Recommendations for adaptation measures to be mainstreamed into the Coastal Management Plan for Boka Kotorska Bay (Montenegro)

- GEF SCCF Project Output 2.1 -

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December 2023

Mediterranean Action Plan
Barcelona Convention

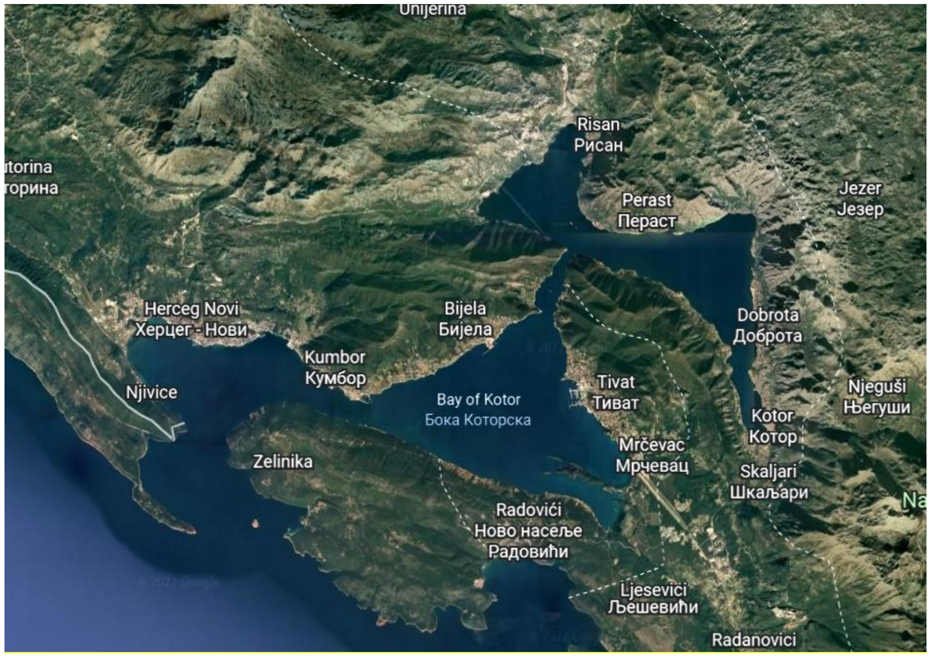
Montenegro
Ministry of Ecology,
Spatial Planning and Urbanism

Contents

1. BACKGROUND

In 2012, Montenegro ratified the Barcelona Convention's Protocol on Integrated Coastal Zone Management in the Mediterranean (the ICZM Protocol), which, in its Article 18, calls for the development of coastal plans that "may be self-standing or integrated in other plans and programmes", and "shall specify the orientations of the national strategy and implement it at an appropriate territorial level, determining, inter alia and where appropriate, the carrying capacities and conditions for the allocation and use of the respective marine and land parts of coastal zones." Preparation of a local coastal management plan that mainstreams climate change adaptation was also identified as one of the priorities in Montenegro's National ICZM Strategy (developed in 2015).

During the preparation of Global Environment Facility's (GEF) MedProgramme, the coastal management plan was agreed to be developed for the Boka Kotorska Bay area under the MedProgramme's Child Project 2.1 (CP 2.1), coupled with mainstreaming climate change adaptation activities developed under the MedProgramme's Special Climate Change Fund (SCCF) project. Boka Kotorska Bay was chosen as a priority area for Plan development during the stakeholder consultations in 2017 (in Rabat, Morocco) and subsequent national consultations held in February 2018This area was selected due to its high vulnerability to flooding, very high population density, but also vulnerability to droughts, forest fires, storms and heavy rains.



Picture 1. Boka Kotorska Bay (from *maps.google.com*)

GEF Medprogramme is a US$43 million assortment of eight projects comprising more than 100 coordinated actions at the regional and national levels, with 10 beneficiary countries: Albania, Algeria, Bosnia and Herzegovina, Egypt, Libya, Lebanon, Morocco, Montenegro, Tunisia and Türkiye. It aims to operationalise priority actions to reduce major transboundary environmental stresses in its coastal areas, strengthen climate resilience and water security, and improve the health and livelihoods of coastal populations. The afore-mentioned Medprogramme's SCCF Project aims to: build the enabling capacity and awareness environment for increasing resilience and adaptive capacity of marine and coastal natural and socioeconomic systems to the impacts of climate change; integrate climate change adaptation measures into national policies, strategies and planning; promote access to existing and emerging finance mechanisms relevant to climate change adaptation; and influence the wider Mediterranean policy processes through its knowledge management strategy.

This output (Output 2.1 of the GEF SCCF project) aims to produce a set of recommendations for adaptation measures that will be mainstreamed in Coastal Management Plan for Boka Kotorka Bay, to enhance climate resilience in the coastal area of the Bay. Adaptation measures were elaborated by a local expert team engaged by PAP/RAC, inspired by discussions of local and national stakeholders at the Kotor meeting on 5 July 2022, organized by Plan Bleu with support of PAP/RAC.

2. CLIMATIC CHARACTERISTICS AND CLIMATE CHANGE IN BOKA KOTORSKA

2.1. Increase in temperature and dry days

The average annual maximum temperature in Boka Kotorska Bay is about 21^{o} C. The most common maximum daily temperature is in the range of 15^{o}C - 19 ^{o} C and 25^{o} C - 34^{o} C in the warmer part of the year. August is the hottest month of the year when the average maximum temperature ranges from 30.7 ^{o}C (in Herceg Novi) to 31.3 ^{o}C (in Tivat). The average minimum temperature in January is from 12.4^{o} C (in Tivat) to 13^{o} C (in Herceg Novi).

For the period 1981-2020, the climate is warmer by +0.7 ^{o} compared to the 1961-1990 period. The difference from the climatological normal is the largest in August (+1.3 ^{o}C), which indicates that **the warming is greater in summer than in other seasons.** The last decade 2011-2021 was the warmest recorded decade ever: 2 ^{o} C warmer compared to the period 1961-1990.

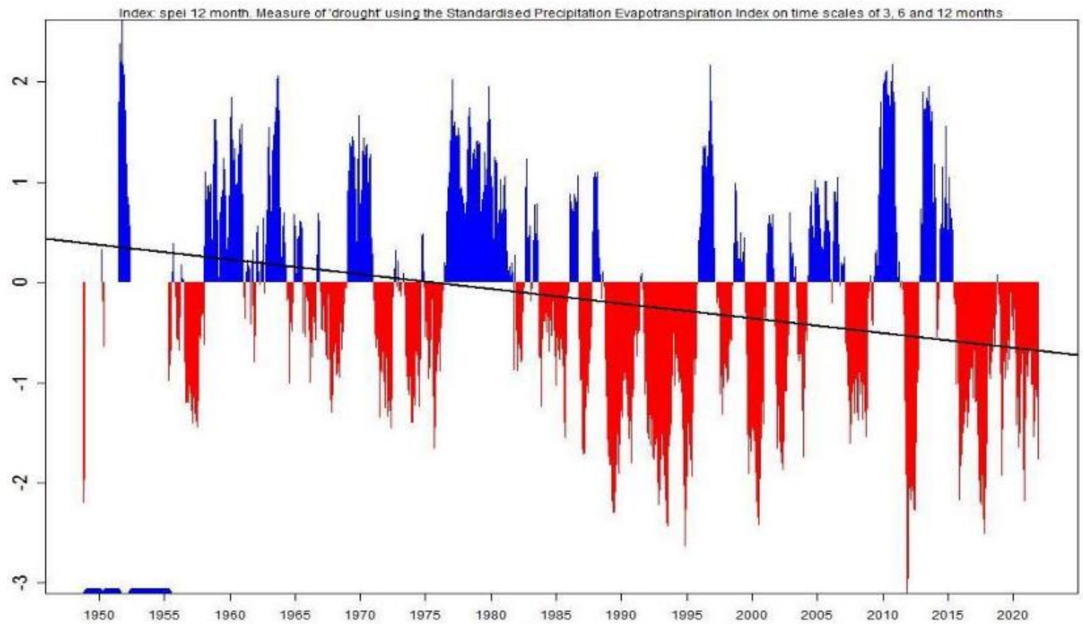
Projections of extreme temperatures show that, for the "most pessimistic" climate scenario - RCP 8.5[1], they will double compare to the period 1971-2020 and the number of frosty days will decrease. Also, the number of summer and tropical days will double in the period 2011-2040 compared to the 1971-2020 period, while the number of tropical nights will increase by about 50%.

For the same scenario, the heat wave duration index will double, the number of heat waves will triple, and the number of frosts will decrease by 50% in the period 2011-2040 compared to the 1971-2020 period.

In conclusion, there is a clear increasing trend in annual temperature after the 1970-1980 decades. Every decade was warmer than the previous one. Expected the temperature rise is 2°C in the summer months (in relation to summer temperatures months for the 1961-1990 period); and from 2 to 2.5°C in winter months (in relation to temperatures in winter months for the 1961-1990 period) in the next 30 years for the entire Montenegro.

[1] RCP 8.5 is the " most dramatic " scenario of greenhouse gases emissions in which emissions continue to grow during 21st century. RCP8.5 does not include no special goal of mitigating climatic change. Emissions and concentrations of greenhouse gases in this scenario increase significantly during time, what leads to a radiating force of 8.5 W/m2 at the end of the century .

Regarding dry days, **the longest maximum number consecutive dry days** in Boka Kotorska Bay was 60 days in 2013 and 2017 in Herceg Novi, while Tivat had 90 straight dry days in 2008 and 99 days in 2017. Standardized index precipitation evapotranspiration (SPEI)[2], one of the indicators of drought, indicates to the drop of the surface humidity, meaning the rise of dry conditions in the area of Boka Kotorska Bay for the 1950-2020 period.



Picture 2. 1SPEI-12 months for the area of Boko Kotor bays for the period 1950-2020

The number of consecutive days without precipitation in the future is expected to increase, what clear indicates that they the droughts will intensify in the future. For the period until 2040 the number of consecutive dry days could increase by 5 to 10% for Luštica, Kotor and Tivat areas during summer. No big changes are expected for the municipality of Herceg Novi, except for the Crkvice location where the number of consecutive dry days could reduce by 5%.

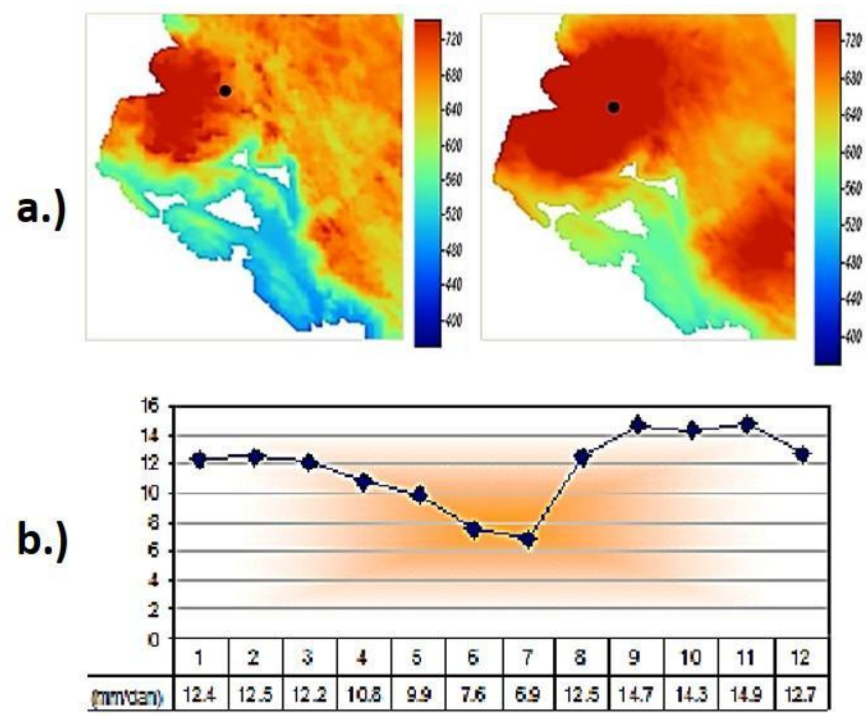
For the 2040-2070 period the number of consecutive dry days could increase by 30% in summer, and by 20% on an annual level.

2.2. Precipitation and changes in extreme precipitation

[2]The SPEI index is designed to take into account both precipitation and potential evapotranspiration when determining drought

The third national communication of Montenegro on climate change [22] lists the areas of the old town of Kotor, Sutorina, Herceg Novi, Crkvice and part of the Luštica peninsula as areas in Boka Kotor that are particularly sensitive to precipitation. The rainiest part of the Bay is in its hinterland, i.e. at the location in Crkvice on Mount Orjen. According to the long-term measurement period, the average annual maximum daily rainfall total in Herceg Novi is 131 mm, in Tivat 106.5 mm and in Crkvice 279.7 mm. Along the slopes of Orjen, the maximum daily precipitation ranges from 150 mm to 500 mm. The municipalities of Herceg Novi and Kotor generally have higher amounts of precipitation in both seasons than the municipality of Tivat.

The cold season (October-March) is also the rainiest season in Boka Kotorska Bay. The rainiest month is November while the maximum intensity precipitation is in September-October-November period. Maximum probability for precipitation is in November and in December, and then in February and March.



Picture 3 a) Spatial distribution of the average annual amount of precipitation in the warm (left) and cold season (right) for the period 1981-2010. The black dot represents the location of Crkvice, the rainiest area in Montenegro and Europe. b). Intensity of precipitation by month (mm/day) for the area of Boka Kotor period 1957 - 2005.

