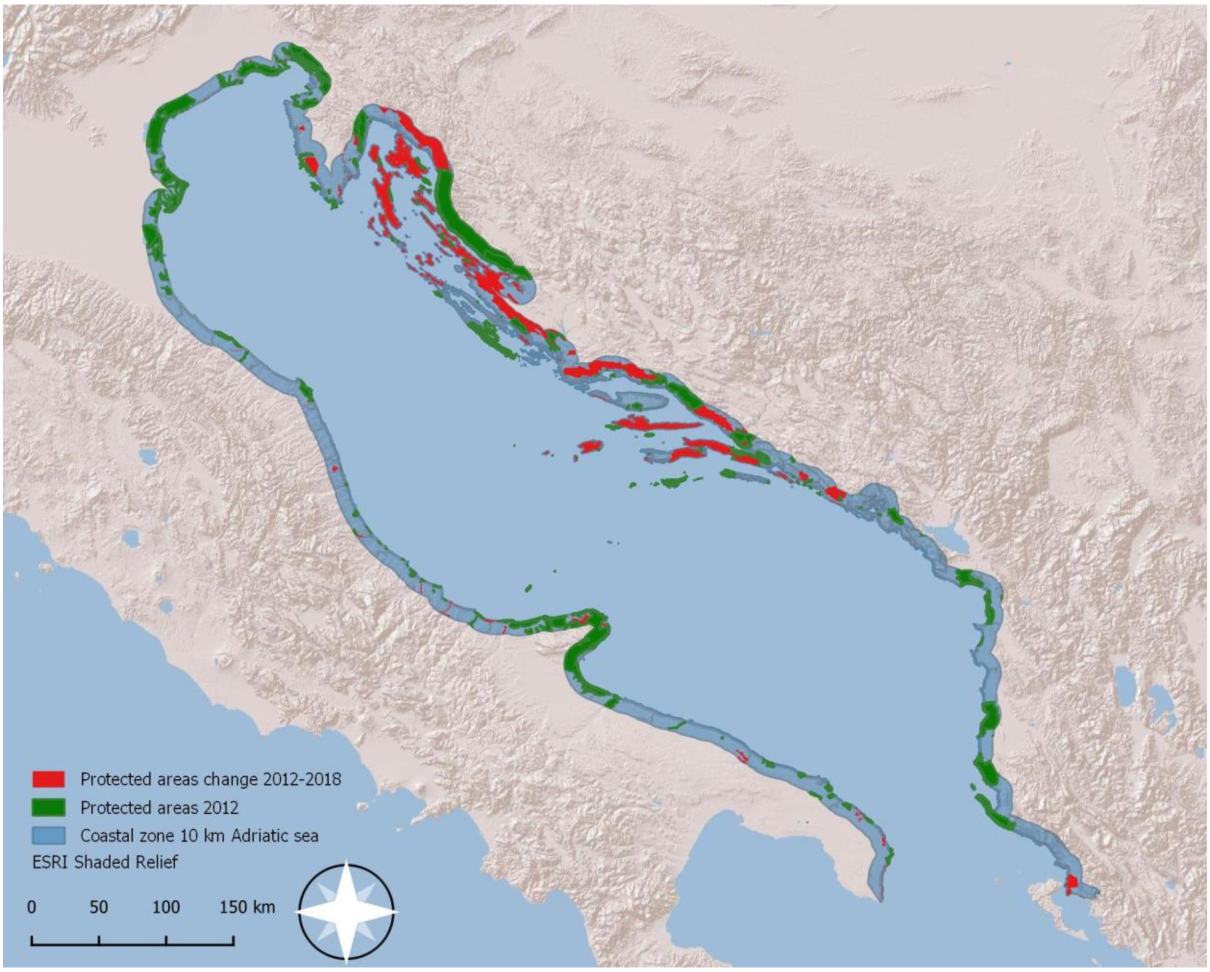


Figure 3.5: Increase of terrestrial protected areas 2012-2018 (in red)

87. The largest increase of protected area occurred in Croatia with a change of 4 400 km^2 in the coastal strip 1-10 km due to joining to NATURA 2000 network. In all countries the change is positive, meaning that the countries increased their protected areas.

