Spatial analysis on length of Montenegro's coastline occupied by human-made structures, as an input to a document on how to approach assessment of Good Environmental Status (GES) of Montenegro regarding IMAP's Common Indicator 16

REPORT

Podgorica, March 2021

TITLE

Spatial analysis on length of Montenegro's coastline occupied by human-made structures, as an input to a document on how to approach assessment of Good Environmental Status (GES) of Montenegro regarding IMAP's Common Indicator 16

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PLACE AND DATE

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TABLE OF CONTETNTS

I. INTRODUCTION

Monitoring the length of coastline subjected to physical disturbance due to the influence of human-made structures (and its trend), is of paramount importance to preserve habitats, biodiversity, and help preventing impacts of coastal erosion and flooding, as well as for its importance in land-sea interactions. Until now there has not been systematic monitoring on Mediterranean level regarding this, in particular not quantitatively based monitoring on a wider Mediterranean basis. That is why UN Environment/MAP has introduced the Ecological Objective 8: "Coastal ecosystems and landscapes" within the application of the Ecosystem Approach to assess the level of the environmental status of sea and coasts (Good Environmental Status - GES). This Ecological Objective is specificity in relation to the Marine Strategy Framework Directive: it is based on a number of articles of the Protocol on the ICZM in the Mediterranean, in particular on Article 8 and Article 16. Ecological Objective 8 and its Common Indicator 16 ("Length of coastline subject to physical disturbance due to the influence of human-manmade structures") are an integral part of the UNEP/MAP Integrated Monitoring and Assessment Programme (IMAP), also developed for Montenegro within the GEF Adriatic Project.

The aim of this report is providing national inputs to the assessment of Ecological Objective 8: "Coastal ecosystems and landscapes", i.e. Common Indicator 16, in terms of providing outputs of the spatial analysis on length of Montenegro's coastline occupied by human-made structures. In this way, the monitoring of the CI16 will be carried out as Contracting Parties agreed, and the results will contribute to the Mediterranean Quality Status Report – QSR planned for 2023, while contributing at the same time to the preparation of the assessment of Good Environmental Status (GES) of marine and coastal areas of Montenegro.

The area of analyzed indicator is the coastal area of Montenegro (from the border with Albania to the border with Croatia). The area includes the coastal area of six coastal municipalities: Ulcinj, Bar, Budva, Kotor, Tivat and Herceg Novi).

This report includes:

I. Spatial analysis on identification of length of Montenegro's coastline occupied by human-made structures. Such analysis follow the national monitoring programme for EO8 for Montenegro developed within the GEF Adriatic project, based on the IMAP indicator guidance fact sheet for Common Indicator 16 (Annex 3);
II. Attribute tables of GIS polyline layers of: (i) human made structures and (ii) artificial/natural coastline, in format that is in line with the IMAP Information Standard for CI16 (Annex 4). In that way, the results of the above study will be made ready for uploading to the Info MAP System, which is a primary platform for data collection and management of Contract Parties to the Barcelona Convention; and
III. Review and complement other CI16-relevant chapters (once prepared by PAP/RAC and

project partners) that will be a part of Good Environmental State (GES) assessment for Montenegro (i.e. pressures and impacts of coastal artificialization, gaps and development needs, possibility to determine GES for EO8 etc.)

PREVIOUS ANALYSES

In Montenegro, the built-up assessment of coastal zone was carried out within the frame of Coastal Area Management Program (CAMP), which served as a basis for Spatial plan for six coastal counties and latter National strategy for integrated coastal zone management for Montenegro. The length of built-up coastline in Montenegro was assessed for each of the six coastal counties (Table 1.). The indicator was calculated by overlapping the built-up areas with generalized coastline to get the share of the built-up coastline in the whole coastline. The coastline was generalized in order to avoid unrealistic length of anthropogenic coastline (e.g. to avoid undulations by marinas, ports, were groins, etc.).
As for the more detailed assessment in Montenegro, the length of built-up coastline was assessed for six coastal counties. The assessment showed around 32% of built-up coastline on national level with notable differences between coastal counties (e.g. 11.6% in Ulcinj County and 40.4% in Tivat County).