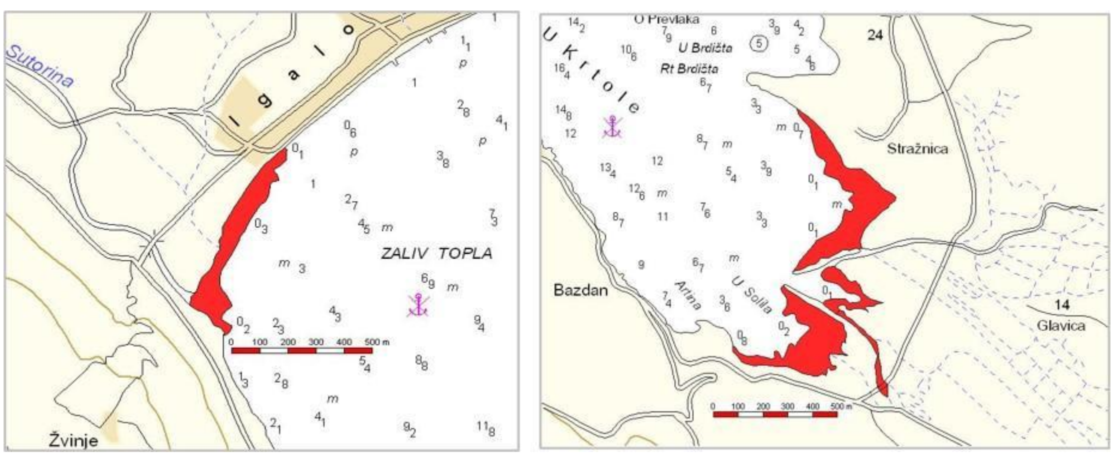
Observed precipitation index and its extremes shows that there are no significant changes during the years in relation to the climatological period of 1961-1990, although the maximum annual five-day rainfall decreases slightly. A certain intensification of precipitation due to climate change is most expected for the winter and autumn seasons.

In conclusion, the total average annual rainfall is expected to decrease (by about 5% for the entire southern region) with a decrease in consecutive days with rain, while an increase in the occurrence of flash floods is expected in the future in the autumn and winter periods.

2.3. Storm surges and sea level rise

Storms occur in strong and relatively large atmospheric systems - cyclones. The main risks accompanying them are stormy waves and their combination with astronomical tides, the so-called **storm surges**, followed by heavy rain, wind and floods.

The impact of waves, unlike in the rest of the coast of Montenegro, is moderate in most of the Boka Kotorska Bay. Exceptions are those locations that have a low coast, and therefore greater vulnerability to flooding due to storm surges (e.g. locations within the Herceg-Novi Bay). Two areas that are particularly sensitive to marine floods are: **the mouth of the river Sutorina** (Herceg Novi municipality) and **Solila area** (Tivat municipality)[3]. Although the mouth of the river Sutorina is inside the Bay itself, the coast of the mouth is low and exposed to large storm surges from the southern direction i.e. the open sea. The Solila area is also located inside the Bay itself, but it is open to the northwest, so strong winds from that direction can develop waves that cause flooding of the coastal zone nearby.



Picture 4 projected flood areas (red polygons): Sutorine river mouth (left) and Solila (right) from of the CAMP Montenegro project , 2013)

Marine floods will pose more danger in the future in combination with **sea level rise** due to climate change, i.e. thermal expansion of seawater, which would, in combination with meteorological and

[3] Plan M (2022) Gender-Sensitive Climate Risk Assessment of Kotor Bay, Montenegro GEF MedProgramme

oceanographic factors, probably lead to greater flooding in areas of Igalo, Morinj , Tivat , Kotor, Krtola (Solila) and Bigova[4].

Sea level rise projections on local level depend on many factors such as topography and geological activity in the area. Regarding projections on a larger scale - Mediterranean, the sea level is expected to rise by 37 to 90 cm until the end of the 21st century, even by 110 cm according to some projections [9].

[4] Plan M (2022) Gender-Sensitive Climate Risk Assessment of Kotor Bay, Montenegro GEF MedProgramme

3. IMPACTS OF CLIMATE CHANGE ON BOKA KOTORSKA BAY

3.1. Impacts of climate change on coastal space and spatial development

3.1.1. Impacts of high temperatures and prolonged droughts

The predicted increase in dry periods in the area of Boka Kotorska will have a significant impact on coastal space, primarily in the form of an impact on forest fires and forestry in general, agriculture, land use and spatial planning.

Climate change presents challenge for land use, cumulated with other non-climate-related challenges, such as increased demand by various usres for limited spatial resources, sometimes turning into land degradation. Sensitivity to high temperatures in cities depends to a significant extent on urban planning (eg presence/absence of vegetation and shaded areas). A rise in temperature and extended periods of heat waves can strengthen the effect of urban heat island, thermal discomfort in indoor and outdoor spaces, and increased demand for energy to supply the building's cooling systems. Cooling of indoor and outdoor spaces, achieved with less environmental impact and lower energy costs, is one of the main challenges in countries with hot climates. High temperatures can also cause certain direct damage (eg asphalt damage), while residential buildings that are extremely exposed to the sun's rays in the summer can suffer overheating of the buildings' roofs and walls.

Dry conditions will prolong the duration and worsen the severity of the fire season, further increase the coverage of danger areas and the probability of large fires, as well as the possibility of spreading the resulting erosion and desertification. Some anthropogenic processes will also contribute to this, such as the process of littoralization, which is featured by the abandonment of villages, agriculture and animal husbandry in the area – these areas are taken over by maquis, garig and forests (mostly highly flammable pine forests). Fires primarily affect forestry, biodiversity and ecosystem service sectors, but can also affect public health, agriculture, energy production and tourism, causing property damage and loss of life. As for fires in the Bay of Kotor, areas of maquis and low vegetation in the municipality of Tivat, and the hills of Bijela, Đenovića and Zelenika, and above Kumbor in the municipality of Herceg Novi, are particularly vulnerable. In the municipality of Tivat in 2016 and 2017, due to a combination of forest fires, and urbanization , about 14% of the municipality's forest cover disappeared [5]. Indicator of Fire The Weather Index

(FWI) for the entire Montenegrin coast is very high to extreme, along with some other areas (around Nikšić, Pljevlja , Žabljak, Cetinje, Podgorica, etc.). The CAMP study [19] showed very high vulnerability to forest fires for the Prevlaka area and parts of Luštica.

Table 1The degree of threat of forest areas for the municipalities of Herceg Novi and Kotor (National Fire Protection and Rescue Plan from 2018 [20])

Municipality	Coastal area (in ha)	Degree of threat			
		First degree (very high risk)	Second degree (high risk)	Third degree (moderate threat)	Fourth degree (low risk)
Herceg Novi	13 198	368	4 657	5 528	2 645
Kotor	19 124	481	9 670	5 923	3 050

Furthermore, the rise in extreme temperatures and drought additionally increases risk from of loss in **agriculture**, related with a lack of water for irrigation, changes in growth cycles, shortage in yields, deterioration of harvest and indirect influence on livestock productivity. This requires the need for development of cultures that are more resistant and more adapted first of all to conditions of lacking water, extreme temperatures and unfavorable weather conditions.

Climate and environmental changes can influence on distribution and change in seasonal phenology of harmful insects, what results in negative effects on health of **forest ecosystems**. Negative effects of environmental and climate change on forests can be seen via physiological changes in trees and their weaken defensive ability. Sudden increase in population of Mediterranean bark beetle (*Orthotomicus erosus*) in coastal area of neighboring Croatian [21] is attributed to chain of unfavorable factors also related to climate changes . Mediterranean bark beetle was also recorded in some areas Montenegro such as Pljevlja and Rožaje and it is a matter of time when it will appear on the territory of Boka Kotorska.

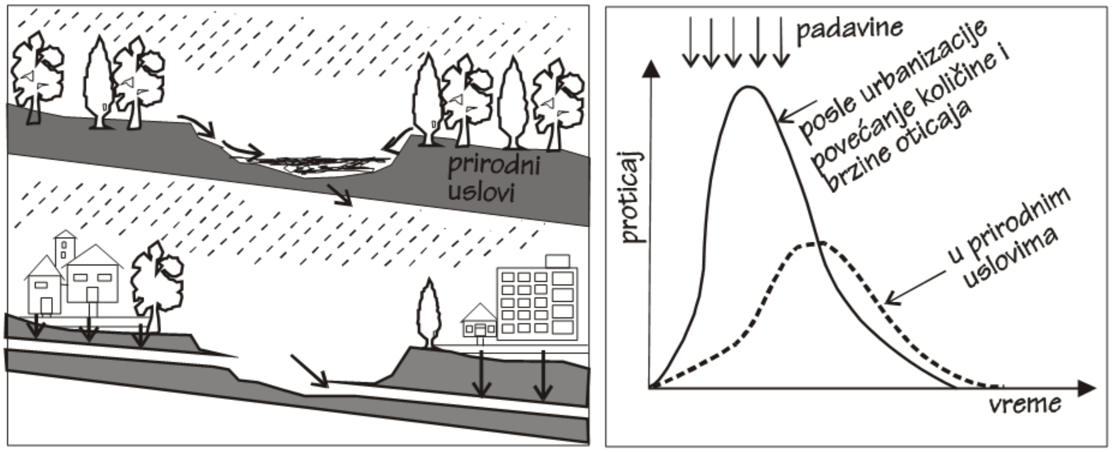
Finally, an important impact of high temperatures which maybe is not directly related to coastal space, but it is related to demography, is impact on **human health**, i.e. increased mortality and morbidity due to heatwaves. Urban areas with a large concentration of people are particularly sensitive on health effects of climatic change.

3.1.2. Impacts of flash floods

Although the hydrological cycle will be disturbed in the summer months through the occurrence of longer periods of drought, on the other hand, there will be more intense precipitation in the basins in winter months, which will result in frequent flash floods. As a result of intense rainfall and extreme conditions, flash floods and landslides can occur, which lead to various negative impacts on coastal space - damage to buildings and other residential facilities, as well as interruption of services such as electricity supply, lighting supply, water supply, etc.

Picture 5 Torrential floods in Meljine (Herceg Novi) and on the road Tivat-Radovići

Urban areas are characterized by a high level of surface sealing in the form of buildings and other impervious surfaces such as roads and parking lots. Sealed soil, as a result of increasing urbanization, leads to the loss of areas for precipitation infiltration. Climate change brings an increase in extreme weather events, including heavy rains. As a result, the occurrence of floods in cities will become more frequent. The complete change of natural conditions in the middle and most downstream parts of the watercourses cause a major change in the outflow regime from these watersheds to the sea. The occurrence of larger runoff in urban areas as a consequence of intensive urbanization and the increase of impermeable surfaces not only reduces the amount of water that could infiltrate into the underground, but during the drainage of precipitation in such circumstances, the peak flows of rainwater also increase, due to reduced retention on the surface.



Picture 6 Urbanization leads to great changes in rainwater runoff [23]

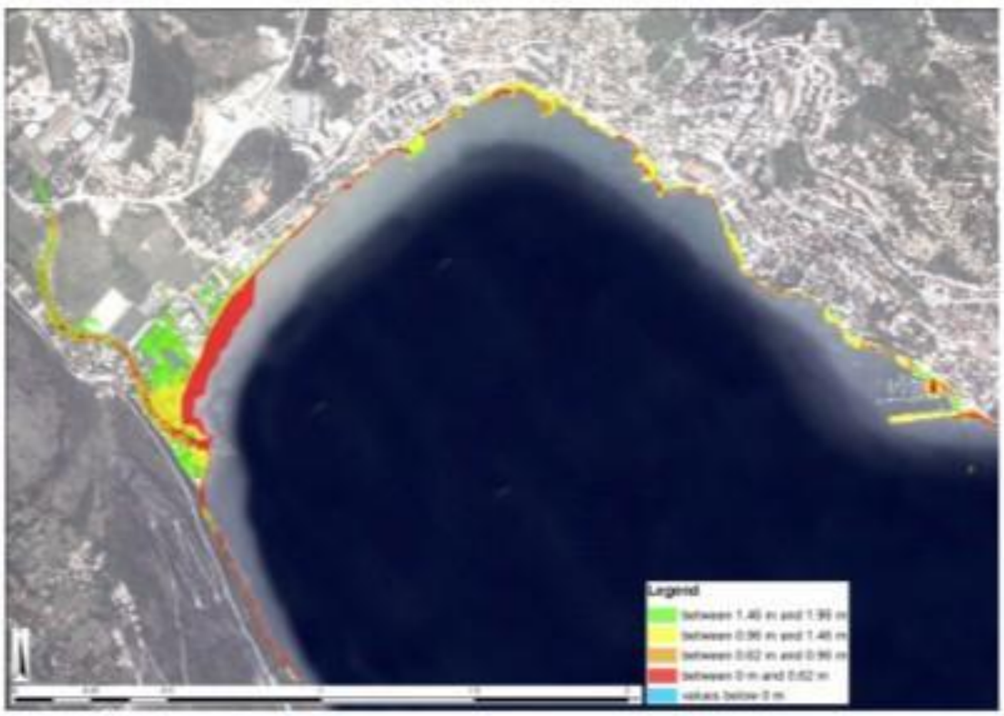
Floods on territories municipality of Kotor caused are flooding from torrential flows and from the underground water with dominant influence of the sea as recipient which is unable to receive such quantities water, which presents danger to citizens and material goods. An example of this is the city of Kotor, where often, during abundant precipitation, flooding occurs. Kotor waterfront, Trg od oružja, Gurdić , as and a few more locations in Old town, are flooded as a consequence of abundant precipitation, rapid increase of underground outflow in Gurdić-Škurda area, and due to rising sea levels [7]. The second part of Kotor municipality that has risk from flooding is Kavačko polje , i.e. main road Radanovići - Lastva Grbaljska , where quite some residential units are constructed below the level of main road. The parts of magisterial road in Perast and Kostanjica are also endangered. More frequent floods in the area of Kotor are in part accelerated by injectable curtain in the immediate hinterland (between Škurda and Tabačine), which goal is prevention of salinization of karst water sources in Tabačina. Sudden outbursts of groundwater water often interrupted the traffic through the tunnel Vrmac.