88. An assessment of land cover change from 2012 to 2018 within terrestrial protected areas shows an increase of built-up areas of 2.48 km^2 out of which 1.48 km^2 in Croatia, mainly in the narrowest coastal strip 0-300 m. It is not a significant increase because it represents 1% of built-up land in protected areas relative to built-up in 2012. Bosnia and Herzegovina and Montenegro have no recorded land-take within protected areas.

Areas with highest risk to be impacted by flooding

89. Most parts of north-west and south-east coasts of the Adriatic sub-region are relatively flat (Figure 3.6). LECZ in those areas extends deep inland and, in some places, even deeper than the width of the coastal zone of 10 km. The first assessment of the Low Elevation Coastal Zone (LECZ) reveals that in the coastal zone of 10 km width there are 4 955 km^2 of low-lying terrain (up to 5m above sea level and contiguous to the coastline). This is a significant surface as it represents 17% of the coastal zone, and it reaches 24% in the narrowest coastal strip of 300 m width.

Figure 3.6: LECZ of the Adriatic sub-region

90. Almost half (47%) of this low-lying terrain is agricultural land (2 317 km²). Built-up areas occupy 10% (484 km²) of the LECZ (Figure 3.7). Both are under high risks of negative impacts by coastal flooding.

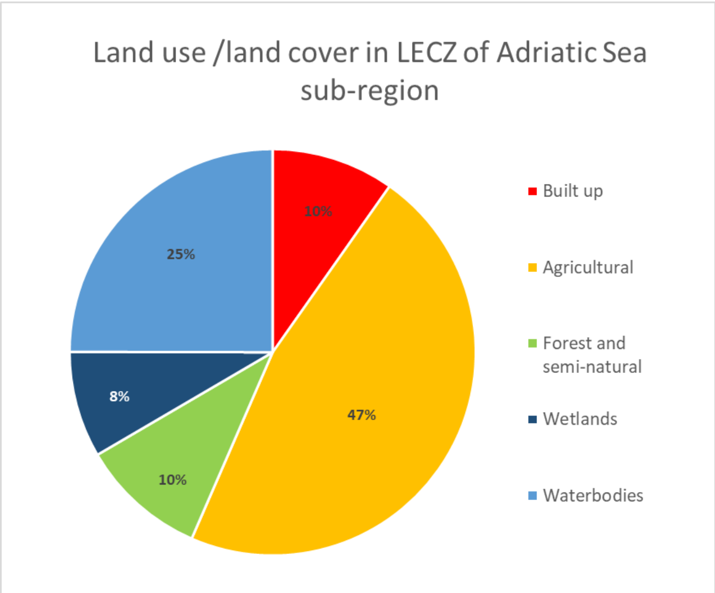


Figure 3.7: Land cover classes in LECZ and their percentage

91. Figure 3.8 provides land cover data in LECZ on county level expressed in percentages. In absolute values, the most built-up land in LECZ is located in Italy (341 km^2), and in relative values per country the largest share of built-up in LECZ is located in Slovenia (34 %).