County	Natural coastline (km)	Built-up coastline (km)	Total (km)	Share (built-up/total) (%)
Bar	23.615	12.549	36.164	**34.7**
Budva	24.505	7.305	31.810	**23.0**
Herceg Novi	32.883	19.715	52.597	**37.5**
Kotor	39.596	23.819	63.415	**37.6**
Tivat	19.008	12.885	31.893	**40.4**
Ulcinj	32.158	4.236	36.393	**11.6**
Total	**171.764**	**80.509**	**252.273**	**31.9**

Table 1. Length of built-up coastline in Montenegro (provided by G. Berlengi)

Indicator of coastal occupancy shows the degree of urbanization or artificialization of the narrow coastal zone. Within the document "Application of selected indicators for monitoring and evaluating the sustainability of spatial development of the coastal areas of Montenegro" (Berlengi, 2013), an analysis of this indicator was provided. This indicator can be calculated according to the current of development or according to the planned construction areas. Also, this indicator can be calculated for the coastline or the coastal strip given width, for example of 500m or 1000m width. Here we notice the difference in relation to the bandwidth of 100m that is prescribed by the Protocol.

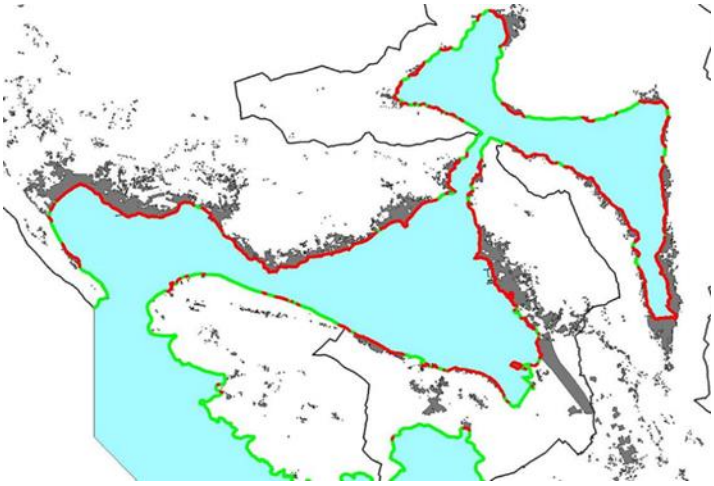

Figure 2. Map showing built-up coastline (in red) and natural coastline (in green) (G. Berlengi)

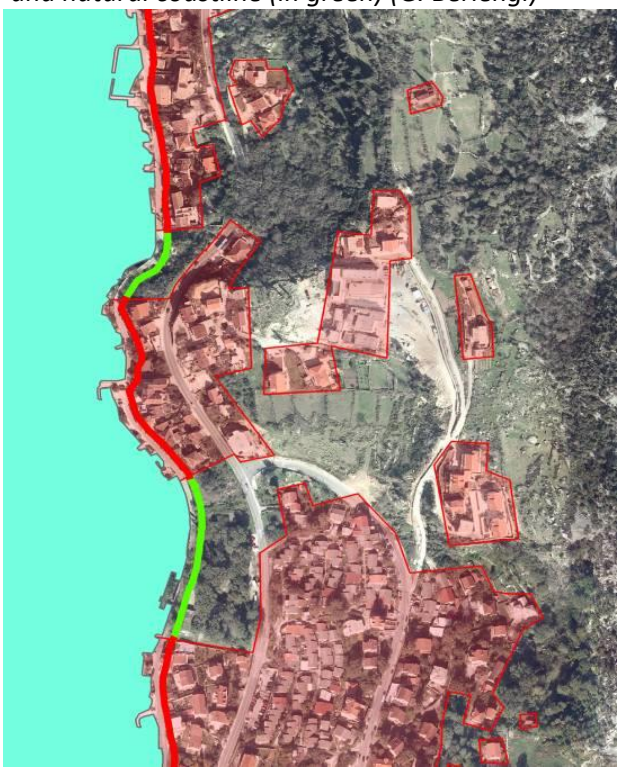

Figure 3. Indicator calculation method - overlapping of built parts of the construction area (red polygons on the orthophoto images) and generalized coastline gives the share of the built shore (red line) in the total length of the coastline. For the purposes of this indicator, the coastline is generalized to avoid the unrealistic length of the anthropogenic coast (ponts, marinas, ports).

Within this Project it was stated that within the "urban area with partly built coast" (as recorded in this study) not all areas are impermeable. This is namely because of the generalization in this area, green areas, forests and agricultural areas between the built-up areas can be included. The length of the coast is measured 50 m from the coastline and is considered as the average length of the reference belt 100 m from the coast. For information on the length of the artificial coast (rigorously) artificial is considered as a part of the coast where there are groups of objects within the 100 m belt (meaning that the entire belt is not 100

m wide). It is considered that the relevant information is for the narrow coastal area (belt), and not strictly for the coast line (that is, for the intersection between the sea and the land).