3.1.3. Impacts of sea level rise and marine floods

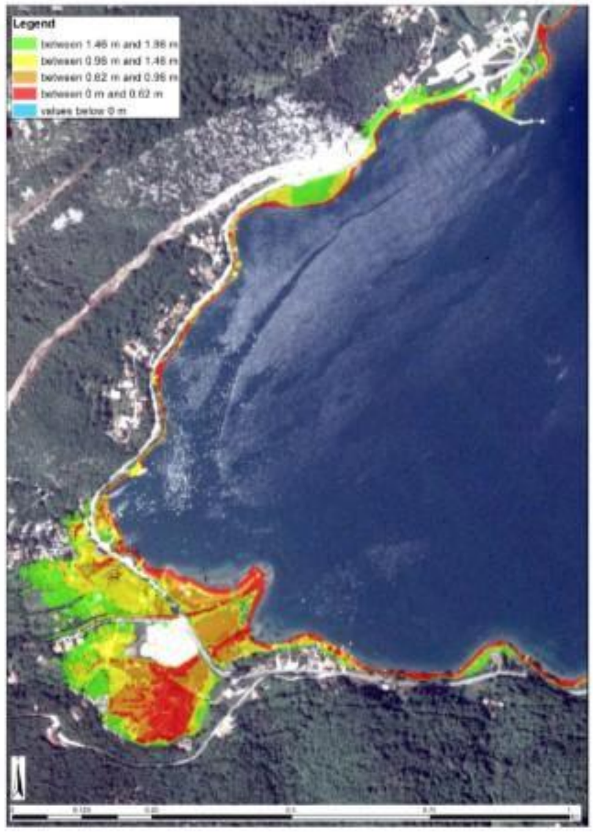
Sea level rise scenarios until the year 2100 were developed for Montenegro within the framework of the CAMP project [6]. The first and second scenarios are based on IPCC projections in combination with local height corrections, so the first scenario is +62 cm, and the second is +96 cm. The third and fourth scenarios add the highest locally recorded sea level in the period 1978-

2013 to the IPCC's sea level rise scenarios, so the third scenario is +146 cm, and the fourth is +196 cm.
Rising sea levels due to its thermal expansion, in combination with meteorological and oceanographic factors, could lead to major floods in the following areas: Igalo, Morinj, Tivat, Kotor, Krtoli (Solila) and Bigova.

Igalo Bay could be problematic in the West part where would the water could progress through the channel. This area would be significantly endangered already in case the first scenario. In case of the second scenario, the threatened area would progress further westward and eastward. Seawater would also cover almost the entire land on the seaward side of the road, except for the elevated residential area.



Picture 7 SLR projections for the Igalo area by the year 2100 on based on four scenarios



Picture 82 SLR projections for the Morinj area by the year 2100 on based on four scenarios

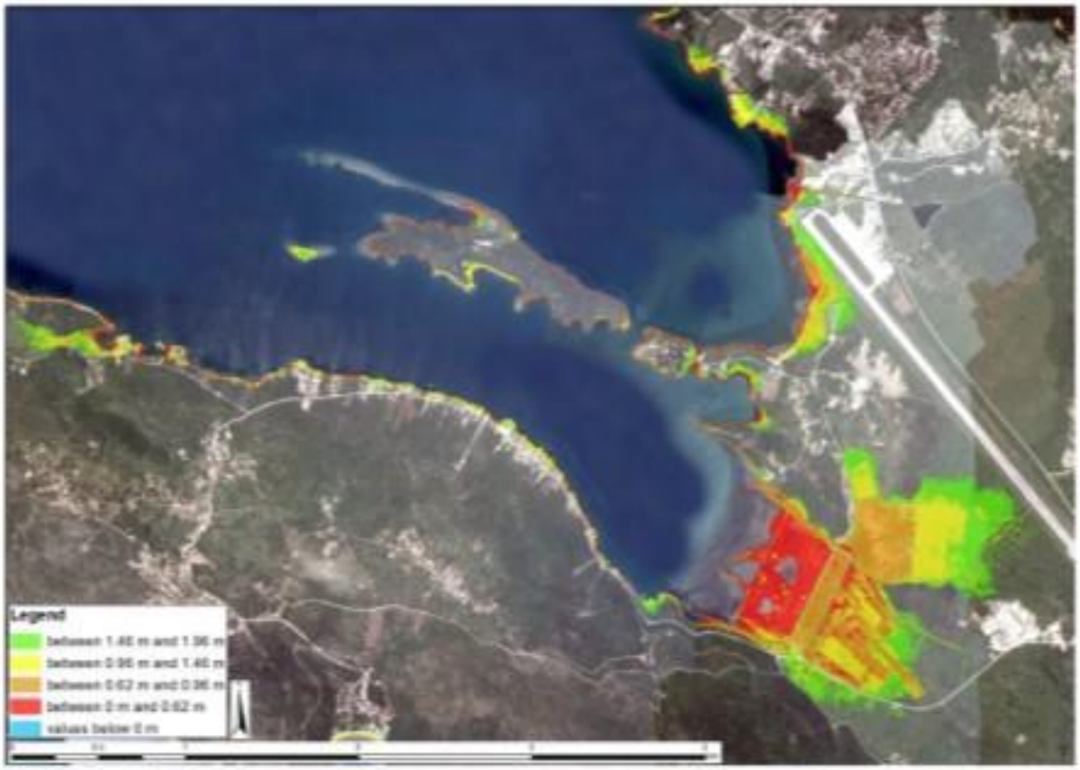
In **Tivat**, only the areas immediately next to the sea have elevations below 62 cm. Therefore, the city is a well-protected scenario in the first scenario. In the case of the second scenario, Tivat seems relatively safe, except for some parts around Kalimanjska road and Ribarski put, where elevations are lower than 96 cm. The situation is significantly worse in the third and fourth scenarios, because the seawater in some parts of the city would progress to the Jadranska magistrala in the southeast, and exceed the Obala Filip Milošević road in the northwestern part.

Picture 9 SLR projections for the Tivat area by the year 2100 on based on four scenarios

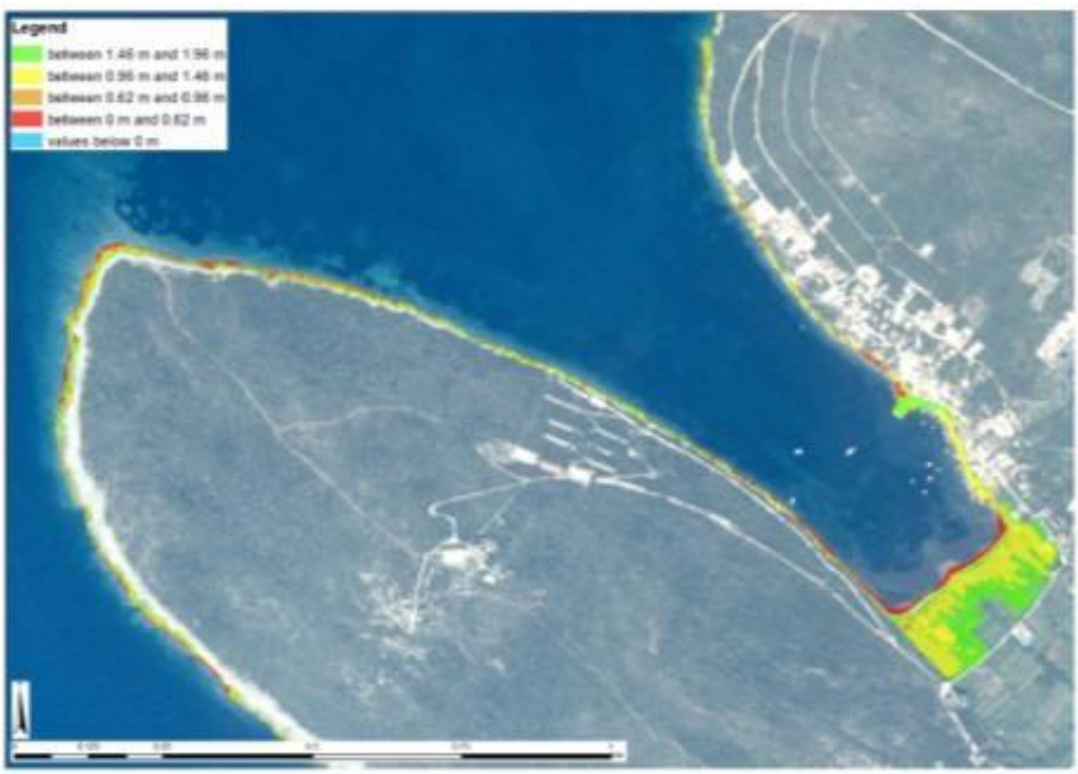
Similar to Tivat, Kotor is also well protected in case of the first scenario. It seems that the lower area around Knežev Dvor is well protected by the higher coastal pavement in the case of the second scenario, but only up to the front of the Monastery of St. Francis, where the pavement descends again. In the case of the third and fourth scenarios, probably the higher pavement would not protect the old town from flooding. Freedom Park would already be under water in the second scenario, as well as the area of the triangle near Trg od oružja (near the seaward city gates).

Picture 10 SLR projections for the Kotor area by the year 2100 on based on four scenarios

Tivatska Solila nature reserve would be significantly submerged already in the first scenario (toward the west to the first road crossing). In the case of the second scenario, the seawater would also flood the area between the two road intersections and advance significantly more to the east and north (towards the Tivat airport). Tivat Airport, however, would remain above water in all four scenarios.



Picture 11 SLR projections for the Krtola/Polja area by the year 2100 on based on four scenarios



Picture 12 SLR projections for the Bigova area by the year 2100 on based on four scenarios

Potential impacts of sea level rise due to climate change will have several physical and ecological effects on the coastal area:

- **Flooding due to storm surges** (combined with intense rainfall)
- **Coastal erosion**

As for the impact of storm surges, i.e. high waves, it is moderate in most of the Boka Kotorska Bay, with the exception of the Hercegnovski Bay, where several locations are exposed to the wind. Two areas particularly sensitive to marine floods, even if we exclude the future rise of the sea level, due to the low coast, are: the **mouth of the river Sutorina** (discussed in chapter 2.2.3) and the area of **Tivatska Solila** (discussed also in this chapter). In addition to the mentioned areas, storm surges also affect Herceg Novi and its **Pet Danica promenade** and can cause damage to the city harbor [7].

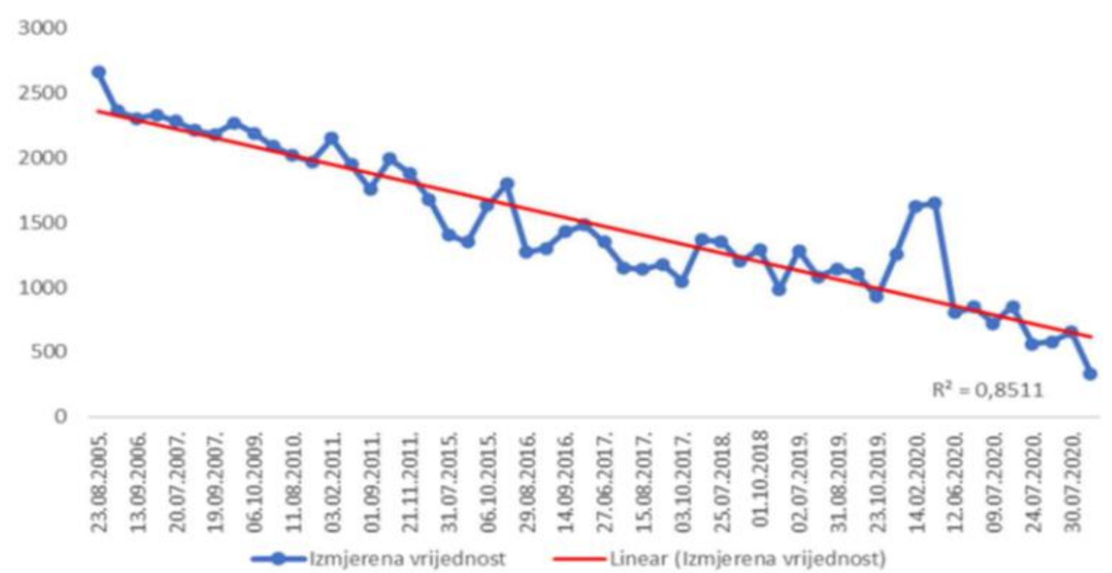
Picture 13 Floods in Kotor due to tidal waves

As for coastal erosion, it is a problem especially on natural beaches in Montenegro due to the effect of natural and anthropogenic factors. In the last few decades, intensive erosion processes have been observed on many beaches, so their widths are gradually decreasing, and their surfaces are significantly reduced. The impact of rising sea levels and storm surges will have an erosive effect, especially on the sandy beaches - **Morinj** and **Igalo**, as well as **Solila** within the BoKa kotorska Bay, and the beaches **Plavi horizonti, Velja Špilja** and **Arza on the Luštica peninsula.**

3.2. Impacts of climate change on water resources

Climate change in the area has manifasted in last decades through an increase in air temperature, an extension of the dry period, an uneven precipitation regime, changes in the intensity of precipitation, occasional record multi-day storm precipitation in the dry period of the year, a decrease in the annual amount of snow – which all led to a disruption of the hydrological cycle, a more pronounced formation torrential flows, floods and landslides. In general, climate change will have significant impact on availability of water resources and on water quality, as well as on frequency of hydrological extremes.