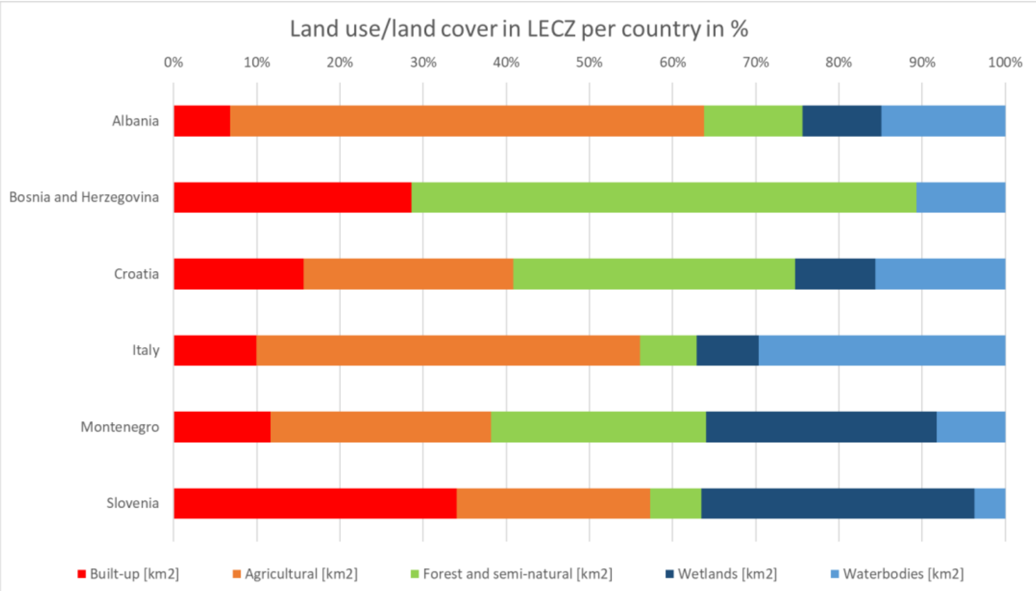


Figure 3.8: Land cover classes in the LECZ per country in percentage

92. The spatial distribution of low-lying built-up areas within coastal strips is illustrated in Figure 3.9. In Croatia and in Italy, low-lying built-up areas are dominantly located in the narrowest coastal strip what multiplies climate change risks.

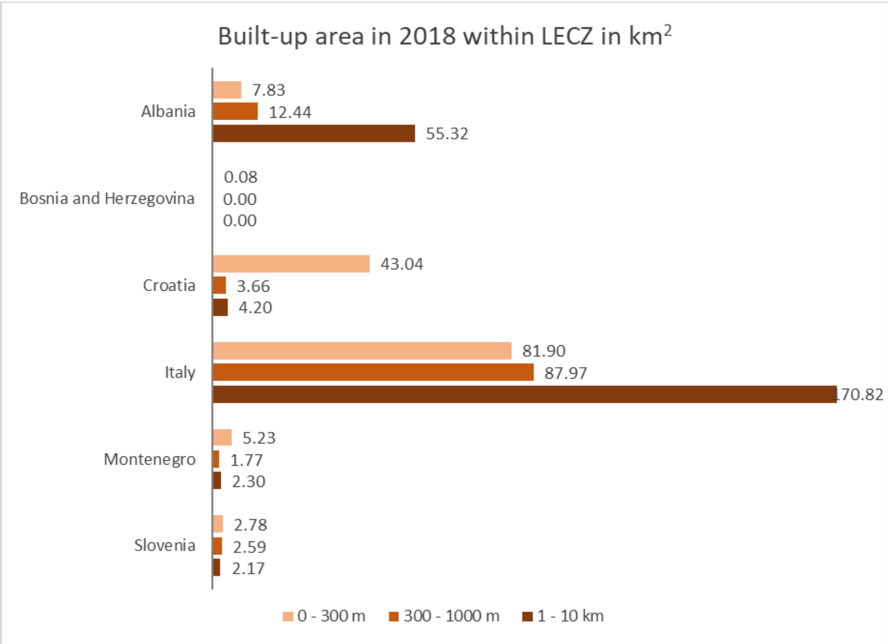


Figure 3.9: Built-up area in the LECZ per country per coastal strips in km^2

93. The assessment reveals also that land cover change (2012-2018) within LECZ goes towards an increase of built-up areas in all countries within the Adriatic sub-region (increase of 6km^2 that corresponds to 1% relative to built-up area in 2012). Figure 3.10 illustrates land-take in countries per coastal strips. Albania has the largest increase of built-up areas within LECZ and most of the land-take took place in the coastal strip 1-10 km, while in Croatia in the narrowest coast strip.

