July 2013

CAMP Montenegro

Vulnerability Assessment of the Narrow Coastal Zone

Summary

Regional Activity Centre for Cleaner Production

MedPartnership

Project commissioned by:

Ministry of Sustainable Development and Tourism of Montenegro
IV Proleterske brigade 19
81000 Podgorica
Montenegro

Priority Actions Programme
Regional Activity Centre (PAP/RAC)
Kraj Sv. Ivana 11
21000 Split
Hrvatska

Project:

CAMP Montenegro
Vulnerability and suitability assessment

Phase:

Vulnerability assessment of the narrow coastal zone

Date:

March 2013

Assessment prepared by:

MSc **Jelena Knežević**, inorganic technology engineer (MSDT)
MA **Marina Marković**, political scientist (PAP/RAC)
Assist. Prof **Aleš Mlakar**, landscape architect (PAP/RAC consultant)
MSc **Gojko Berlengi**, architect (PAP/RAC consultant)
MSc **Vasilije Bušković**, biologist

Studies prepared by:

Habitats Mapping for Selected Locations and Assessment of Their Vulnerability
Assist. Prof Danka Petrović

Erosion Map of the Immediate Coastline
PhD Budo Fuštić

Study of Seismic Categorisation
Prof Branislav Glavatović
Ljiljana Vućić, BSc mathematics

Study of Storms in the Coastal Region of Montenegro
MSc Mirjana Ivanov, meteorologist (IHMS)
Prof Mlađen Ćurić (Institute for Meteorology, Physics Faculty of Belgrade University)
MSc Dušan Slavnić, geographer (IHMS)

Study of Sea Level Rise
Aljoša Žerjal, PhD Nataša Kolega, PhD Sašo Poglajen, Dean Mozetič, Črt Rudman,
Petra Slavec, Harpha Sea, d.o.o. Koper

MONTENEGRO
MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM

UNEP

MAP

July 2013

CAMP Montenegro

Vulnerability Assessment of the Narrow Coastal Zone

Summary

PAP/RAC

UNDP
Empowered lives. Resilient nations.

Regional Activity Centre for Cleaner Production

RAC/SPA

MedPartnership

Table of Contents

List of Tables

List of Illustrations

1. Introduction

Coastal area management programme for Montenegro (CAMP MNE) is implemented jointly by the Mediterranean Action Plan (MAP) and the Ministry of Sustainable Development and Tourism (MSDT). Local self-governments from the area covered by the project are also included, as well as other competent institutions. CAMP MNE project supported by the MAP promotes integrated coastal zone management (ICZM) as an instrument which enables coordination of diverse human activities in coastal zones and their management in the framework of reaching sustainability objectives.

As a part of the **Vulnerability and Suitability Assessment of the Coastal Zone of Montenegro, Assessment of General Vulnerability** was completed in December 2012 within CAMP MNE as one of the baselines for preparation of the Special Purpose Spatial Plan for the Coastal Zone of Montenegro (SPSPCZ MNE) and of the Integrated Coastal Zone Management Plan Montenegro.

In general terms, vulnerability is defined as a state of the environment, space, soil or phenomena that can cause negative impacts on the environment in case certain interventions are implemented. Vulnerability assessment i.e. determination of sensitivity or susceptibility of space is a method (a mechanism, task or process) that determines more vulnerable spatial segments for a given intervention or activity. The purpose of vulnerability assessment is to determine those parts of space where it is less suitable or unsuitable to plan certain activities or interventions. In the context of preparing analyses needed for spatial planning and environmental protection and in the spirit of the Protocol on Integrated Coastal Zone Management in the Mediterranean, Assessment of General Vulnerability was prepared within CAMP MNE based on vulnerability of individual environmental segments. Degree of spatial vulnerability derived from the assessment of general vulnerability does not depend on potential impacts of individual activities or interventions but on (individual) characteristics i.e. value of space.

Detailed Vulnerability Assessment of the Narrow Coastal Zone represents an amendment to the Assessment of General Vulnerability. The purpose of this analysis was primarily **to prepare expert baselines for identification of areas where conditions exist for expansion of the coastal set back** i.e. of the zone where construction along the shore is limited or prohibited in line with the ICZM Protocol.

In order to prepare Vulnerability Assessment of the Narrow Coastal Zone and Analysis for Defining the Coastal Set Back Zone (especially for determination of areas where adaptation leading to a decrease of the coastal set back is not possible) as well as for other spatial planning activities in the coastal zone the following individual assessments and studies have been completed:

- habitats mapping for selected locations (Velika plaža Ulcinj, Buljarica, Platamuni, Tivat Saltpans) and assessment of their vulnerability;
- erosion map of the immediate coastline;
- study of seismic categorisation of space in coastal municipalities of Montenegro;
- study of storms in the Montenegrin coastal region; and
- sea level rise study.