Climate change scenarios indicate on worrying picture of growth in number of consecutive dry ones days and dry period (see chapter 2.1), which additionally stresses out the importance and **endangerment of water supply for Boka Kotorka** . These extended dry periods will have a negative impact on the exploitation of water from most local springs, and further worsen the water supply problem, bearing in mind the declining yield of the regional spring "Bolje sestre" (from planned 1500 l/s to current 334 l/s).



Picture 14 Declining yield trend on Bolje Sestre source (CEMA 2020 [38])

Starting from projections that indicate disruption of the hydrological cycle, we will have more intense precipitation in the basins, which will result in **frequent flash floods**.

In the case of low coastal karstic aquifers, prolonged periods of drought lead to more pronounced earlier d**isturbances of the equilibrium boundary zone between salt and fresh water and**

salinization of the source. Such is the case with the karst springs of Boka Kotorska included in the water supply systems: the source of Škurda, included in the water supply system of Kotor; the Spilje source, included in the Risan water supply system; and Plavde, included in the Tivat water supply system. These impacts, combined with rising sea levels, will become even more common.

From projected climate change and pressures on water resources, we can expect following changes in the hydrological balance and water regime in the future:

- more penetration of seawater into land and reduction of capacity of coastal freshwater resources,
- changes in water exchange/balance in the bay,
- changes in the domain of urban hydrology due to dramatic land cover change in small watersheds
- hydromorphological changes in smaller basins;
- change of seawater quality due to changes in regime freshwater inflow regime.

Expected problems based on the above are:

- problems in water supply especially during the tourist season;
- problems in functioning of system for drainage of wastewater and storm water runoff;
- extreme precipitation which will generate flash floods waves on torrential watercourses. All which is located in vicinity of coastline will be flooded, with urban areas particularly endangered (see chapter 2.3) and more pronounced problems with landslides and eroding coasts
- more frequent marine floods due to storm surges, as well as due to the overflow of underground water in the area of the old town of Kotor. The combination of these two factors can cause a big problem (*compound flooding*)

3.3. Impacts of climate change on Bay's marine ecosystem

The warming of the sea will lead to multiple changes in the composition and distribution of different marine life communities. The **increase in sea temperature** creates favorable conditions for the **spread of thermophilic species**. New species can become domesticated and suppress native species,wghic can lead to the disappearance of domestic species and affect the change in biodiversity. In the area of Boka Kotorska Bay, new species of fish, crabs, sponges, shells, crustaceans and algae have already been registered, but due to the lack of a monitoring program, there are no data on their impact on indigenous species. An increase in seawater temperature leads to changes in sessile organisms, so the death of the stony coral *Cladocora caespitosa* and the appearance of bleaching of corallites are associated with sea warming and changes in the seawater chemistry. In addition to changes in sea temperature, climate change also leads to **changes in salinity**, where salinity on the surface increases due to large evaporation. As organisms are adapted to certain salinity values, any significant change can lead to the disruption for certain species.

An increase in the concentration of CO_2 in the atmosphere also leads to its increased solubility in the sea. The increased number of hydrogen ions in the sea is a problem because it reacts with carbonate ions (CO_3^{2-}) that marine organisms with carbonate body parts incorporate for construction. This process is known as **ocean acidification** (lowering the pH values) and causes the dissolution of carbonate structures and prevents their construction due to the reduced number of carbonate ions used for this purpose. The increase in the concentration of CO_2 in the seas directly affects a number of marine organisms, especially those that calcify and use carbon to build shells. Corals are considered to be the most threatened by ocean acidification.

The rise in sea temperature, accompanied by the thermal expansion of seawater, will, in combination with the melting of glaciers, lead to a **sea level rise**, which will have multiple consequences on marine biodiversity, as well as on terrestrial, coastal life. When the sea level rises, there are changes in the structure of the biocenosis in the littoral zone. Salty sea water that enters terrestrial parts leads to changes in the chemical composition, which causes changes in the biocenoses of terrestrial organisms. Erosion processes are accelerated, which results in changes in habitats and in the chemical composition of the marine environment.

Episodes of higher amounts of precipitation in a shorter period of time lead to a sudden rise in water levels and river inflows, and the overflowing of local rivers and streams, as well as sewage systems. The consequence of such floods in the marine environment is the **deterioration of seawater quality**, which can lead to microbiological pollution of bathing water, eutrophication and damage to local mariculture. Due to the influx of large amounts of nutrients, which can be a consequence of sudden and uncontrolled rainfall, there are changes in the composition and biomass of plankton, as well as unwanted blooms that have negative consequences for the ecosystem, as well as for tourism, recreation, fishing and mariculture. High abundances of algae can clog the gills of fish and other marine organisms and thus cause suffocation. Certain species also produce phycotoxins that reach humans through the food chain and cause poisoning.

In the *Third National Communication on Climate Change for Montenegro* (2020), the assessment of the sensitivity of the marine ecosystem to changes in seawater temperature showed the sensitivity of the populations of autochthonous marine organisms that inhabit the Adriatic. The key impacts concerning the marine ecosystem are:

• changes in the composition of natural communities, an increase in the number of certain species, and a decrease or complete disappearance of some other species;

• increase in the number of new species of marine organisms because they lack natural predators and do not compete for food and space; and

• impacts on local communities in the coastal area, such as reduction of fish catches, damage to fishing gear, as well as the presence of highly toxic puffer fish, dangerous to human health.

Monitoring results in the fisheries sector show that five new species of fish were recorded: *Saurida undosquamis*, *Siganus rivulatus*, *Iniistius pavo* and two species of barracuda *Sphyraena viridensis* and *Sphyraena chrysotaenia*. In addition, data on autochthonous species show that some species have completely disappeared (*Acipenser naccarii, Squatina squatina, Trachipterus trachypterus* and *Argyrosomus regius*), while some have decreased in number (*Labrus merula* and *Sciaena umbra*).

4. RECCOMENDATIONS FOR MEASURES OF ADAPTATION TO IMPACTS OF CLIMATE CHANGE

4.1. Measures of adaptation of coastal space to climate change impacts

4.1.1. Implementation of coastal setback zone

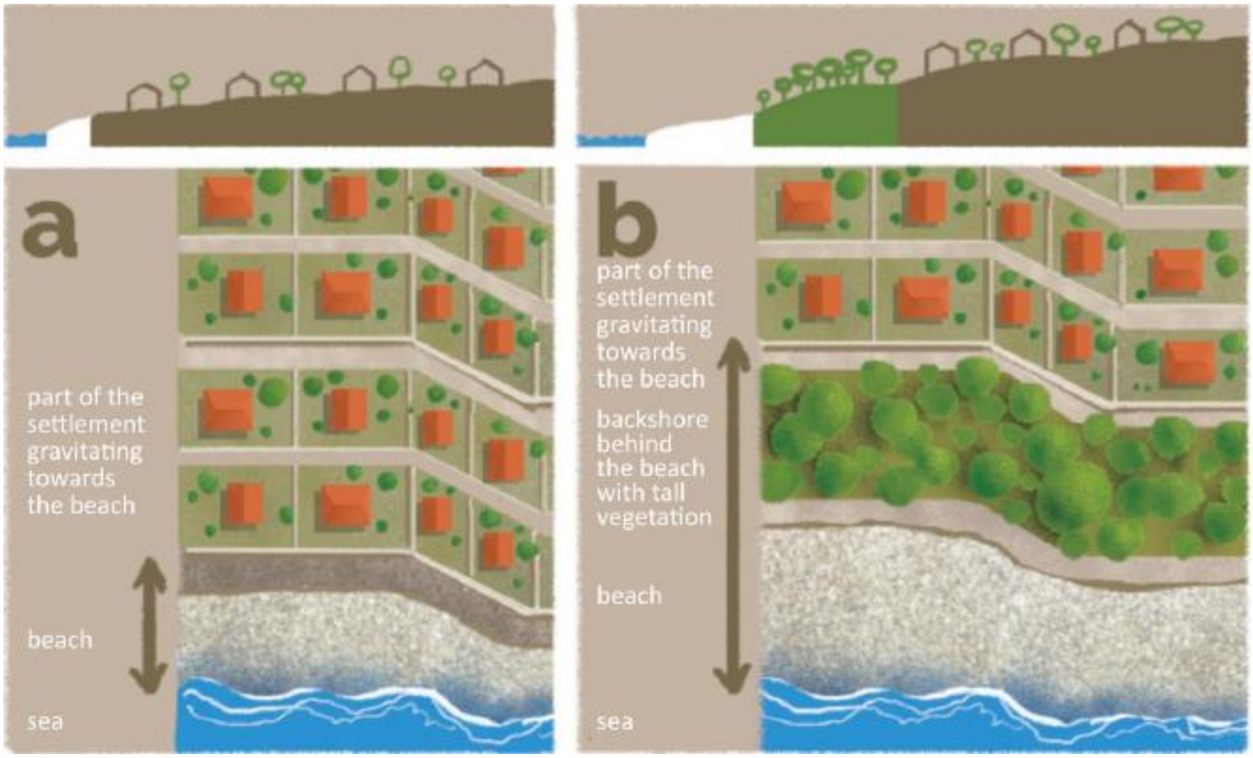
Respecting the coastal setback line ensures the protection of the population and settlements on the coast, primarily from floods and erosion, by reducing the number of new properties along the coastline itself (e.g. residential buildings, infrastructure and business premises). These impacts are expected to become more intense with climate change, so the implementation of coastal setback is also a way of proactively planning adaptation to climate change. The application and respect of the coastal setback also contributes to the preservation of biodiversity and creates the potential for new habitats. This is also in accordance with its protective function: space is provided for vegetation that can mitigate the effects of waves. There are other ecosystem service benefits of coastal setback applications, such as maintaining water quality and enabling natural cycles of sediment balance.

In addition to its "protective role", the coastal setback ensures its public use, as well as the passage along the coast itself. The application of the setback line in planned tourist zones does not represent an obstacle or limitation for investment, but increases the possibilities for tourism development, economic use of beaches and recreational activities. Setback should be welcomed by tourism projects of a higher standard, since it allows for the arrangement of public, green, recreational, beach and similar facilities, while the accommodation part is realized behind the setback line. The public interest in the use of marine resources needs to be ensured both in populated areas, tourist resorts, ports of nautical tourism, as well as in uninhabited and natural zones.

In a recent study by Lincke et al. (2020)[5] on the example of Croatia, by combining protection and restrictions on construction in coastal setback zones, future costs incurred as a result of flooding of coastal areas can be reduced by up to 39%. It should be emphasized that the study only took

[5] Lincke, D., Wolff, C., Hinkel, J., Vafeidis, A.T., Blickensdörfer, L., Povh Skugor, D. (2020). The effectiveness of setback zones for adapting to sea-level rise in Croatia. Regional Environmental Change 20(46). https://doi.org/10.1007/s10113-020-01628-3

into account the benefits of coastal setback zones in terms of exposure to coastal flooding, while benefits in the area of biodiversity protection, maintenance of ecosystem services, coastal erosion or benefits for tourism and recreation were not taken into account.



Picture 15 Illustrated concept of coastal setback zone (illustrated by Luka Duplančić)

The Protocol on Integrated Coastal Zone Management of the Barcelona Convention (ICZM Protocol) identifies a width of at least 100 m from the coast as an agreed measure to protect coastal settlements and infrastructure from the negative impacts of coastal processes (Article 8 of the ICZM Protocol). Article 8 of the ICZM Protocol allows several exceptions to the designation of coastal setback zones, namely "for projects of public interest" and "in areas that have special geographical or other local restrictions".

Montenegro ratified the ICZM Protocol with the Law on Confirmation of the ICZM Protocol ("Official Gazette of Montenegro" - International Treaties, No. 16/11) and thus the Protocol became an integral part of the internal legal system of Montenegro. In the narrower coastal zone of Montenegro (100m from the coastline) in the zones outside the settlement, the construction of buildings is prohibited according to the criteria defined by the Special Purpose Spatial Plan for the Coastal Area of Montenegro (PPPOCG, 2018), and based on the analysis from the CAMP project[6] and in accordance with National ICZM Strategy of Montenegro. These criteria have been

[6] CAMP Montenegro (2013) Defining the Coastal Setback, PAP/RAC, October 2013.

transferred, or are currently in the transfer phase, to lower-order plans - spatial urban plans (called PUPs) of the three municipalities of Boka Kotorska.