MONTENEGRO COASTAL AREA

Figure 4: Administartive borders of Munipacilities in Cosatal region

The Montenegrin coast is located in the southeastern part of the Adriatic basin, which forms the dividing line between the eastern and western Mediterranean. It stretches from the entrance to the Bay of Kotor (Cape Oštro), to the mouth of the Bojana in the Adriatic Sea. Inland, it consists of a narrow coastal belt, only 2-3 km wide, bounded by a steep mountain, limestone rim of Orjen, Lovćen, Sutorman and Rumija, which rises 900-1000 m.n.m.

The sea area from the Bay of Kotor to the mouth of the Bojana, leans on the coast, which is mostly rocky and with well-formed cliffs, while in the extreme southeastern part is low, sandy, partly lagoon type and strongly influenced by freshwater from the mainland.

The Montenegrin coast has a relatively young relief. It almost entirely has an invasive coast of tectonic and karst type. The longitudinal extension of the coast in relation to the mountainous hinterland is characteristic

The appearance of the coast of the Montenegrin coast is a reflection of the composition of the rocks that make it up. Where the rocks are softer, bays and coves have been created, and in the hard limestone rocks there are numerous cliffs, ditches and caves. Along the coast stretches a coastal terrace, which spreads over part of the terrain built of softer rocks. The Bay of Kotor is the most complex part of the Montenegrin coast in terms of relief, which consists of several narrowings and expansions. The shores of the Bay of Kotor, which are built of limestone, are steep, and those, which are built of flysch, are slightly sloping and gradually sinking under the

sea.
Administratively, the Coastal region includes 6 municipalities: Herceg Novi, Tivat, Kotor, Budva, Bar and Ulcinj. According the Spatial plan of the special purpose for coastal area (2018), length of the Montenegrin coast is 293.5 km.

II. METHOD AND INPUT DATA

Monitoring of the Common indicator 16 focuses on measuring the length of artificial coastline and its share in total coastline of the Montenegro. Primary input data for the research was a digital ortophoto imagery, taken in 2018, performed with spatial resolution of 20 cm and provides by state Geodetic Administration.

The length of artificial coastline should be calculated as the sum of segments on reference coastline identified as the intersection of polylines representing manmade structures with reference coastline ignoring polylines representing manmade structures with no intersection with reference coastline.

The coastline has been corrected by making changes that have occurred in the area in the period since the coastline was officially established. (Figure 5)

Figure 5: Diference between corrected and official coastline (official coastline is presented with yellow color)

It is important to note that the official coastline in the Spatial plan of the special purpose for Coastal area of Montenegro also considers a line along the Bojana River, but for the purposes of this study only the line of land/sea interaction, (i.e. the line separating the mainland from the sea) was considered. This is the reason why a longer coastline may be found in the literature elsewhere.

The minimum distance between coastal defense structures is set to 10 m in order to classify such segments as natural, i.e. if the distance between two adjacent coastal defense structures is less than 10m, all the segment including both coastal defense structures is classified as artificial. (Figure 6)

Figure 6: Examples of defining the type of coastline along the main road in the Bay of Kotor

Figure 7: Examples of defining length of artificial coastline for seaports and nautical tourism ports

The information in the attribute table associated with the GIS information layer, according to the information standards for the Common indicator 16, for the coastline of Montenegro are:

- **CPCODE:** (Two-letter code of Country) MN
- **ART_NAT**: Code for type of segment of coastline.
  - 0 Natural coastline
  - 1 Artificial coastline
- **ASCODE**: Code of type of artificial infrastructure.
  - 1 Breakwaters
  - 2 Seawater/Revetements/Sea dike
  - 5 River mouth structures
  - 12 Port and marinas
- **Municipal:** Name of municipality or local administrative region where the polygon/polyline of segment of coastline is located

- **Year**: Year of production of the information layer
- **Ref_Year:** Year of the reference coastline used to represent natural and artificial segments

III. RESULTS

The results are prepared according to Indicator guidance factsheet for EO8 Coastal Ecosystems and Landscapes Common Indicator 16 “Length of coastline to physical disturbance due to the influence of manmade structures“

The length of natural coastline of Montenegro is 223 km or 67.48% while the total length of artificial coastline is 107.46 km or 32.51%. (Figure 8.)