2. Method of Work

Theoretical basis for vulnerability assessment is laid out in the Vulnerability and Suitability Assessment: General Vulnerability Assessment from December 2012.

Model of vulnerability assessment of the narrow coastal zone is based on direct evaluation of the most significant environmental elements singled out and analysed in line with the article 10 of the Protocol on Integrated Coastal Zone Management in the Mediterranean which determines protection of the following specific coastal ecosystems:

- wetlands and estuaries,
- marine habitats[1],
- coastal forests and woods, and
- dunes.

These ecosystems are considered to be areas of very high vulnerability.

Besides specific coastal ecosystems, the following aspects were taken into account as additional arguments for expanding the coastal set back in the vulnerability assessment of the narrow coastal zone:

- Nature protected areas are areas where unsuitable/ extensive construction could endanger natural characteristics that are being preserved, while construction is prohibited in nature reserves (e.g. Tivat Saltpans);
- Areas of excessive erosion – abrasion are areas where implementation of coastal zone erosion protection measures and suitable planning is necessary;
- Areas of very high seismic vulnerability are areas which are absolutely not recommendable for planning and construction of built structures;
- Water springs protection zones I (zones of direct protection) with strict protection regime, mineral springs and zones with peloid deposits represent limits for construction;
- Areas with significant impacts of storms and sea level rise i.e. areas where due to storms and sea level rise major changes in the shore line are happening must be taken into account with a view to expanding coastal set back so that determination of the coastal set back zone will be based on a definition of the shore line having in mind sea level rise and additional negative impacts of storms from the marine side (see subsequent elaboration);
- Non-built areas: expanding coastal set back is only justified for (partially) non-built areas.

Data that have been used for the Vulnerability Assessment in the Narrow Coastal Zone of Montenegro are shown in the tables in the following paragraphs. The tables also contain data/ evaluations that have been used in the Assessment of General Vulnerability of the Coastal Zone of Montenegro by applying a model of pronounced protection of the most significant environmental elements. It is also recommended this model is applied in the Analysis for Defining the Coastal Set Back Zone in

[1] Requirement on preservation of marine habitats does not affect directly expansion of the coastal set back as they are located in the marine part of the Montenegrin coastal zone. Preservation of marine habitats and of marine biodiversity needs to be ensured through consistent limitations to the development of marinas, ports, docks and other structures in the zones of significant marine habitats (see conclusions of the General Vulnerability Assessment).

the context of determining areas where adaptation in the sense of reducing the coastal set back is not possible (where there are areas of very high vulnerability – see chapter 4). The following table contains an overview of environmental segments that have been evaluated in the course of vulnerability assessment of the narrow coastal zone by using vulnerability results gained through application of various models of cumulative vulnerability of the coastal zone. For vulnerability assessment of the narrow coastal zone, data have been classified into most important ones – i.e. around environmental elements singled out and analysed in line with the article 10 of the Protocol on Integrated Coastal Zone Management in the Mediterranean, and into additional ones gained through vulnerability assessment of the coastal zone as well as through individual analyses and studies conducted for the purpose of assessing vulnerability of the narrow coastal zone such as:

- habitats mapping for selected locations (Velika plaža Ulcinj, Buljarica, Platamuni, Tivat Saltpans) and assessment of their vulnerability;
- erosion map of the immediate coastline;
- study of seismic categorisation of space in coastal municipalities of Montenegro;
- study of storms in the Montenegrin coastal region;
- sea level rise study.

Graphic supplements provide a preliminary illustration of the areas where conditions for expanding the coastal set back zone exist, while as guidelines for determination of the coastal set back line will be defined through the respective analysis.

Vulnerability of the narrow coastal zone expressed through vulnerability grades for environmental elements/ segments evaluated in the context of vulnerability assessment of the narrow coastal zone is shown in the Vulnerability Matrix (Table 2). At the same time, this matrix contains informative overview of vulnerability grades obtained through application of the model of pronounced protection of the most significant environmental elements/ segments in the general vulnerability assessment of the coastal zone.