Within the framework of the previous activities of the CAMP project[7], a vulnerability analysis was made for the narrow coastal zone[8], which determined the vulnerability of the narrow coastal strip by individual segments of the environment. This analysis identified areas where there are conditions for extending the coastal setback, because the ICZM Protocol provides for exceptions to the application of the coastal setback for areas with special geographical and other restrictions, as well as for projects of public interest that must be determined by a national legal act in accordance with the principles and objectives of this Protocol. Within the framework of this analysis, zones for the expansion of the coastal zone were proposed for some locations in the Bay of Boka Kotor: the mouth of Sutorina, the mouth of the Morinjska river and the Tivat salt marsh.

Picture 16 Example of the setback line (turquoise line), built and unbuilt areas in part of the municipalities of Herceg Novi and Tivat (taken from[9])

[7] https://iczmplatform.org/page/montenegro

[8] CAMP Montenegro (2013) Vulnerability Assessment of the Narrow Coastal Zone, PAP/RAC, July 2013.

[9] CAMP Montenegro (2013) Defining the Coastal Setback, PAP/RAC, October 2013.

4.1.2. Preservation of natural beaches and coastal forests, and coastal afforestation

It is necessary to preserve natural beaches and coastal forests, encourage the natural regeneration of forests and indigenous vegetation, and reforest where necessary. In the narrow coastal zone this is especially important because of the tackling coastal erosion, which could become more intense with climate change due to rising sea levels and stronger waves. The intensity of erosion processes can be reduced by maximum protection of the natural features of the coast and coastal marine and plant habitats, with the prohibition of the construction of buildings in the immediate vicinity of the coastline.

Coastal setback zone gives the opportunity to develop a green cover which, in addition to anti-erosion properties on the coast itself, also provides mild microclimatic conditions - lowering the temperature and enabling shading, which benefits the local population and tourists on warm days. Coastal vegetation and forests provide shade, scents, color, sounds, protection from the wind, and generally deepen the feeling of touch and connection with nature, which is also reflected in the increased tendency of guests to stay in "greener areas".

The narrow coastal belt supports natural vegetation that is evolutionarily adapted to live in rather harsh conditions of exposure to the sun, wind, waves and salt (eg *Tamarix sp.*, *Crithmum maritimum*). Tamarix, for example, is planted on some beaches in neighboring Croatia precisely because of its resistance to drought and particularly high salinity. In Montenegro, in Ulcinj, right next to Velika plaža, there is a coastal pine (*Pinua pinaster*). With the support of the Japanese State Agency for International Cooperation (JICA), and as part of the Capacity Building Project for Disaster Risk Reduction through the National Information System for Forest Fires, in October 2022 afforestation (filling) of the existing stand was carried out. At the end of 2023 it can be stated that, bearing in mind the very high level of "received" seedlings, the action was absolutely successful.

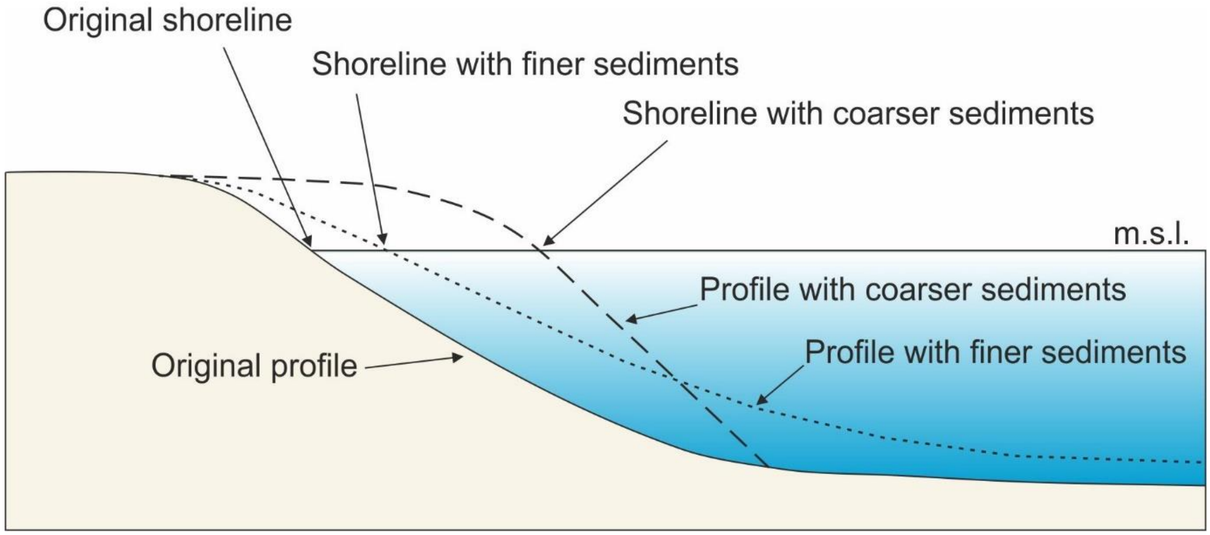
Due to the above-mentioned conditions (drought, salt water) in the narrow coastal area, the choice of species is very important when reforesting, one should give priority to autochthonous vegetation and use seedlings from seeds of autochthonous provenance from registered seed facilities in the territory of Montenegro (PPPNOPCG, 2018). Different species thrive differently on certain substrates, so with selected species, before each major planting, it is necessary to ask the Forestry Administration for advice.

Picture 17. Coastal reforestation on the island of Vis, Croatia (photo: I. Belamarić)

4.1.3. Measures for the adaptation of beach areas with minimal environmental impact

The growth of tourism in recent decades has initiated the practice of transforming the natural coast, that is, expanding the coast (and beach areas) towards the sea in order to provide space for new tourist infrastructure. Although tourism is the main motive for expanding the beach area, such operations should be carried out according to different criteria, starting from adaptation to climate change (floods and erosion), taking into account the preservation of the landscape and biodiversity.

The most common type of beach area creation is beach nourishment, i.e. the artificial placement of sand/gravel on the eroded coast, which keeps the material on the coast and mitigates the impacts of erosion, and protects the area from storm surges. Although the two terms are often used for the same process, as a rule, beach nourishment should not be confused with beach extension, i.e. its expansion beyond the dimensions of the beach for tourist and recreational purposes. Often, under the justification of remediation of beach erosion, large amounts of fine material are poured into the sea at the bathing areas along the Boka Kotorska Bay, whereby some beaches grow in surface area, and the sea that is covered with this material. This is done mainly before the tourist season for the needs of beach tourism.



Picture 18 Beach profile after nourishment performed using materials of different particle sizes (based on an illustration by E. Pranzini)

Nourishment can have a harmful effect on living life in the coastal zone, especially on the burial of benthic (macrobenthos, meiobenthos and microbenthos) organisms, but also on commercial species (such as shellfish, crabs, sponges, bottom fish, etc.). Nourishment with finer material can lead to turbidity of the water column (and thereby impact on photosynthesis) and to congestion - clogging of fish gills, harmful effects on plankton larvae, molluscs, etc. According to research by the Beachex[10] project in Croatia, **significant harmful effects are caused by admixtures of particles smaller than 0.063 mm** that float and cover a wide area around the beach, **therefore the proportion of such particles in the material should be as small as possible**. Feeding activities should be limited, especially in areas where they can have a serious impact on protected species (for example, *Pinna nobilis*) and other important marine habitats (for example, meadows of *Posidonia oceanica* and other seagrass species).

[10] http://grad.hr/beachex/


Picture 19. Example of dispersion of finer sediment after nourishment (source: http://jabuka.tv)

Nourishment material should match the source material in terms of size, color and mineral composition, so finding a source with sufficient quantity and quality of such material is a challenge. In some cases, material taken out for another purpose can be used when nourishing the beach, which enables reuse of the material and reduction of costs, but also calls for special caution because such material can be contaminated. Regarding the use of concrete in the formation of beaches, the PPPNOPCG proposes a complete ban on this practice.

Beach replenishment activities must be approved through an environmental impact assessment and the consent of the competent institutions. One of the main findings of the study "Variant models for the formation of new bathing areas in the Bay of Kotor" (JPMDCG)[11] is that "in addition to certain beneficial effects, the current practice of embankment of the coast and the unscientific approach in the selection of locations for the construction and embankment of the bathing area resulted in negative effects in terms of natural and artificial environment and investments." The study of the Institute of Marine Biology "Research and mapping of biological parameters of the sea at locations intended for use and construction" established the level of influence of sand filling on the biological parameters of the sea in certain localities: in a large number of localities, sand filling has a significant impact on biological parameters must and sometimes so much that it should not be allowed. For some larger bathing areas, a study of the possibility of stabilization of the embankment and solution projects should be done, which would ensure the rationality of the intervention and the elimination of negative consequences for the marine environment, while checking the impact on the biological parameters of the sea. Such a possibility was hinted at in the

[11] JPMDCG (2021) STUDIJA VARIJANTNI MODELI ZA FORMIRANJE NOVIH KUPALIŠTA U BOKOKOTORSKOM ZALIVU. Podgorica, August 2021

IBM Study (2018). An example of a beach for which the possibility of sediment stabilization should be checked is Đenovići (Herceg Novi municipality). The model of beach replenishment in combination with the construction of some protective measures in the sea, in order not to achieve permanent protection of the coast from erosion solely through nourishment, was also hinted at in the PPPNOPCG. Marine Spatial Plan of Montenegro[12] specifies the implementation of beach nourishment without protective structures, but in exceptional situations with the construction of submereged breakwaters to prevent the movement of bulk material along the coast.

On the other hand, the study "Variant models for the formation of new bathing areas in the Bay of Kotor" mentions a pronounced lack of bathing space in the Bay, referring to a study on the tourist reception capacity of the Montenegrin coastal area[13]. According to that study, in relation to the users of the municipalities of Boka (Herceg Novi - 36,224; Kotor - 15,585; Tivat - 7,029), there is a lack of approx. 294,000 m2 of bathing area in the Bay, counting at least the minimum area of 5 m^2 of bathing area per user. It should be said that in Article 18 of the Law on the Protection of the Natural and Cultural-Historical Area of Kotor, it is established that "the existing coastline cannot be changed and the embankment of the seashore cannot be done, except in the case of its rehabilitation and revitalization", which limits the possibilities of overcoming the difference between the carrying capacity of the beaches and pressure on them.

JPMDCG has been nourishing smaller local beaches/swimming areas on several occasions in recent decades, usually in the spring after winter storms (which erode the beach) and before the summer season. In recent years, replenishment has been carried out on the basis of the *Beach Nourishment Program* approved by the Environmental Protection Agency. The program from 2016/2017 provided for nourishment in the municipality of Herceg Novi approx. 1000 m^3, Kotor approx. 400 and Tivat approx. 140 m^3. It is irrational to maintain some smaller beaches/swimming places with nourishment because they are mainly: either located in the UNESCO protected area; or the slopes of the coast and seabed are greater than 10 or even 15%; or there is an evident or expected negative impact on the biological parameters of the sea.

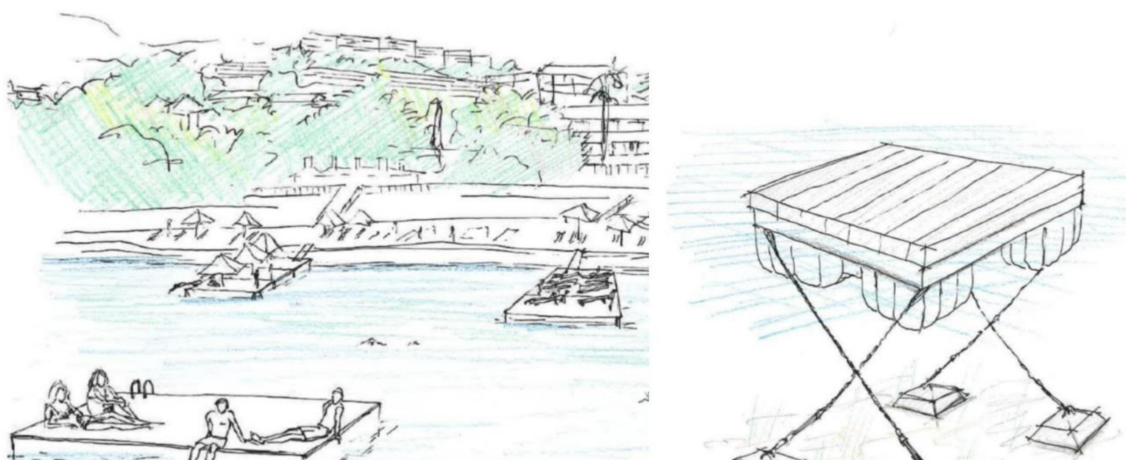
According to the study "Variant models for the formation of new bathing areas in the Bay of Kotor", the piers should be made of stone, concrete should be avoided. In addition to the exploitation of river aggregate[14], the aggregate can also be shaped by leaving it to the action of rivers. In the case of revitalization and rehabilitation, it is necessary to solve the washing-away of the beach by setting thresholds, strengthening the groynes/piers, thus securing the embankment from further washing-away and negative impact. There is already a significant number of beaches, which have

[12] UNEP/MAP-PAP/RAC i MEPPU (2021) https://www.adriatic.eco/wp-content/uploads/2021/12/WEB-MSP-for-Montenegro.pdf
[13] Klarić, Z., Kranjčević, J., & Marković, I. (2013). Turistički prihvatni kapacitet crnogorskog priobalnog područja. PAP/RAC, Split.
[14] "Aggregate" refers to a combination of particles of certain materials of a certain size

a negative effect on the ecosystem, and significantly disrupt the aesthetics of the environment (beaches in front of tourist facilities in Baošići, Bijela, Jošice, Dobrota...)". The price of the mentioned aggregate (5-50 mm) is approx. 30 euros per cubic meter. Taking into account that the recharge of existing bathing areas is not below 10 cubic meters, more often it is 30, and that this kind of intervention is done often, the profitability of new creation in this way is clearly questionable.