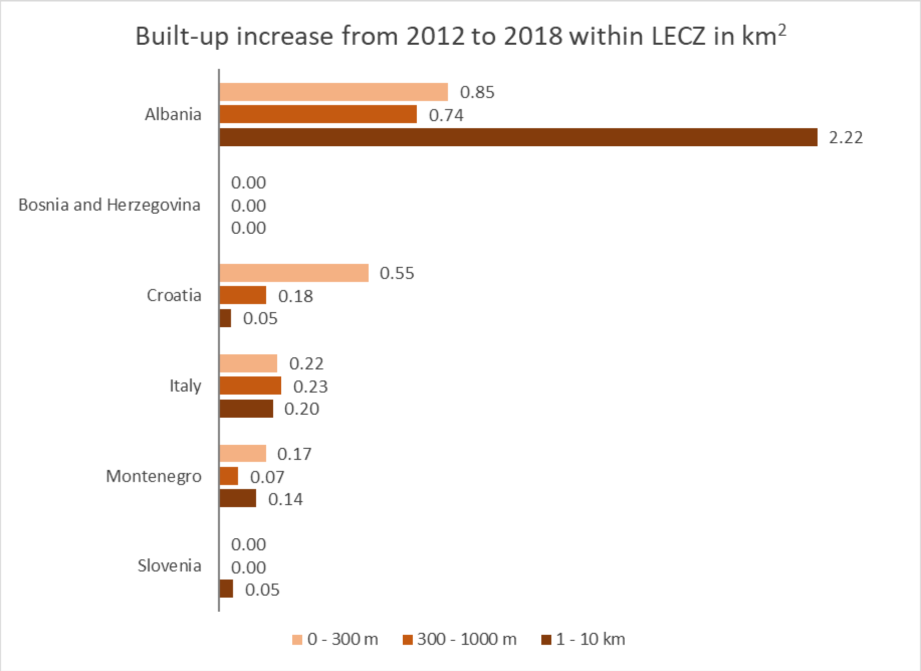


Figure 3.10: Land take in the LECZ per country per coastal strips in km^2

5. Key findings

94. The results of the CCI 25 assessment for the Adriatic sub-region show the increasing trend of coastal urbanisation, i.e., increase of built-up areas (27km^2 out of 29 km^2 land cover change was land-take mostly from natural areas). On the other hand, the areas under protection have also increased showing good practice of preserving and improving GES. However, there is a slight increase of built-up areas in the protected areas. CCI 25 indicator parameters clearly identify the linear coastal development, especially pronounced in Croatia. The assessment could help countries in establishing the right measures and actions to achieve GES.

95. The reporting unit of LECZ shows that large areas of coastal zones are located in the low-lying terrain and that the built-up areas continue to increase there as well. This sheds new light on the problem of coastal artificialization, which will lead to a decrease of resilience to climate change. A detailed analysis at the level of municipalities and cities could help address the problem and set new requirements for urban planning, e.g., no land-take in LECZ.

96. A plethora of GIS data was prepared for the elaboration of this assessment report and is available to be used for other statistics and analyses, and for further GES assessment and setting up measures and actions.

97. The methodology applied in this study confirms that the CCI 25 assessment can be made with open-source data such as OpenStreetMap, World Database on Protected Areas and Forest and Buildings removed Copernicus DEM (FABDEM) global elevation map. All these datasets are available for the whole Mediterranean. The key data for CCI 25 is land cover data, here the Copernicus Land Monitoring – Coastal zones service was used. Currently, it is not available for the entire Mediterranean. However, the best available data for the future could be the ESA World Cover Project providing global land cover maps at 10m spatial resolution, in particular if national most updated and accurate datasets are not available. As new global land cover maps are emerging monthly, having better and better spatial, thematic and temporal resolution land cover monitoring is becoming feasible for the whole Mediterranean at relatively low cost.

6. Measures and actions to achieve GES

98. Varying geographic, socio-economic, cultural and environmental contexts of coastal zones require the application of specific measures and actions in order to achieve GES. First, in order to define GES in a more objective way a technical manual should be prepared that will allow better understanding of concepts of integrity and diversity of coastal ecosystems and landscapes and their importance for ecosystem approach. This will also allow better assessment of land cover changes in the next QSR period, in particular for the areas with significant changes.

99. Second, more objective GES should be prepared either at the sub-regional level or at country level that will allow more objective assessments for the future QSR.

