MONITORING AND ASSESSMENT METHODOLOGICAL GUIDANCE ON LAND USE CHANGE

Candidate common indicator of EO8
Coastal ecosystems and landscapes

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1. Introduction

Coastal areas are very dynamic domains as a result of its particular position at the interface between the land and the sea. Coastal areas receive pressures and impacts accumulated through the river basin and, at the same time, exert a certain pressure on the marine side. All these interactions are interconnected with the human activity which has been shaping the coastal landscape in the Mediterranean for centuries. Therefore, the monitoring and assessment of land use changes has been largely used to identify hot spots and critical areas where to prioritise actions to ensure the preservation of the biodiversity (EEA, 2015).

The Ecological Objective 8 “Coastal ecosystems and landscapes”, and in particular the Operational Objective 8.2 ‘Integrity and diversity of coastal ecosystems and landscapes and their geomorphology are preserved’, does not have a precedent in other regional EcAp initiatives, such as Helcom or OSPAR. While their objectives are fully oriented towards marine environment, the Mediterranean countries have opted for a somewhat different approach. While most of the EOs are marine environment oriented, this EO is based on the requirements originating from the geographic coverage of the revised Barcelona Convention and the ICZM Protocol, as well as the LBS Protocol. In all these documents, the spatial coverage extends to the terrestrial part of the coastal zone. The ICZM Protocol best defines such approach through its definition of the coastal zone which says that it is the "...geomorphologic area either side of the sea shore on which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities." In fact, this definition is very close to the definition of the "coastal ecosystem". Because the coastal ecosystem is such an important element of the regional Mediterranean space, the introduction of this EO is fully justified. Therefore an EcAp-MED pilot project was undertaken on the Adriatic (2015).

The main conclusions of the Pilot project suggest that by using the common remote data and a common method for processing and presenting the results is feasible and a very positive step forward as far as monitoring the processes, the state and evolution of the coastal zones. Consequently, the interpretation of the monitoring results can provide information on the impacts to coastal ecosystems, habitats and landscapes. However, the Pilot concluded that the interpretation of the results and the assessment which should lead to the definition of management measures and the achievement of GES should be left to the countries.

The reasons are related to the definition of the coastal zone and in particular of the analytical units in a respective country, and a very strong socio-economic, historic and cultural dimensions in addition to specific geomorphological and geographical conditions in each country that have to be taken into account.

Therefore, the interpretation of the results should be descriptive and should point out the negative trends and status of coastal zones that are not in line with the ICZM Protocol requirements or/and national policies, plans and programs regulating the development of coastal zones and the definition of GES or similar descriptions of good status of coastal zones including specificities for good environmental status. However, the method proposed provides a strong and appropriate tool to make land use changes visible on the maps and provides information if required management measures are needed. Since the management and related measures to achieve GES incorporate all those dimensions of sustainable development and impacts on the coastal ecosystems, biodiversity and landscapes depend on the results of such an analysis, i.e. the indicator itself, it should be left to the countries to build-in the flexibility to reflect countries' local specificities and conditions for the management purposes.

2. GES and targets for Operational objective 8.2

Given the number of interrelated factors that determine the quality of the landscapes, and the different scales of the process modulating its ecological integrity, it may happen that there is not a single combination of elements that would define a good environmental status for a specific land. The local knowledge is, therefore, of prime relevance to better understand this complexity.

However, we know and we can quantify to a certain extent the impact of land use changes, in particular those originated from new urban developments. The main impacts can be summarised as follows:

- Habitat loss. Substitution of the existing habitat by new constructions. It also has side effects by modifying the soil functions (in particular water infiltration and decrease on the capacity of C sequestration).
- Fragmentation. The impact is not only on the specific part of the land affected by the land sue change. It has also an impact on the broader context by creating a barrier effect (fragmentation) and reduced area of habitats.
- Loss of ecosystem integrity as a result of the above impacts.

Therefore the good environmental status can be defined as a combination of the presence of certain land uses favourable of ecosystem integrity, and the absence (or minimum development) of those land use changes that have a stronger impact on the ecosystem integrity.

Given all these elements, in particular the need of specific knowledge of local geographic and biotic conditions, the definition of the GES should be developed accordingly by each country. However, there are some orientative recommendations that could be considered:

- Objectives
    - Perpendicular coastal development, with linear development minimised.
    - Mixed land-use structure achieved (within coastal spatial units,).
    - Perpendicular and linear coastal development is in balance with integrity and diversity of coastal ecosystems and landscape.
- Targets proposed are related to some explicit requirements of the ICZM, such as 'No further construction within 100 m width setback zone is established'.