All of the above indicates that it is necessary to develop a **formal procedure and guidelines for beach nourishment in Boka Kotorska Bay, which will have a minimal negative impact on the environment**. All relevant institutions, such as the Environmental Agency, Institute of Marine Biology, JPMDCG, and others, should participate in the drafting of such guidelines. The current plans and programs do not provide a reliable procedure for the implementation of quality solutions, even in the case of planning solutions of a detailed level. Marine Spatial Plan of Montenegro also states the need for beach nourishment to be carried out on the basis of special analyzes of the possible impact on wildlife in the coastal zone, and that it should be carried out along with biological measures to protect the coast from erosion by establishing a vegetation zone in the coastal area exposed to erosion.

In addition to beach nourishment, one of the options for creating an alternative beach space are **floating surfaces**, that is, **smaller pontoon bathing areas of a demountable nature**, which are considered to have a less harmful impact on the environment. This variant was discussed in detail in the study "Variant models for the formation of new bathing areas in the Bay of Kotor" by JPMDCG, in which it was emphasized that floating surfaces should be avoided in areas of large *Posidonia* meadows due to shading.



Picture 20. Illustration of pontoon bathing areas (source[15])

[15] JPMDCG (2021) STUDIJA VARIJANTNI MODELI ZA FORMIRANJE NOVIH KUPALIŠTA U BOKOKOTORSKOM ZALIVU. Podgorica, August 2021

The existing, traditional **small piers**, which are the specificity of Boka Kotor, should be preserved, but should not be extended beyond the existing dimensions and should not be extended with concrete. Small piers should be bolstered using traditional drywall methods in order to preserve them as a form of cultural heritage and tradition, and they also have potential as a habitat for certain marine organisms. Access to the small piers in the area of Boka is often impossible, but in recent years, with the efforts of local inspectors, municipalities and controllers of the JPMDCG, an increasing number of once usurped small piers are now accessible to the local population and tourists.

4.1.4. Measures for flood protection

Flood protection implies an integral approach to the resilience of coastal area, which entails the limitation of anthropogenic activities in zones of high vulnerability, as well as the lands use change in certain areas (for example, the conversion of low-productivity and degraded areas into forest complexes).

Protection against the harmful impacts of excess water includes works and measures to protect against floods and erosion caused by rainfall, overflown streams and rivers, and the sea; as well as drainage from the surface and elimination of the consequences of such harmful effects. Protective works such as the construction and maintenance of protective infrastructure (various types of "hard" structures) and the performance of protective works (afforestation, weeding, terracing, riverbed cleaning, etc.) benefit the integrated flood protection.

Regulation, cleaning and maintenance of flood channels

It is necessary to carry out regular **cleaning and maintenance of channels and streams** in order to minimize flooding caused by heavy rains, i.e. to ensure the flow of water also in parts that are currently disrupted by various waste, auxiliary infrastructure, etc. In order for such activities to be functional, it is necessary to regularly **update databases on active torrential channels**.

The emphasis should be on the **natural regulation of torrential flows** as well as the protection of housing and other infrastructure from floods. Such regulation implies the use of natural materials in mandatory combination with living biological materials (grasses, reeds, bushes, shrubs, trees, etc.), which achieves multiple effects. In addition to natural regulation, the **renaturalization of the riverbed** should also applied, which refines the existing regulated riverbeds with the help of biological materials. It is also necessary to provide **retention areas** that serve for the maximum overflow of streams and rivers, thus preventing the occurrence of floods in other places. Such areas can be located along main streams to receive large amounts of water in extreme conditions with the aim of preventing life-threatening situations and major damage to urban or agricultural areas.

In addition that rehabilitation and revitalization of streams and rivers contribute to flood risk management by supporting the natural water retention capacity, they also strengthen the natural functions of streams and rivers that may have been lost or degraded due to human interventions: they also provide seasonal aquatic habitats, corridors of indigenous coastal vegetation, and encourage the refilling of groundwater and improving water quality.

Maintenance and construction of flood and erosion protection facilities

In order to prevent and eliminate the harmful effects of floods and erosion, it is necessary to implement special preventive measures: **build and maintain protective structures**. The construction of such infrastructure includes various embankments - which can be stone, concrete, defensive walls, etc. The construction includes embankments, flood ramps, and other objects in the riverbed, intended for its stabilization and improvement flow regime, etc.

As for the occurrence of **landslides**, certain measures to prevent such occurrences are also necessary. In addition to measures related to drainage, i.e. prevention of water accumulation (drainage), as well as afforestation measures due to root stabilization, there are certain geotechnical measures to stabilize materials at micro-locations that are vulnerable to landslides, such as the installation of protective geogrids. The locations in the area of Boka that could be sensitive to landslides are Mojdež and Savina in the municipality of Herceg Novi.

For **defense against sea flooding and consequent erosion**, the following measures are usually implemented: coastal fortifications, seawalls, breakwaters and various types of barriers. Detailed analyzes should be made of which methods are most relevant for protection against floods, erosion and sea level rise in locations known for their vulnerability to such phenomena (e.g Igalo, Morinj, Sutorina estuary, the old town of Kotor, etc.).

Due to climate change and increased vulnerability to waves and stormy seas, there is a certain possibility of protection in **seawalls**, which on the eastern side of the Adriatic usually have a lower height than on the western side. From the perspective of adaptation to climate change, the advantage of seawalls is the possibility of gradual upgrading, by increasing the height of the structure in response to sea level rise. Today, many such walls are made in a way that they have a certain slope, because the vertical ones repel the energy of the waves instead of dispersing it, which makes the coast in front of such structures susceptible to erosion. Considering the certain impacts on habitats in the intertidal zone, one should be extremely careful when choosing this form of protection against flooding from the sea. Recently, rough and hollow mounting blocks have been produced and installed, which favor the attachment of marine organisms. Although seawalls can reduce the attractiveness of the landscape, on the other hand, they can create additional space in the function of a coastal promenade, sunbathing area or bicycle path.


Picture 21. Seawall, in addition to its defensive function in case of bad weather, can have the function of a resting place in case of good weather (photo: Ivan Sekovski)

As for **breakwaters**, they have recently being placed underwater - *submerged breakwaters* - to reduce their impact on the landscape and to improve the circulation and quality of seawater. **Artificial reefs** are increasingly being used, which, in addition to reducing wave energy and protecting the coast from erosion, provide protection for fish and other marine organisms with their cavities, so they can also have a positive impact on biodiversity.

All technical measures for flood protection have certain impacts on the environment and it is very important to project/assess these impacts before deciding which measures to apply in a specific location!

Afforestation of degraded areas in the hinterland

Afforestation of degraded areas helps in absorbing excess water, i.e. in mitigating rapid runoff as well as preventing significant erosion effects. In the eroding areas, **forests and other vegetation should be preserved**, that is, any devastation, clearing and logging of forests should be prohibited; uncontrolled digging and leveling of meadows, pastures and uncultivated areas for the cultivation of annual crops; and undertaking all other actions that could lead to erosion and the creation of torrents. It is also necessary to afforest the upper courses of streams and rivers in accordance with the adopted plans on afforestation.

Mediterranean forests, although mostly made up of species normally resistant to drought, are increasingly threatened today due to the increase in the intensity, duration and frequency of droughts over the last few decades. This can lead to reduced resistance to harmful organisms, the spread of invasive species, forest fires and the release of CO_2. Therefore, a strategic approach to afforestation is needed by **choosing suitable species for planting and maintaining existing and new trees**, which takes into account local climatic and habitat conditions. In cases of poor choice of species, inappropriate planting or outdated forestry methods, afforestation will not be successful and will bring negative ecological and financial consequences. When choosing species for planting, it is definitely advisable to seek the opinion of the relevant institutions (Forestry Administration).

It is necessary to carry out **regular monitoring and control of the condition of the trees**, especially in the form of **pest control**, the occurrence of which could be more frequent due to climate change due to the fact that they certain pests can be favored by higher temperatures (eg Mediterranean bark beetle).

Picture 22. Dried pines due to the action of the Mediterranean bark beetle (photo: https://drustvomarjan.hr)

4.1.5. Fire prevention and rehabilitation measures

Forest fires affect a wide range of sectors such as forestry, agriculture, livestock, tourism and public health, and they also affect climate change by interrupting the function of the forest in absorbing carbon and creating new carbon emissions during the fire itself. An integral approach that recognizes the importance of including preventive fire protection measures in spatial planning and other sectoral plans is needed for efficient prevention and dealing with fires. Such an approach implies changes in spatial planning, the establishment of an early warning system, the application of activities before, during and after a fire, anti-erosion sanctions, strengthening the capacity of firefighters and others. It is easiest to divide the measures into fire prevention measures and fire rehabilitation measures.

Fire prevention measures

Special attention must be paid to fire prevention activities in open areas - green areas and forest areas, which have a high fire risk. **Cleaning dead trees, dry vegetation and waste** from the forest floor reduces the risk of ground fires, which are the most common type of fire. It is also necessary to **plant protective vegetation - olive groves, vineyards, orchards**, etc. In this case, in addition to the vegetation itself, the paths leading to the olive groves, orchards and vineyards are also restored, which makes it easier for firefighters to access. This kind of practice can be stimulated by incentives for ecological agriculture as well as animal husbandry (which helps to reduce dry low vegetation).

Picture 23. Treated surfaces stop the spread of fire (photographed by Nikola Tramontana)

The establishment and maintenance of firefighting routes and fixed facilities for monitoring forest fires is of great importance for extinguishing the fire itself. A certain type of fire roads can also be used for tourist purposes - as bicycle/panoramic paths, which opens the possibility for the tourism sector to participate in their construction and maintenance.

Places for water supply are also of great importance - **various retentions and ponds**, but also the **development of a hydrant network** (especially near locations vulnerable to fires). Retentions are very important in populated areas that do not have a built-in water supply system. On the contact areas between forests and urban areas, the possibility of using recycled water from wastewater treatment plants for firefighting should be investigated.

It is important to provide an **early warning system** - the technology for monitoring and detecting fires has advanced greatly and now various tools are available that warn of fires in "real time". One of such technological conditions for an efficient fight against forest fires is the **installation of a surveillance system with cameras for early detection of fires**. In neighboring Croatia, this type of system has proven to be quite successful - for example, in the operational center in Divulje (Split-Dalmatia County), a system of 99 cameras in 50 locations (working area of 8 km and visibility, depending on the weather situation, of 12 or more kilometers) enables firefighters to approach certain locations where the start of a fire is noticed within half an hour. Also, the **use of drones** is becoming more and more common, which can provide information on the structure of forests, their composition, volume or biomass, and provide precise information on the location, extent and development of fires.

Finally, **awareness-raising activities** to promote responsible behavior in fire prevention and proper response in emergency situations are also of key importance.

Fire rehabilitation measures

Burnt stands must be cut down and restored. It is necessary to rehabilitate burned areas by creating new forest or agricultural areas. The formation of new forest areas is also an anti-erosion rehabilitation measure. It is important that woody species that are not highly vulnerable to fires are used for afforestation. One of the key measures is the **prohibition of construction on burned areas**, which prevents a permanent change of use from green and undeveloped to urbanized areas.

4.1.6. Measures related to the preservation of green areas and urban greening

The system of green areas improves the urban areas in many ways. Green surfaces cool the air by shading and by increased evaporation of water, and thus reduce the occurrence of health problems of the population caused by the heat, but also reduce cooling costs in the summer. Green corridors in cities can change the urban microclimate of an area and improve the flow of cooler air from the environment into urban areas, which **reduces the urban heat island effect**.

Vegetation of green areas absorbs carbon dioxide and thus participates in mitigating climate change. The ability of vegetation areas to retain water and absorb water into the soil is an important property for preventing urban flooding and can reduce storm flows, while roots stabilize the soil and thus reduce erosion.

Urban vegetation reduces noise pollution, improves air quality, urban aesthetics and finally, green landscaping in cities creates jobs. Connecting fragments of green spaces is also useful for improving biodiversity and the dispersion of animal species in the urban landscape. Residents' health and feelings of happiness, security and protection improve when they have access to parks and other public (and private) green spaces.

Measures to preserve existing green areas in urban areas

It is important to **preserve and improve valuable natural landscapes** and specificities within them, and to **preserve the existing Mediterranean vegetation**, especially in the urban areas of the coastal zone where it also has an important anti-erosion effect. It is important to encourage the preservation of authentic landscape structures (obligatory greenery within the urban plot, preservation of the protected cultural landscape in the area of the protected natural area represented by: olive groves, chestnut forests, laurel, oak, oleander, pine, cypress and pittospora).

Due to the appearance of invasive species (e.g. the tree of heaven) and pests (e.g. Mediterranean bark beetle), as well as the potential danger of falling old/rotten trees on people and property, usually due to storms, it is very important to carry out **continuous monitoring** of such habitats and take certain steps - removal invasive species but also rotten trees that represent a potential danger. It is also necessary to remove vegetation with a high allergenic potential.

Creation of new green areas and green infrastructure in urban areas

By creating green areas and green infrastructure in urban areas, resilience to the impactsof climate change - heat, floods and erosion - is strengthened. In the spatial planning and arrangement of public areas, it is therefore necessary to ensure sufficient representation (or planned increase) of green areas within the construction plots themselves.