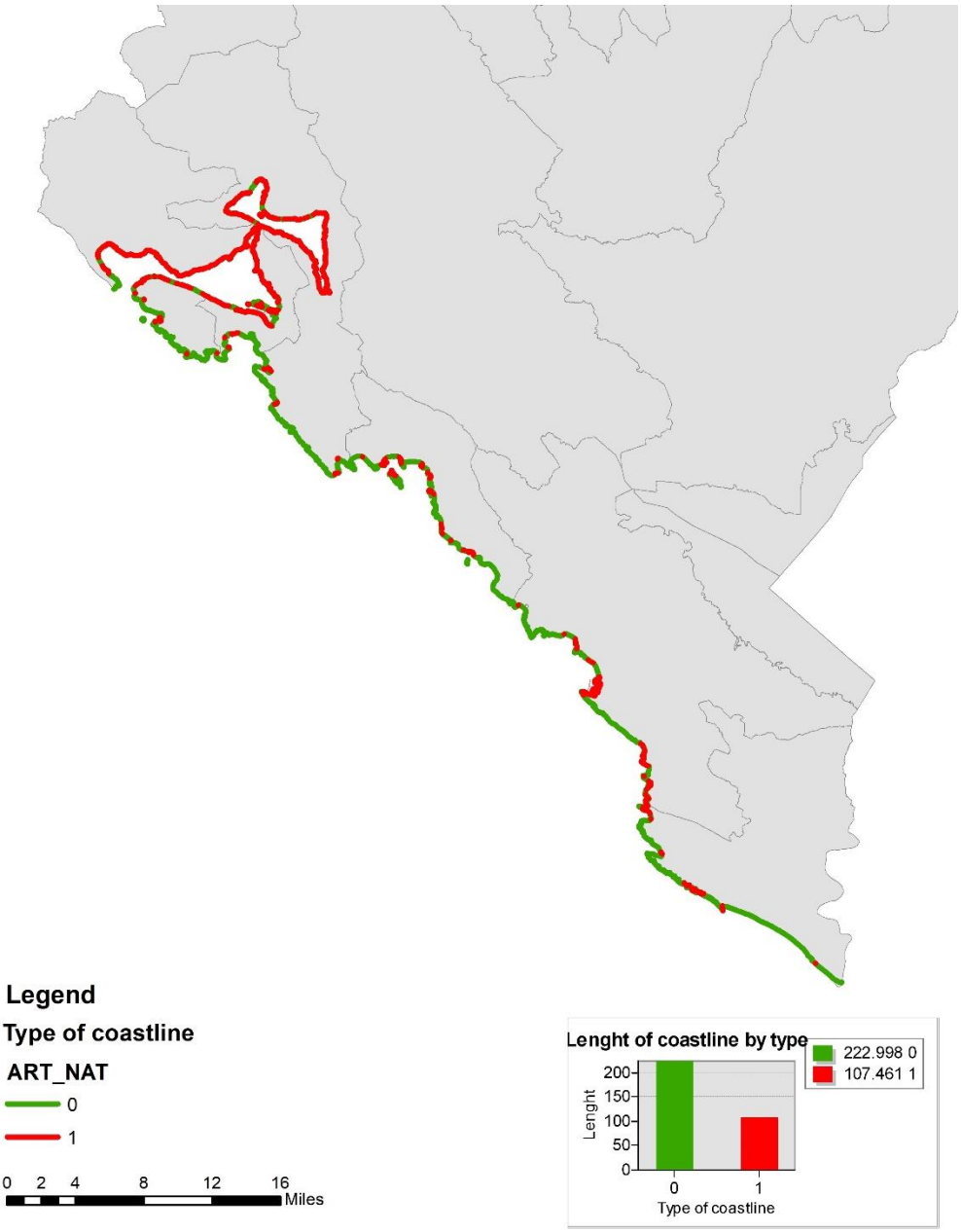

Figure 8: Spatial presentation of coastal delineation by type of coastline in Montenegro

As we can see on Figure 8, most of the artificial structures are located on the coastline in close proximity to the major settlements with strong economic activities. From its total coastline length, 107.46 km (32.51%) are artificial, manmade structures.

Spatial distribution of different type of artificial infrastructure is shown in Figure 9. The artificial structures are dominated by "Seawaters/ Revetments/Sea dikes -2", 54.57km (16.51%) and "Port and Marinas -12 ", 16.27km (4.92 %) and "River Mouth Structures- 5", 0.12km (0,04%).

Type of artificial coastline	Lenght (km)	Share in artificial coastline length (%)	Share in total coastline legth (%)
Seawaters/ Revetments/Sea dikes	54.57	50.78	16.51
Port and Marinas	16.27	15.14	4.92
River Mouth Structures	0.12	0.11	0.04
Other	36.50	33.97	11.04