3. Objective of the Indicator 'Land use change'

The increase in built-up areas has a potentially high impact on the environment and the living and non-living resources due to soil-sealing, to disturbance resulting from transport, noise, resource use, waste dumping and pollution, and others. Marine and terrestrial transport networks that connect areas of intensified activities in the marine and coastal zones, in particular to build infrastructures (oil and gas platforms, windmills, ports, recreational beaches, coastal towns and urban centres) add to the fragmentation and potential degradation of the natural landscape, both terrestrial and underwater. The intensity and patterns of urban sprawl and the built-up area are the result of three main factors - economic development, demand for housing, and extension of transport networks.

This indicator aims to monitor progress towards achieving the first goal for coastal sustainability set out in the ICZM Protocol. The indicator has one measurement - the percentage of built-up space on land. The aim is to allow for the evaluation of the trends in urban areas so as to avoid urban sprawl and limit linear extension of urban development including transport infrastructure along the coast.

The objective is to know the extent to which the coastal zone has been built-up over the past several years because this will indicate the degree of pressure on the coast and the likelihood of further changes in the future. We also want to know whether development on the coast has been greater and more intense than in the wider region. It can also help to understand patterns of development and unravel cause-effect relationships.

4. Monitoring Strategy

4.1. Spatial consideration

4.1.1. Geographic coverage

The geographic coverage comprises the coastal zone of the Mediterranean Sea at competent coastal units (defined by the countries according to the ICZM Protocol). The Mediterranean ICZM Protocol defines the coastal zone by:

- The seaward limit of the coastal zone, which shall be the external limit of the territorial sea of Parties to the Protocol; and
- The landward limit of the coastal zone, which shall be the limit of the competent coastal units as defined by the Parties. (Article 3)

Additionally analytical units will be further defined as follows:

- 10 km buffer from the shoreline
- Segmentation by the following bands to the coastline in order to better understand the land use changes
  - < 300 m. This includes the setback zone.
  - 300 m – 1 km
  - 1 – 10 km
- Inclusion of the elevation component to reflect the altitudinal conditions for different habitat distribution. Tentatively, the following ranges are suggested:
  - < 50 m asl
  - 50 – 300 m
  - >300 m

4.1.2. Spatial resolution

The resolution of the source data is a compromise between precision and efforts needed in processing the satellite images. The following indications could be tentatively considered minimum requirements:

- Minimum mapping unit of 25 ha and 100 m of linear elements
- Minimum change detection 5 ha.

4.2. Temporal consideration

Since urbanisation is one of the most dynamic processes, the temporal scale should be 5 years, in order to be effective on the counteracting negative effects and taking early actions on hot spots. It could also be considered to have different time lapse for monitoring all land cover changes (5 to 10 years), and a shorter one to just analyse land take (e.g. every 3 years).

4.3. Definitions

Table 4.1 provides the definitions for the concepts used on the indicator “Land use change”

Table 4.1. Definition of the concepts used on the indicator

Concept	Definition

Land cover	The ecological state and physical appearance of the land surface (e.g., closed forests, open forests, grasslands).
Land use	The purpose to which land is put by humans (e.g., protected areas, forestry for timber products, plantations, row-crop agriculture, pastures, or human settlements)
Landscape	The mosaic of land uses and their patterns. The term has many components including visual, political, socio-economic and cultural.
Land take	Urbanisation on previous undeveloped land. Land take represents a proportion (%) of a specific area that changed between two land cover inventories from a non-artificial to an artificial area
Ecosystem management	The process of land use decision-making and land management practice that takes into account the best available understanding of the ecosystem's full suite of organisms and natural processes
Land management	The way a given land use is administered by humans
Biodiversity	The variety of life and ecological systems at scales ranging from populations to landscapes
Habitat fragmentation	The alteration of previously continuous habitat into spatially separate, smaller patches

4.4. Data compilation

4.4.1. Data sources

Land cover classes are typically mapped from digital remotely sensed data through the process of a supervised digital image classification. The overall objective of the image classification procedure is to automatically categorise all pixels in an image into land cover classes or themes. The maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns when classifying an unknown pixel so that it is considered to be one of the most accurate classifiers since it is based on statistical parameters. For example Corine Land Cover datasets could be considered as reference in terms of methodology for satellite image processing and process production.

Table 4.2 provides the description of the LU/LC classes needed for the indicator. Those classes are the minimum requirements for the indicator. However, the classification for artificial surfaces can be further refined (e.g. residential, industrial,…) to provide deeper understanding of the land take process.