Table 1: Overview of environmental segments evaluated in the vulnerability assessment of the narrow coastal zone by using vulnerability results gained through application of various models of cumulative vulnerability of the coastal zone

Models by environmental segments	Cumulative vulnerability – principle of maximum value	Cumulative vulnerability – principle of reg. average value	Vulnerability of natural characteristics – pronounced protection	Vulnerability of natural characterist. – the lowest level of acceptable protection	Cumulative pollution/ the level to which environment is endangered	Accidents	Climate	Vulnerability assesment of the narrow coastal zone
1. Environment and human health								
1.1 Noise								
1.2 Air pollution								
1.3 Soil pollution								
2. Flora and fauna								
2.1 Flora and fauna								
2.2 Nature protected areas								
2.3 Marine biodiversity								
a) Concept 1								
b) Concept 2								
3. Soil								
3.1 Erosion								
3.2 Agriculture and agricultural land								
3.3 Seismic vulnerability								
4. Water								
4.1 Terrestrial surface water								
4.2 Groundwater								
4.3 Sea								
a) Bathymetry								
b) Waves								
c) Accidents								
d) Sea level changes (tide)								
e) Quality of the coastal sea								
f) Bathing water quality								
g) HOT-SPOT locations – sea								
h) HOT-SPOT locations – sediments								
i) HOT-SPOT locations – bio-indicators								
j) Wastewater								
4.4 Floods								
5. Climate, climate change								
5.1 Droughts								
5.2 Forest fires								
5.3 Strong rains								
5.4 Strong winds								
5.5 Sea level rise								
6. Landscape								
6. Landscape								

The most significant segments/ data

Additional segments/ data which represent further arguments for expanding the coastal set back

Table 2: Matrix of the vulnerability of the narrow coastal zone

Segment	Categories	General vulnerability – model of pronounced protection of the most significant elements[1]	Vulnerability assessment of the narrow coastal zone[1]
1. Life and health	*	-	-
2. Flora and fauna Model of cumulative vulnerability	Areas of very high vulnerability (5) from the joint vulnerability model for flora and fauna and for protected areas	5[3]	-
	Areas of very high vulnerability (4) from the flora and fauna vulnerability model	3[3]	-
2. Flora and fauna 2.1 Flora and fauna	**Corine Land Cover**		
	1. Artificial surfaces		
	111[2] Continuous urban fabric	1	-
	112 Discontinuous urban fabric	1	-
	121 Industrial or commercial units	1	-
	122 Roads and rail networks and associated land	1	-
	123 Port areas	1	-
	124 Airports	1	-
	131 Mineral extraction sites	1	-
	132 Dump sites	1	-
	133 Construction sites	1	-
	141 Green urban areas	3	-
	142 Sport and leisure facilities	2	-
	2. Agricultural areas		
	211 Non-irrigated arable land	2	-
	221 Vineyards	2	-
	223 Olive groves	3	-
	231 Pastures	3	-
	242 Complex cultivation patterns	2	-
	243 Land principally occupied by agriculture, with significant areas of natural vegetation	3	-
	3. Forest and semi natural areas		
	311 Broad-leaved forest	4	-[4]
	312 Coniferous forest	4	-[4]
	313 Mixed forest	4	-[4]
	321 Natural grasslands	4	-
	323 Sclerophyllous vegetation	4	-
	324 Transitional woodland-shrub (degraded forest)	4	-
	331 Beaches, dunes, sands	5	5
	332 Bare rocks	4	5[6]
	333 Sparsely vegetated areas	4	-
	334 Burnt areas	2	-
	4. Wetlands		
	411 Inland marshes	5	5
	421 Salt marshes	5	5
	422 Salines	5	5
	5. Water bodies		
	511 Water courses	5	-
	512 Water bodies	4	-
	522 Estuaries	5	5
	523 Sea and ocean	3	-
	MN 25000		
	2001-arable land	2	-
	2002-vineyards	2	-
	2003-orchards	2	-
	2005-forest plantations	3	-
	2006-broad-leaved forest	4	-
	2007-coniferous forest	4	-