Picture 24. The role of greening in mitigating the heat in cities (illustrated by Luka Duplančić)

The greening of plots should be carried out by planting indigenous coastal vegetation, such as olives, citrus fruits and other Mediterranean fruits, cypress trees, palms, oleander, laurel and the like, i.e. priority should be given to indigenous types of greenery that are more resistant to extreme weather conditions, i.e. that tolerate them well high summer temperatures, high degree of drought, and gusts of strong winds. It is necessary to take care about planting plant species with the appropriate vegetation period (adaptation of the sowing date, securing the crop, increasing the yield).

Picture 25. Multiple functions of urban green infrastructure in the city of Dubrovnik, Croatia (photo: Igor Belamarić)

Examples of creating multifunctional and innovative green infrastructure include the following:

Greening of grey infrastructure

Greening and arrangement of green areas at brownfield locations, creating the potential of connecting green areas from neighboring plots. Green belts should be planned especially with critical infrastructure - hospitals, schools, kindergartens, nursing homes, parking lots, roads, etc. The greening of grey infrastructure also includes the greening of squares (mostly due to the cooling effect), as well as urban gardens on buildings with flat roofs and on larger terraces, and balconies of multi-apartment and public buildings (schools, kindergartens, etc.).

Green roofs and walls

A **green roof** is a multi-layer extension of a building's roof that is partially or completely covered with vegetation and substrate planted over the drainage layer. Green roofs reduce the temperature of the surrounding air by increasing evapotranspiration, and slow down the runoff of rainwater (they can retain from 40% to over 90% of precipitation)[16]. Vertical structures can also be covered with vegetation and form **green walls**.

[16] https://adriadapt.eu/adaptation-options/green-roofs/

Picture 26. Green wall in Aix-en-Provence, France (photo: Ivan Sekovski)

Green roofs are intended primarily for flat roof surfaces (although the slope of the roof can go up to 30 degrees), with the necessary soil layers and plant species adapted to the local climate, which should be self-sustaining. The weight of green roofs may require significant strengthening of the existing roof structure or the inclusion of additional structural support to the buildings. It should be emphasized that in cities with low rainfall, the costs of green roof irrigation may exceed the savings due to the reduced demand for energy in air conditioning units[17]. The city of Barcelona has issued detailed guidelines for the promotion of green roofs[18].

[17] Ascione, F., Bianco, N., de' Rossi, F., Turni, G., & Vanoli, G. (2013). Green roofs in European climates. Are effective solutions for the energy savings in air-conditioning? Applied Energy, 845-859.
[18]https://bcnroc.ajuntament.barcelona.cat/jspui/bitstream/11703/98795/5/Guia%20de%20terrats%20vius%20i%20cobertes%20verdes%20angl%C3%A8s.pdf

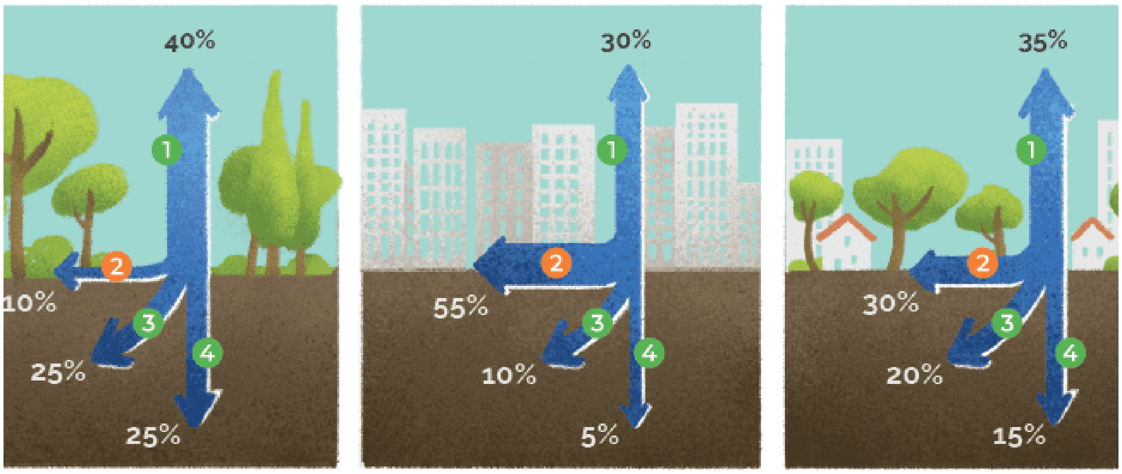
Picture 27. Green roof example (photo: Igor Belamarić)

In Boka area, as a first step, **a GIS cadastre of infrastructural facilities** in Boka municipalities that are suitable for green roofs (primarily public buildings with larger roof areas that have flat roofs or roofs with a slight slope) should be developed.

Reduction of impermeable surfaces in urban areas

Stormwater runoff in urban areas depends not only on the amount and intensity of precipitation, but also on soil permeability. In order to reduce the vulnerability of urban areas to floods, which will become more intense with climate change and create even greater pressure on urban drainage, it is necessary to form green areas with the aim of absorbing and purifying rainwater, primarily in key locations that often get flooded.

Sustainable urban drainage systems (SUDS) imitate natural drainage. Such systems usually incorporate vegetation (trees, shrubs, plants in general) and soil into artificial structures with the aim of increasing the permeability of the soil, which leads to positive effects, not only in reducing flooded areas, but also in restoring groundwater (a system of "rain gardens" and infiltration ditches). By increasing the absorption of rainwater, the runoff into the sewerage systems is reduced, thereby reducing the pollution load, as well as the risk of damages due to possible failures of the drainage systems due to floods. With the use of certain separators (oil and sediment), filters (for sand), sieves, sediment basins and channels, it is possible to remove pollutants and sediment from stormwater. Also, the water collected in this way can have its own purpose (e.g. for public watering), which can reduce the pressure on the potable tap water that is currently used for such an activity.



Picture 28. Contributions of permeable surfaces in reducing water runoff (1. evaporation, 2. water that remains on the surface, 3. surface absorption, 4. absorption in the aquifer) (illustrated by Luka Duplančić)

In addition to completely natural greening to increase the permeability of the soil, "grey" materials that contain voids through which rainwater can infiltrate should be considered. This model can be used on large flat surfaces that are otherwise completely "clogged/sealed" (eg **parking lots** whose surface is made of hollow blocks that are filled with sand or some other material that has the potential to absorb rainwater).

Picture 29. An example of a parking lot with a higher permeability of the material (photo: https://www.respectourwaters.org/pervious-pavement)

Measures for improved management of green areas

It is necessary to **establish a geo-information system for the management of public greenery and create a cadastre of public green areas** (the municipality of Kotor has such a cadastre, while the municipality of Tivat has one, but it is incomplete). Such GIS systems and cadastres should be regularly maintained and filled with as much information as possible for better management and maintenance of public areas (inventory of trees, description of localities and trees, photo documentation, historical facts, etc., which enables easier planning and implementation of maintenance of public green areas).

It is also necessary to **strengthen the inspection control of green areas** in order to determine the state of vegetation, the presence of pests and invasive species, checking the "health" of trees and the like.

4.2. Measures for water supply, sewage water and drainage of storm water, in light of changing climate

4.2.1. Analysis of the potential of existing and potential water springs

Bearing in mind the problems caused by the drastic drop in the yield of the spring "Bolje Sestre" and the uncertainty with the required amount of water in the future from this spring, coastal municipalities will inevitably face the **maximum possible exploitation of water from local springs** and from existing systems that do not use water from the spring "Bolje Sestre". This requires full dedication to enabling local springs for exploitation, which implies technical equipment, reduction of losses in the network, as well as the determination, establishment and control of sanitary protection zones of all springs for public water supply in accordance with legal regulations.

It is necessary to **analyze the potential of existing springs** from the aspect of capturing additional amounts of water, as well as to investigate potential springs in the area of Boka Kotorska that have not been explored so far, and which are assumed to be interesting in terms of the yield and quality of drinking water.

Although almost all springs in the coastal region have already been captured, there are parts of the Boka Kotorska terrain that justifiably represent potential underground water deposits. This refers primarily to the basin of the Morinj springs and the possibility of capturing additional quantities of water from the basin of the Opačica spring in Herceg Novi. It is completely justified to carry out the necessary research on the existing sources in order to assess the possibility of increasing the existing underground water reserves in the hydrological minimum at the following locations: parts of the Grbaljsko polje where underground water has already been determined by exploration and exploitation wells, the alluvium of the Gradiošnica River, the source of Plavda - construction of an underground barrier in order to increase exploitation possibilities in the summer period.

At all potential sources of surface and underground water, it is necessary to organize the monitoring of relevant parameters determined by the rulebook that defines the parameters of the state of surface and underground water.

4.2.2. Reduction of losses in water supply systems

Water shortages are mostly associated with insufficient amounts of water at sources, and are especially pronounced in the summer period, when the need for water is the highest. More pronounced droughts as a result of climate change, combined with the increased demand for drinking water in the warmer part of the year due to the increased number of tourists, will further exacerbate this problem in Boka Kotorska. Therefore, it is necessary to determine priority works and their dynamics to **reduce losses in water supply systems**. Water losses are large and unsustainable, so reducing losses represents the safest reserve of additional water quantities.

As capturing and bringing in additional amounts of water is almost always more expensive than eliminating water losses in the system, it is undoubtedly necessary to approach the reduction of losses in the existing system, especially in the current situation of drastically reduced capacities from the regional source from the hinterland of Boka Kotorska.

When **installing the future water supply network**, due to climate change, it will be important to take care that the water infrastructure is laid as far as possible from the coastline and as high as possible (at least 1m) above the mean sea level, so that the contact of waves with such infrastructure is as small as possible. Also, the materials of the water supply infrastructure must be resistant to the corrosive effects of seawater, and withstand high temperatures and temperature fluctuations well. On the other hand, the water supply infrastructure must be laid deep enough to protect against higher temperatures, because a higher temperature of the drinking water means a faster consumption of the concentration of chlorine residues and a lower potability of the water.

An integral part of regular measurements at the sources should be the **measurement of the salinity of the exploited water** in order to more accurately determine the beginnings of salinization and growth trends during the period of increased salt concentration in the source water. The salinity of spring water depends on the distance from the sea, the hydrological regime, and the intensity of spring water use. Rising sea levels due to climate change could further threaten groundwater.

4.2.3. Provision of water for drinking and watering in public areas

In light of climate change and health problems caused by high temperatures, it is of great importance to **maintain public drinking fountains and install new ones** in public areas in Boka Kotorska, where a large number of local residents and tourists reside. Not only does this activity contribute to cooling off and quenching thirst in the hot summer months, but it also consequently leads to a reduction in the amount of plastic waste (i.e. plastic water bottles used in the absence of publicly available water).

As for the watering of public green areas, rational water consumption should be ensured - parks and other green areas should be irrigated using the "drop by drop" system. It is also necessary to consider the possibility of irrigation with non-potable water (collected rainwater or purified waste water) in order to rationalize consumption as efficiently as possible.

4.2.4. Climate-resilient wastewater infrastructure

Regarding the impact of climate change, as well as with the infrastructure for water supply (see 4.2.2), the infrastructure for sewage water should be laid as far as possible from the coastline; and as much as possible (at least 1 m) above mean sea level, due to the action of waves, but deep enough to protect against higher temperatures - warmer sewage water means accelerated decomposition of organic substances in the water and greater release of harmful gases and unpleasant odors from sewage. Increased air and water temperatures also affect the biological processes in sewage water treatment devices, so the operation of the devices will have to be adapted to the new climatic conditions.

4.2.5. Development of stormwater drainage system

The stormwater drainage system in Boka Kotorska can be considered underdeveloped, floods are a regular occurrence with more intense rainfall, and the pollution of the environment is increasing due to the connection of the stormwater and sewage networks. Rainwater in the mixed system will further intensify and exceed the capacity of the constructed sewage system due to the construction, i.e. the lack of absorbent surfaces in the basin. In case of intense rainfall, which could be worsened by climate change, there is an overflow of sewage and storm water, and flooding of the surrounding areas occurs, which leads to pollution of the environment and marine waters.

All of this points to the need for the preparation of appropriate documentation at the conceptual level, for all three Boka municipalities, which would serve to further harmonize engineers and spatial planners regarding the resolution of this sensitive issue. The general concept of the solution would be a **separate drainage system**, in which the drainage of sewage water is carried out separately for rainwater.

The area of Kotor is especially characterized by large amounts of precipitation, so it is necessary to pay special attention when **dimensioning the atmospheric system**, as well as its regular maintenance. All newly planned roads that will be bounded by a sidewalk on one or both sides must be equipped with an adequate drainage collector. In addition to regulated watercourses that pass through the city center, it is necessary to regularly maintain unregulated watercourses, atmospheric sewage collectors, as well as all existing open canals. Efforts must be made to purify all collected water from traffic roads and parking lots, before discharging into the recipient, in accordance with the *Rulebook on quality and sanitary conditions for the discharge of waste water into the recipient and public sewers*.

Given that during intense rain episodes water quickly drains from the surface, it is necessary to work on solutions for **retention and storage of rainwater** that can retain water that can later be used for watering public areas, in agriculture, as an aid in extinguishing fire. Such above-ground retentions also gradually evaporate and thus mitigate temperature oscillations. Such retentions in the Boka area are a challenge due to the karst terrain that prevails there.