Table 4.2. Definition of the concepts used on the indicator

LU/LC class	Definition

Artificial surfaces (also referred as built-up areas)	Surfaces with dominant human influence but without agricultural land use. These areas include all artificial structures and their associated non-sealed and vegetated surfaces. Artificial structures are defined as buildings, roads, all constructions of infrastructure and other artificially sealed or paved areas. Associated non-sealed and vegetated surfaces are areas functionally related to human activities, except agriculture. Also, the areas where the natural surface is replaced by extraction and / or deposition or designed landscapes (such as urban parks or leisure parks) are mapped in this class. The land use is dominated by permanently populated areas and / or traffic, exploration, non-agricultural production, sports, recreation and leisure.
Agricultural	It includes: arable land, permanent crops, pastures and heterogeneous agricultural areas (complex cultivation patterns, land principally occupied by agriculture, with significant areas of natural vegetation).
Forest and semi-natural land	It includes: forests, scrub and/or herbaceous vegetation associations, open spaces with little or no vegetation
Wetlands	Inland marshes, peatbogs, salt marshes, salinas, intertidal flats
Water bodies	Water courses, water bodies, coastal lagoons, estuaries, sea and ocean.

4.4.2. Data processing

In order to obtain the parameters to calculate the indicator “Land use change” it is necessary to process the data in order to obtain the appropriate format, reporting unit and parameter. So the needed steps are described:

- Pre-processing data. The main object of these processes is to prepare the different datasets that will take part in the analysis. It is needed to rasterize those vector data, aligning all the produced rasters to a reference dataset). The ‘Maximum area’ criterion is used, as it is one of the most standard methods for rasterization processes. An adjustment to an extent of analysis should be applied to all the input datasets. This extent of analysis will be determined by the dataset covering the maximum area. Moreover, and considering the following combine step, all ‘no-data’ values should be reclassified to 0 in order to be computed by the combine tool.

- Combining data. We are combining all the datasets that are participating in the analysis:

    - Baseline land cover data (y_0, y_1,.. y_n).

    - Administrative units (coastal zone)

    - Elevation data categorised by the selected altitude classes (e.g. 0-50m, 50-300 m, > 300m).

- Distance to the coast differentiating the setback influence, 1 km and 10 km stripes.

- Extracting statistics. The combination of the different layers described in the previous step results in statistics proving status and changes at the different reporting units.

4.4.3. Parameter(s)

The evaluation of the land use changes requires the calculation of parameters indicated on Table 4.3. The combined analysis of these parameters entails an inventory of the urbanisation pressures on coastal ecosystems. In practice these parameters can identify

- Where the pressure is higher (by amount of change and by pace of the process)
- Spatial trends (along the coast and landwards)
- Hot spots

However, the local knowledge is necessary to correctly interpret these process and to understand the drivers behind them.

Table 4.3. Description of the parameters calculated for the indicator Land use change.

Parameter	Units	Data required	Reporting units	Meaning
Area of built-up land in coastal zone as a proportion of the total area in the same unit	% of artificial areas	Artificial surfaces (land use class 1) at a single time shot	Coastal strips (<300m, 0,3-1 km, 1-10 km) Elevation breakdown (<50 m, 50-300 m, > 300 m)	State of urban areas at a particular time. This is used as a baseline, i.e. initial condition for the analysis of changes. It is of particular relevance the parameter reported on the first 300 m of the coast, since this is used as a proxy for the stateof urbanisation on the setback zone.
Area of built-up land in coastal units as a proportion of the area of built-up land in the wider reference region	% of artificial areas	Artificial surfaces (land use class 1) at a single time shot	Wider administrative region	This parameter shows to what extent the process of urbanisation has been more intense on the coast than on the inland. It also reflects the relevance of economic activities on the coast as a driver of urban development.

Parameter	Units	Data required	Reporting units	Meaning
Land take as % initial urban area on the coastal zone	% of increase of urban areas	Artificial surfaces (land use class 1) at t_0 and t_1	Coastal strips (<300m, 0,3-1 km, 1-10 km) Elevation breakdown (<50 m, 50-300 m, > 300 m)	Intensity of the process of urbanisation in a given period of time.

5. Scope for improvements

Integration of biodiversity information existing at local scale could assist to rank the severity of the pressure.

Development of higher resolution datasets would allow to identify linear structures along the coast.

Develop methodologies, datasets and classifications for 'built-up' in the coastal waters (e.g. windmill parks, oil and gas rigs, energy convertors, mooring facilities).