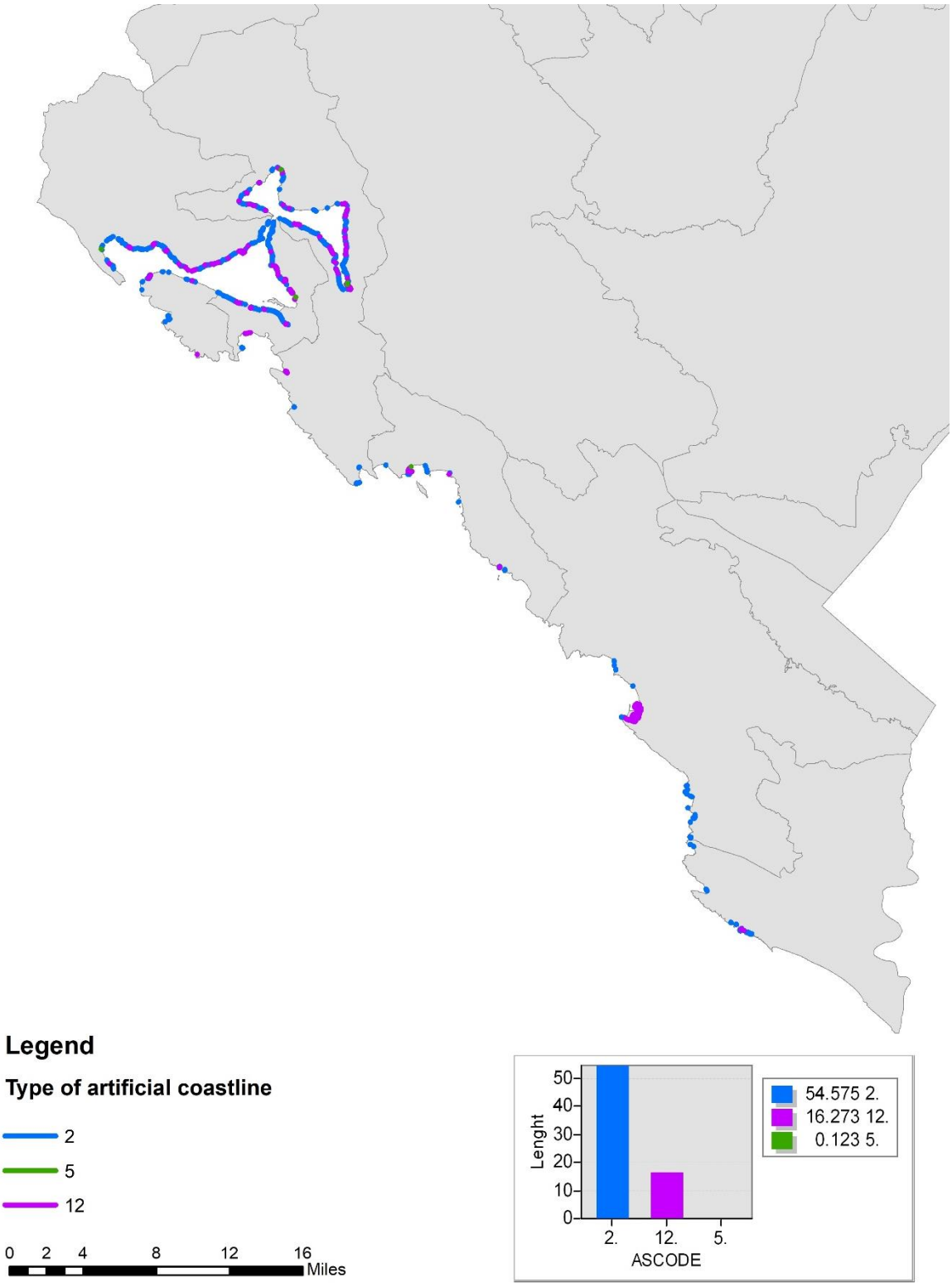

Figure 9: The length and type of artificial coastline in Montenegro

The "Breakwaters" (ASCODE=1), whose projection to the coastline coincided with the purpose of the seaports and nautical tourism ports, were designated as "Port and marinas"

(ASCODE=12). Port of Bar, with long docks and breakwater structures, is the largest Montenegrian port (Figure 10). Port structures are common sight in numerous new settlements of the County (Figure 11, 12 and 13).

Figure 10. Luka Bar
https://volimpodgoricu.me/wp-content/uploads/2017/10/Luka-Bar-1000x555.jpg

Figure 11. Marina Porto Montenegro
https://waytomonte.com/en/p-935-porto-montenegro

Figure 12. Turističko naselje Lištica Bay – breakwaters - seaport structures
https://www.build-review.com/lustica-bay-montenegro-over-100-percent-increase-in-prices-in-seven-years-and-highly-competitive-rental-yield-among-highest-in-europe/

Figure 13. Seaport strucutres – Porto Novi
https://www.total-montenegro-news.com/business/2956-portonovi-hn

Although there are several examples of natural sandy and pebble beaches in Boka Bay, coastline is generally rocky and difficult to access. Therefore, some units of local government and tourist resorts have decided to flatten and concrete rocky coast in order to provide citizens and tourists easier access to the sea. Aforementioned concrete beaches (Figure 15 and 16) are coded under "Seawaters/ Revetments/Sea dike" (ASCODE=2), as well as sea fronts typical of any seaside town. Those manmade structures are defence against the sea waves and serve mainly as promenades (Figure 14, 17 and 18).