100. The main targets under EO8 could include the following:

- Avoid further construction within the setback zone and the flooding prone low-lying coastal zone;
- Give priority to low-lying coastal zone when preparing adaptation plans to climate change;
- Maintain diverse and harmonised coastal land cover structure, and reverse dominance of urban land cover;
- Keep and increase landscape diversity.

101. These general recommendations should be further elaborated and adapted to particular regions. In general, measures and action could be of the following types:

- Particular management actions needed in order to move towards GES;
- Measures aimed at obtaining new knowledge about assessing and achieving GES (e.g., scientific research, application of innovative solutions at pilot locations);
- Measures with the aim of disseminating knowledge to all stakeholders and involving them in the actions for achieving GES.

102. Particular management actions regarding land cover change could include:

- Analysis of existing built-up areas and their categorization into those that are necessary, those that can be reduced and those that can be returned to nature (e.g., abandoned industrial zones, etc.).
- When planning new built-up areas, first analyse whether human needs can be achieved through better management of existing built-up areas and their functional transformations.
- In existing built-up areas: improve monitoring of environmental impacts and implement measures to reduce negative impacts (such pollution, habitat fragmentation, noise, light pollution, water cycle).
- For new construction areas, examine the use of nature-based solutions and ensure financial or other benefits for their implementation.
- Encouraging the use of space in a way that consumes spatial/natural resources as little as possible: e.g., restricting land-take for second homes.
- Protect, restore, conserve and enhance threatened coastal ecosystems and habitats (e.g., dunes, wetlands and coastal forests and woods, in particular).

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OPEN SOURCE DATA *(used for CCI25 calculation for the Adriatic countries)*

1. Land use/land cover data

Copernicus Coastal zones (CLMS-CZ) *It is a part of the Copernicus Land Monitoring Service and it covers coastal area of EEA39 countries that is within 10 km of the coastline (partly modified EU-Hydro coastline). Currently, CLMS-CZ is available for 2012 and 2018, and it is planned to produce a new dataset every six years.*

https://land.copernicus.eu/local/coastal-zones

CLMS-CZ data for year 2012 can be downloaded from https://land.copernicus.eu/local/coastal-zones/coastal-zones-2012?tab=download

CLMS-CZ data for year 2012 can be downloaded from https://land.copernicus.eu/local/coastal-zones/coastal-zones-2018?tab=download

CLMS-CZ data for change 2012-2018 can be downloaded from

https://land.copernicus.eu/local/coastal-zones/coastal-zones-change-2012-2018?tab=download

2. Coastline and administrative units

OpenStreetMap (OSM) data

OpenStreetMap (OSM) is based on crowdsourced volunteered geographic information, it is often being used as a valuable data source for extracting useful information.

OSM coastline can be downloaded from https://osmdata.openstreetmap.de/.

Administrative boundaries from https://osm-boundaries.com/.

3. Elevation data

Copernicus DEM 30

Copernicus DEM is a digital surface model (DSM) in resolution of 30 m, it has world cover and is freely available.

https://land.copernicus.eu/global/content/annual-100m-global-land-cover-maps-available.

4. Protected areas

World Database on Protected Areas

World Database on Protected Areas is the most exhaustive global database on terrestrial and marine protected areas, managed by UNEP World Conservation Monitoring Centre (UNEP-WCMC) and is being updated on a monthly basis.

https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA.

GIS AND TABULAR DATA SETS

Link to data sources as calculated for the CCI 25 and shape files for the CI 16 and CCI 25

Available from
https://gradsthr-my.sharepoint.com/:f:/g/personal/fgilic_gradst_hr/EvYZM0_maehAp7TqhRFWj54BV8-qtEfS6kcGfHON4PVBog
Password: IMAP#2023

1. Directory CI16

Tabular data is provided in Excel and Word format and GIS data sets in GIS directory (GIS shape files are stored by countries). QGIS project file is provided for GIS data viewing and mapping purposes (CI16_med.qgz).

2. Directory CCI25

Tabular data is provided in Excel and Word format (subdirectory Tables) and GIS data sets in GIS directory (geopackage files stored by themes in the subdirectories)). QGIS project file is provided for GIS data viewing and mapping purposes (QGIS_CCI25.qgz).