4.2.6. New precipitation and hydrological-hydromorphological analyzes, and analyzes of the geological composition of the terrain

There are numerous torrential occasional watercourses and drainage canals in the area of Boka Kotorska. The rapid and uncontrolled urbanization of the entire coast, that is, the terrain belonging to the catchment areas of these watercourses, has changed the natural conditions in many ways and caused a major change in the outflow regime from these watersheds to the sea. This will require **new analyzes of precipitation and characteristics of the terrain in the catchment areas**, as well as **hydrological-hydromorphological analyzes of these catchments** for adequate planning of protection against floods, landslides and erosion, as well as future designs of all types of infrastructure, primarily road and hydrotechnical.

In addition to the above, for the preparation of hydrological-hydromorphological analyzes (studies), the **geological composition of the terrain** of small coastal watersheds, from which material was once washed into the sea forming coastal sediment and beaches, **must also be taken into account**. Disruption in the deposition of these sediments is the cause of changes in the coastal sediments, and also in the morphology of the beaches. Bearing in mind the problems with the beaches in Boka Kotorska, the proposed studies should also include an analysis related to the geology of the watershed and the most precise identification of the rocks in the watershed from which coastal sediments and beaches were formed.

4.3. Adaptation measures related to marine environment

Since the state of the marine environment depends significantly on the pressures from the land, the implementation of certain measures described in the previous chapters will have a great impact on the state of the marine environment. This is especially important for the Bay of Kotor, which by its nature is a semi-closed water area, with a slow water exchange, so it is very sensitive to the influence of pressure from the land. For example, the quality of the sea water in the bay will depend on the rate of connection to the sewage system and the resolution of atmospheric water drainage, the condition of the coastal benthic habitats will depend on the sealing and construction near the coastline etc. This chapter focuses more on measures that directly concern the improvement of the state of the marine environment, which were not covered in the previous chapters.

4.3.1. Measures in the fisheries sector - controlled capture of certain species that are new to the Adriatic Sea

As a result of the change in climate conditions, specifically - an increase in temperature, there are recognized pressures related to changes in the composition of natural marine communities: reduction or complete disappearance of some species; increase in the abundance of other species as well as the reproduction of new types of marine biota (especially those species that do not have natural enemies and competition for food and space). This can have an impact on local coastal communities, such as a reduced catch by fishermen, material damage to nets, and the appearance of fish dangerous to human health (eg puffer fish, peacock fish and similar). Scientific data show that, for example, sea bass needs very specific temperature conditions and photo-period, so that any disturbance of the mentioned factors can threaten its population, both in the wild and in cultivation (UNEP/MAP- Plan Bleu, 2009).

As adaptation measures which should be undertaken in order to alleviate the pressure on more sustainable fisheries, recognized in the *Third national report of Montenegro on climate change*, these are refered primarily to the controlled capture of certain species that are new to the Adriatic Sea or have drastically increased their abundance, and testing opportunities to catch and export new species to areas where they are valued as food.

In order to implement these measures, it is necessary to strengthen capacities at the level of management units (competent ministries) and professional (scientific) institutions; it is necessary to establish a national center for monitoring foreign and invasive species; to provide education of the local population and fishermen on the measures and procedures to be implemented in case of finding a new species, as well as on the application of new techniques and tools for catching them (for example, in the case of blue crab, a relatively new species in Montenegro, which can be commercially exploited but requires traps of stronger material so that the blue crab would not destroy them). It is possible to combine the activity of catching invasive species with a tourist offer in the form of a competition in catching targeted invasive species (such as, for example, the Lionfish challenge in Florida).

Picture 30. Blue crab in a trap (source: https://www.zastita-prirode-dnz.hr/)

Adaptation measures in the fisheries sector include the continuation of the application of local ecological knowledge and citizen-science methods in monitoring and covering as many fishermen as possible in as large an area as possible, as well as thinking in the direction of diversifying activities and introducing new offers in the fishing sector that would compensate economically loss in a situation of insufficient number of resources. In accordance with the Law on Non-indigenous and Invasive Species of Plants, Animals and Mushrooms, it is necessary to establish an early warning system and involve the general public.

4.3.2. Adaptation measures in mariculture sector

Locations for mariculture should be sought in places that are less sensitive to the effects of climate change, such as areas with a more stable water temperature and protected from extreme weather (due to possible cage damage). It is also recommended to consider making the cages as resistant as possible to extreme weather conditions. Regular monitoring programs are also needed to monitor changes in water temperature, salinity, pH and other relevant parameters.

4.3.3. Protection of benthic communities

One of the most reliable ways to preserve the marine environment in the Boka Kotorska Bay is to protect as much of the Bay as possible. In this way, the disturbance under the anthropogenic impact is prevented, and resilience to climate change is streghtened.

In order to observe changes, it is necessary to **monitor the distribution and condition of species and communities in bottom habitats** that are of special interest. In the area of Boka Kotorska Bay, these are coralligenous habitats within which *Savaglia savaglia* (golden coral) is recognized as the dominant species, as well as meadows of *Posidonia oceanica* (density and coverage are monitored, as well as the lower limit of distribution). Both posidonia meadows and coralligenous habitats, which are under pronounced anthropogenic influence, become even more sensitive to changes in temperature and chemistry of sea water under the influence of climate change.

In the area of Sopot and Dražina vrta, where rich coral communities have developed, there are underwater springs (hot springs) that will oscillate in the inflow of water depending on the amount of rainfall on the mainland. Those oscillations will certainly have a certain impact on corals and other sessile organisms, and only a healthy and numerous population that is spared from anthropogenic influence will be able to resist the changes. Both locations - Sopot and Dražin vrt have been placed under preventive protection with the aim of protecting the valuable coralline communities in these locations.

As for posidonia meadows, they are quite fragmented and underdeveloped within the Boka Kotorska Bay. The situation is somewhat better in the outer part of the Bay, more precisely in the Hercegnovi Bay and at the very entrance to the Boka Kotorska Bay. Considering the multiple roles of posidonia meadows in mitigating the impact of climate change, such as preventing erosion and stabilizing the coast, depositing carbon and mitigating the effect of sea acidification, great attention must be paid to their protection. The arrangement of the sewage system will prevent the inflow of waste water, which negatively affects the condition of posidonia meadows. Bottom communities are greatly threatened by the anchoring of vessels, of which during the summer season there are a large number of them at the level of the entire Bay. **The formation of nautical anchorages on buoys** should be considered, especially in the area of the Tivat Bay, so that this measure would lead to directing nautical vessels to precisely defined locations and at the same time reduce the destruction of bottom habitats of great importance. The first step would be to analyze the locations suitable for placing such buoys, as well as the feasibility analysis of such operations. In exceptional cases when it is necessary to carry out underwater activities in areas where posidonia is present, its transplanting should also be considered as a measure of protection.

Picture 31. „Eco-friendly“ buoy in Kornati archipelago, Croatia (photos: Interreg SASPAS project)

4.3.4. Preservation of pelagic habitats

Phytoplankton communities are also changing in response to warming, acidification, and stratification of marine environmental conditions. Ecosystems that are already under multiple anthropogenic stresses (eg the inflow of untreated wastewater and other waters that bring a large amount of nutrients causing changes in the number of populations and species composition) are more sensitive to further pressures, including those resulting from climate change.

By protecting areas from damage and degradation and enabling ecosystem recovery, marine protected areas will help ecosystems and coastal communities adapt to climate change. It is necessary to **monitor the number of the population and the composition of the species present**, because this is the only way to determine the degree of trophicity of the marine environment in Boka Kotorska Bay.

4.4. Other adaptation-related measures

4.4.1. Early warning systems

It is necessary to build a common early warning system on natural hazards and disasters. Early warning systems are key elements of adaptation to climate change and disaster risk reduction, and their goal is to avoid or reduce damage caused by environmental hazards - floods and torrents, storms, forest fires, heat waves and droughts. The activities of precise monitoring, modeling and forecasting of climate variables are crucial for providing reliable data necessary for the operation of early warning systems. Such systems are useful and effective when they are followed by the activation of specific measures aimed at saving people, infrastructure and households (eg evacuation routes, shelters, activation of flood protection measures, etc.).

4.4.2. Awarness-raising and climate literacy

Effective information of citizens through the transparency of management plans and processes, and effective communication towards users in general, are key to building the trust and consensus necessary for the joint action of all actors, with the aim of achieving the desired results.

In addition to the informative web portal, it is necessary to hold a certain number of workshops, seminars and conferences on sustainable coastal development and adaptation to climate change, as well as on the consequences of the degradation of coastal resources. Information campaigns can be aimed at target groups (fishermen, farmers, tourist operators) as well as at the general public - the local population. In such campaigns, it is necessary to use all available tools: posters, brochures, videos and other communication tools, and distribute them with messages about how they can contribute to the sustainability of the coastal area. It is necessary to include local media: television, radio stations, newspapers, local web portals.

In cooperation with kindergartens and elementary schools, educational modules and projects should be developed that promote awareness of the importance of adaptation to climate change (climate literacy), principles of sustainability and preserving coastal resources.

4.4.3. Adaptation-related measures related to tourism sector – focus on rural agro-tourism

In addition to the attractive coastline, the coastal region can also offer a valuable rural hinterland. Valorizing the potential of rural development achieves balanced development in the region, the development of agriculture and **rural tourism**, encourages the retention and return of the population, and reduces the pressure on urban areas and the narrow coastal strip. Food production is ensured and habitats and natural ecosystems are preserved.

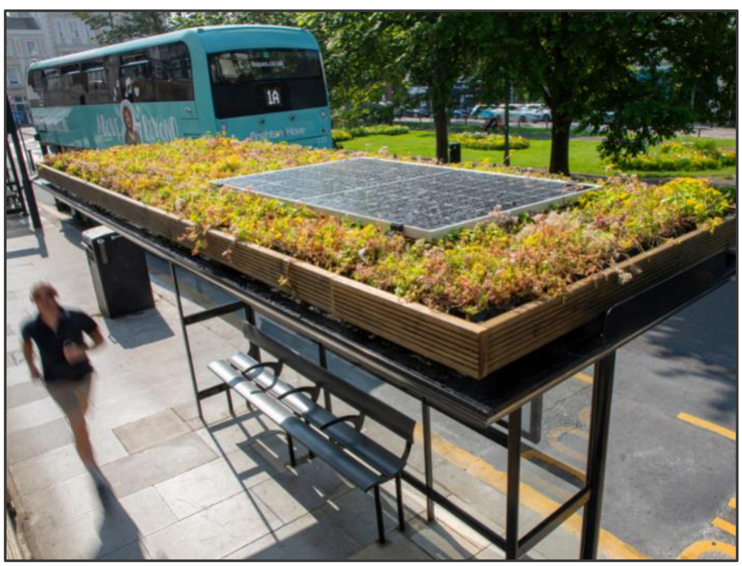
Rural areas face numerous challenges caused by climate change, but they can also offer some solutions in this regard. Agriculture has additional opportunities to contribute to mitigating climate change by reducing its emissions of methane and nitrogen oxides, and by improving the carbon sequestration system in agricultural areas. Agro-tourism activities like agroforestry, where trees are integrated into agricultural landscapes, and contribute to carbon sequestration. Trees play a vital role in capturing and storing carbon dioxide, thereby mitigating the impacts of climate change.

It is also necessary to concretize **the guidelines for the development of sustainable tourism**, in which there must be clearly defined and operational tourist products and experiences, commercially interesting, but also environmentally friendly, primarily bearing in mind the needs and possibilities of the sector of micro, small and medium tourism enterprises. In the aforementioned redefined approach, it is necessary to provide more space for the development of agritourism in the rural areas of Boka Kotroska, especially in the hinterland and the areas of Luštica, Vrmac and Grblje.

It is necessary to improve awareness and understanding of the dangers of (un)sustainable tourism and climate change among the local population, the economy, civil society and the public sector. It is probably the most complex and long-term measure, primarily due to its global, multidisciplinary and intersectoral nature. The challenges imposed by climate change in the future exceed the limits of autonomous adaptation capacities at the level of individual companies or businesses, and common policies will be needed, which will enable all stakeholders to cope with the changes that are necessary in tourism and other systems (e.g. rural and/or or agricultural).

4.4.4. Adaptation-related measures related to transportation sector

Supporting the transition to new technologies and cleaner fuels is one of the main ways in which decision-makers promote reduction of carbon dioxide emissions in transportation. At the local level, pricing and management programs can encourage the use of low-emission or fuel-efficient vehicles. Low-carbon buses can play an important role in the overall urban transport system, while, at the same time, it is important to increase the fuel efficiency of existing buses and privately-owned vehicles. Bearing in mind that the aim is to **increase the use of public transport**, it is necessary to foresee the renewal of the bus fleet with more energy efficient vehicles. Bus services can also be provided using electric minibuses, as well as buses powered by liquid petroleum gas (LPG) and compressed natural gas (CNG). Special study documentation for each municipality individually and/or for the entire area of Boka Kotorska should define: phase of replacement of the existing fleet, criteria for vehicle selection (type of fuel, vehicle capacity, maintenance method, achieved savings in harmful gas emissions, suitability of vehicles for all categories of users, etc.) and adequate types of low-carbon buses depending on the area of implementation (urban centers, municipal areas, regional connections). Equip existing and new infrastructure in the form of maritime passenger terminals and bus stations (canopies at bus stops, piers, etc.) with green solutions that will protect passengers while waiting or transferring from extreme weather conditions (sun, wind, rain). Existing canopies at bus stops need to be covered with vegetation in such a way that they provide adequate shading and reduce the impact of direct solar radiation, along with the function of protection from rain.



Picture 32. An example of a green canopy roof (source: www.brighton-hove.gov.uk)