Figure 14: Seaside front of turistic complex Lazure
https://www.total-montenegro-news.com/travel/2016-grand-opening-of-lazure-hotel-marina-in-herceg-novi

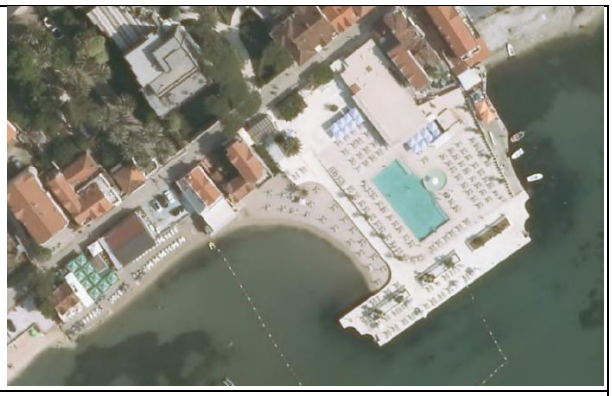

Figure 15: Concrete beach Hotel Palmon Bay, Herceg Novi
Source:Ortophoto
http://www.geo.mrt.gov.me:3800/www/

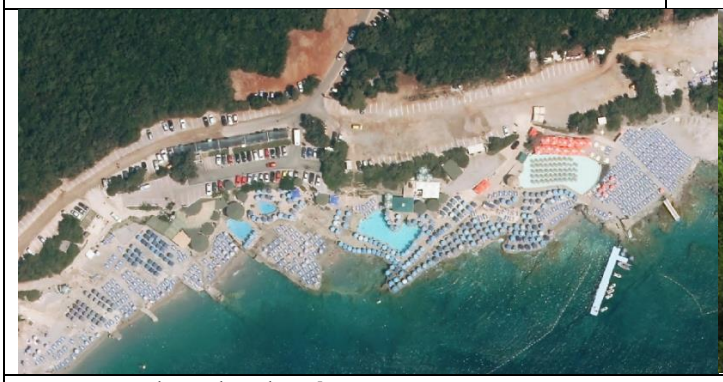

Figure 16:"Ploča" beach - Platamuni
Source: left-ortophoto, right- National strategy for integrated coastal zone management of Montenegro

Figure 17: Seawater promenade – City of Budva to Mogren beach
http://bisag.ru/en/karp/plyazh-mogren-budva-kak-dobratsya-foto-i-otzyvy-plyazh-mogren-samyi.html

Figure 18: Seawater promenade – Perast, Kotor
https://monvista.com/tour-item/kotor-perast/

Since karst areas are characterized by the lack of surface water, there are only few examples of river mouth structures (dikes, embankments etc.) (Figure 19 and 20).

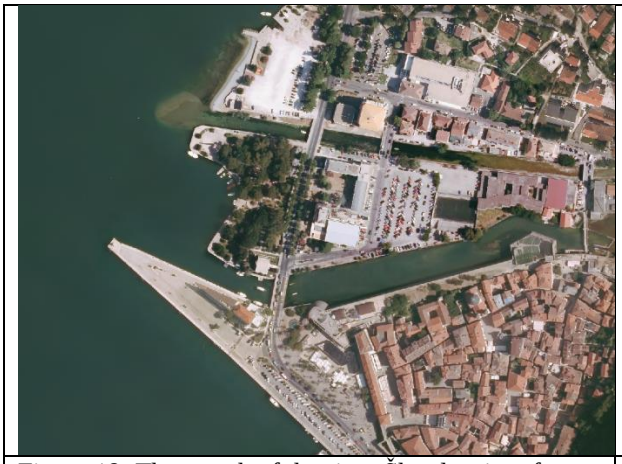

Figure 19: The mouth of the river Škurda, city of Kotor

Source: Ortophoto

Figure 20: River mounth near airport Tivat

Source: Ortophoto

Other manmade structures

Figure 21: Construction works near the coastline – Kumbor- Porto Novi

Source:Ortophoto

Figure 22: Shipyard- Bijela

Source: Ortophoto

IV. CONCLUSION

The purpose of this report is to produce information for Common Indicator 16 “Length of coastline to physical disturbance due to the influence of manmade structures“ for Montengro coast**.**

The length of natural coastline of Montenegro is 223km or 67.48% while the total length of artificial coastline is 107.46km or 32.51%. The artificial structures are dominated by "Seawaters/ Revetments/Sea dikes", 54.57km (16.51%) and "Port and Marinas", 16.27km (4.92 %),) and "River Mouth Structures" (0,04%). Other structures are represented with 36.50 km (11.04%) .

Digital data (shapefile format with required attributes) is an integral part of this report.

V. REFERENCES

- Spatial plan of the special purpose for Coastal area (2018)
- Study of landscape analysis, selection and mapping of landscape types for the needs of Spatial plan of the special purpose for Coastal area for the coastal area of Montenegro
- Digital ortophoto

Additional chapters needed for GES Assessment

A1 Impacts of coastal artificialization

Coastal zones 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 etc. These coastal human-made structures cause irreversible damage to landscapes, loss of habitat and biodiversity, and have 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 system contribute to coastal erosion phenomena by lessening the beach resilience to sea storms. Coastal defense infrastructures have been implemented to solve the problem together with beach nourishment but preserving the natural shoreline system with adequate sediment transport from rivers has proved to be the best solution.

In addition, the closer the artificial structures are to a coastline; the more exposed they are to waves and storm surges, and sea level rise. Considering that these pressures will intensify in future due to climate change, each further construction in coastal zones should be carefully thought trough, since it can create additional financial burden of protecting and repairing such structures from the damage caused by climate hazards.
On the other hand, the increase in sea level will require in the future the construction of breakwaters and similar structures in the sea in order to preserve the existing beaches (Velika plaza, Ada Bojana, etc.).

The key pressures coming from coastal artificialization and related environmental impacts are are:

- overload of communal infrastructure in the summer months (wastewater and impacts on seawater quality, overloaded electrical network, pressure on water resources that are already scarce)
- more terrestrial sources of pollution in general (wastewater, solid waste, pesticides/herbicides);
- pollution from maritime activities (from ports, marinas and vessels)
- impacts from shipyards and industrial activities
- inadequate location of mariculture activities (if not well planned)
- impacts on marine biota and biodiversity (loss of valuable marine habitats; increased number of endangered species; reduced functionality and stability of marine ecosystems)

The key climatic pressures that affect coastal artificialization (and consequently can impact marine biota and seawater quality) are rising sea levels, stormy winds and heavy rains. From the aspect of vulnerability of the narrow coastal area due to the impact of sea level rise, an increase of 0.62-0.96 m in sea level (depending on different IPCC scenarios) is anticipated in Montenegro (National Strategy for Integrated Coastal Zone Management of Montenegro,

2015).[1]

From the aspect of the impact of storms accompanied by rising sea levels, it is necessary to expand the coastal setback zone, and limit or prohibit construction along the coast in a certain number of localities.

The implementation of certain interventions is also a priority, such as the renewal of the coastal infrastructure and beach nourishment (where suitable) in order to mitigate and rehabilitate the impact of natural hazards.

The erosion that takes place under the action of sea waves is expressed, for example on the islands of Mamula, Sveti Stefan and Sveti Nikola, while on Ada Bojana there is also aeolian erosion. Therefore, interventions are necessary in order to protect or rehabilitate certain parts of the coast.

The Action Plan of the National Strategy for Integrated Coastal Zone Management of Montenegro envisages measures and sub-measures to reduce the damage caused by storms and stormy winds, which should be carried out preventively. Some of them are raising protective barriers in critical areas – anti-erosion measures (eg for Velika plaža, Jaz, etc.) and relocation of objects outside the zone of wave range during stormy winds from the southern quadrant.

From the aspect of the impact of storms accompanied by rising sea levels, it is necessary to expand the setback zone at priority locations determined in accordance with the ICZM Protocol: Sutorina estuary, Morinjska river estuary, Tivat salt marshes, Buljarica, Velika plaža and Ada Bojana.

A2 How to approach the GES assessment

In 2019, at the meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) on Coast and Hydrography cluster, the Contracting Parties of the Barcelona Convention expressed the importance of the definition of Good Environmental Status (GES) regarding the Common Indicator 16. In addition, it was emphasized in particular that, due to national circumstances such as socio-economic, historic, cultural and alike, unique targets and GES cannot be applicable to all Mediterranean countries and hence, cannot be specified quantitatively as a threshold value (UNEP/MED WG. 467/6). It was therefore agreed that the

[1] Based on global projections, transposition of projected sea level rise to the space of Montenegrin coastal zone was carried out by applying Digital Terrain Model (DTM), without downscaling of the global model to the regional level, and by taking into account sea level changes in the Adriatic basin. The analysis does not take into account the effects caused by stormy winds and sea waves. The basis for the analysis of the scope of areas that will be affected by sea level rise was obtained by applying the latest LiDAR set of DTM data for Montenegrin coastal zone with data provided in relation to Trieste vertical datum as a reference point for measuring heights at land. In order to calibrate projections of sea level rise in relation to Trieste vertical datum, a height of 0.27 m was added to projected sea level rise values as a value of height expressed in the national system.

definition of GES and related targets and measures should be left to each Contracting Party, taking legal obligations of the Barcelona Convention into account, in particular the ICZM Protocol (especially its Articles 8 and 16).

Acording to the National strategy on integrated management of the coastal zone of Montenegro (NS ICZM MNE) the strategic goal is to develop a sustainable spatial planning system.
The envisaged measures are systemically monitor and research state and processes in the space of the coastal zone and develop information system for the spatial planning/ arrangement. This is planned to be achieved through: performing analyses and undertaking research to serve as a basis for reporting on the state in space; developing and using indicators to monitor state of the coastal zone spac;e and establishing a basic GIS database on space at the national and local level.

Improving the quality of planning documents, as one of the measures, is planned to be achieved through improving the methodology of the planning process, improving procedures and methods of environmental impact assessment (strategic and project) and providing more objective evaluations by using quantitative analyses, indicators and GIS (a way to correct/ improve methodology).
The planned goal of Spatial planning system and Special purpose spatial plan for the coastal zone is to regulate construction in the narrow coastal strip – coastal setback – coastal area within 100 m from the coastline with limited possibility of construction.

In addition, the National ICZM strategy for Montenegro identified baseline value (2015) of built-up coastline at 31.9%., with the same indicated target value/share for 2030, i.e. there should be no further construction on the coastline.

Since the GES definition for IMAP's CI16 is to minimize negative impacts due to new structures with no influence on the larger scale coastal and marine system, it is essential to observe the temporal trends in coastal artificialization. Although Montenegro had a similar assessment previously (i.e. the 31.9% of built-up coastline mentioned above), that assessment was not carried out according to exact methodology defined in IMAP's Indicator Guidance Factsheet for CI16, so the establishment of the 2015-2020 trend would not be consistent and hence, prone to faulty interpretations.

A3 Gaps and development needs

In order to implement the Common Indicator 16 with an acceptable level of accuracy, recent data sources with proper spatial resolution and complete coastline coverage were used with adequate GIS tools and by qualified expert. At the moment, there are no evident obstacles regarding this part in the future as well. What needs to be ensured is that the methodology of the next assessment will be the same as in this one, so that the trends between two time periods can be observed properly.

When defining the artificial coastline within this study, situations were encountered where the road was very close to the coast. If this road were taken into account as a built-up area, the wrong result would be obtained as if the whole coast were artificial. This is especially true in the areas of the Bay of Kotor due to the morphology and relief of the terrain, ie the narrow coastal belt with extremely steep terrain in the hinterland.

Some other concerns regarding the Code of type of artificial infrastructure should also be noted. Namely, the question arises how to mark the structures that do not belong to ASCODE provided in the IMAP CI16 Informaton Standard.

A4 Connections between Coastal Ecosystems and Landscape and other ecological objectives

Ecological Objective 8 is linked (to different extent) to following Ecological Objectives:

- *EO1 Biodiversity*: Constructions along the coastline affects primarily supra and medio littoral habitats and its typical species, and also benthic habitats in near-shore shallow waters due to smothering. In addition, in case construction takes place near important birds/reptiles' habitats, such as beaches and coastal wetlands, it could seriously impact their distribution and abundance.

- *EO5 Eutrophication*: Urbanised areas in coastal zone could be significant source of eutrophication in near-shore marine areas, in particular in the absence of the appropriate wastewater treatment.

- *EO7 Hydrography*: Physical alteration of the coastline, due to human-made structures, could have direct impact on the changes of thy hydrographic conditions, which can in turn lead to changes in marine habitats and biodiversity.

- *EO9 Contaminants*: Type of specific construction/near shore activities (such as shipyards, marinas etc) could lead to contamination of marine area.

- *EO10 Marine Litter*: It can be expected that urban areas could have larger quantities of marine litter deposits on the beaches or in the seawater.

These complex interactions are being in (constant) process of re-examination and discussion.

VI. ANNEXES

ANNEX 1: Information standards for the Common Indicator 16

ANNEX 2: Indicator guidance factsheet for EO8 Coastal Ecosystems and Landscapes
Common indicator 16 “Length of coastline subject to physical disturbance due to the influence of manmade structures”