Segment	Categories	General vulnerability – model of pronounced protection of the most significant elements[1]	Vulnerability assessment of the narrow coastal zone[1]
	2008-mixed forest	4	-
	2009-shrubs	4	-
	2010-grasslands and pastures	4	-
	2011-bushes	4	-
	2012-undergrowth – low forest	4	-
	2013-sandy terrain	5	5
	2014-rocky terrain	4	5[6]
	2015-clay terrain	4	-
	2017-lakes	4	-
	2018-wetlands	5	5
	2019-water/ river surfaces	5	-
	2021-park surfaces	3	-
	2022-olive plantations	3	-
	Forest communities		
	Fagetum montanum sesierietosum	4	-
	Olives	3	-
	Orno - Quercetum ilicis	5	5[5]
	Pinetum heldereichii	5	5[5]
	Various types of grassland and pastures of the hilly area, association Bromion erecti, Arrhenatherion, Scorzonerion vilosae, Ulcion	4	-
	Various types of dry grasslands and rocky pastures, evergreen areas, association Cymbopogo - Brachypodion, to a small extent Scorzonerion	4	-
	Rusco - Carpinetum orientalis	4	-
	Rusco - Carpinetum orientalis petterietosum	4	-
	Rusco - Carpinetum orientalis punicetosum	4	-
	Rusco - Carpinetum quercestosum	4	-
	Seslerio - Ostryetum carpinifoliae	3	-
2. Flora and fauna 2.2 Nature protected areas	Protected plant species	5	5[6]
	Special nature reserve	5	5[6]
	National park	4	5[6]
	Monument of nature	3	5[6]
	Landscape with exceptional features	3	5[6]
	Area protected under municipal decision	3	5[6]
	Protected dendrological object	5	5[6]
	National park (potential)	4	5[6]
	Regional park (potential)	4	5[6]
	Monument of nature (potential)	3	5[6]
2. Flora and fauna 2.3 Marine biodiversity	Areas of very high vulnerability (5) from the marine biodiversity vulnerability model - concept 2	5	-
	Areas of high vulnerability (4) from the marine biodiversity vulnerability model - concept 2	4	-
	Areas of very high vulnerability (5) from the marine biodiversity vulnerability model - concept 1	-	-
3.1 Erosion	I category - excessive/ intense/ erosion	3	-
	I ab category, excessive erosion – abrasion	3	5[6]
	II category, strong erosion	2	-
3.2 Agricultural surfaces	Areas of very high vulnerability (5) from the vulnerability model	5	-
	Areas of high vulnerability (4) from the vulnerability model	4	-
3.3 Seismic vulnerability	Index 5 - areas of very high vulnerability from the vulnerability model	5	-
	Index 4 - areas of high vulnerability from the vulnerability model	4	-
	Index – areas of very high vulnerability from the seismic micro-zoning	-	5[6]

Segment	Categories	General vulnerability – model of pronounced protection of the most significant elements[1]	Vulnerability assessment of the narrow coastal zone[1]
4.1 Surface waters	Permanent flows and significant intermittent flows	5	5[7]
	Intermittent flows	4	-
	Šasko lake	5	-
	Skadarsko lake	4	-
4.2 Groundwater	Supervisory zone - III protection zone (wider protection zone)	3	-
	Zone of limited protection regime - II protection zone (narrower protection zone)	4	-
	Zone of strict protection regime - I protection zone (zone of direct protection)	5	5[6]
	Sanitary protection belt (pipelines belt)	5	-
	Zone of mineral springs	5	5[6]
	Zone of peloid deposits	5	5[6]
	Carbonate rocks of cavernous cracked porosity with good karstification	2	-
4.3 Sea	*	-	-
4.4 Floods	Areas of very high vulnerability (5) from the model	5	5[8]
	Areas of high vulnerability (3) from the model	3	-
5. Climate	Droughts	-	-
	Forest fires	-	-
	Strong rain	-	-
	Strong winds	-	-
	Storms (winds along the shore and flooding)		5[6]
	Sea level rise (first scenario – up to 0.62 m)		5[6]
6. Landscape	Areas of very high vulnerability (5) from the vulnerability model	4	-
	Areas of high vulnerability (4) from the vulnerability model	3	-

Notes:

- Model was not considered for the purpose of vulnerability assessment of the narrow coastal area.

1. Vulnerability grades mean:
   1 – very low vulnerability: in case of an intervention or land use change – there is no impact or impact is negligible;
   2 – low vulnerability: in case of an intervention or land use change, impact is moderate i.e. change in the environmental elements is small/ moderate and is not qualitatively determined, meaning that the change can be easily remedied;
   3 – moderate vulnerability: in case of intervention or land use change, impact is significant meaning there is a large change in environmental segments the remediation of which is difficult;
   4 – high vulnerability: in case of intervention or land use change, impact is very high meaning there is a very large change or loss of environmental elements that is qualitatively defined and very difficult for remediation;
   5 – very high vulnerability: in case of intervention or land use change, impact is inadmissible/ unacceptable and exceeds tolerance threshold meaning a very large change or loss of environmental elements which is especially qualitatively defined and not possible to be remedied.
2. The number denotes category of data in the Corine Land Cover map.
3. The basis for flora and fauna vulnerability model are Corine Land Cover, MN 25000, and forest communities data;
4. Categories of Corine Land Cover data which have been used in combination with forest community data to define areas of significant coastal forests;
5. Categories of forest community which have been used in combination with Corine Land Cover data to define areas of significant coastal forests;
6. Additional segments/ data from supplementary analyses prepared for the purpose of vulnerability assessment of the narrow coastal zone and other relevant data taken over from the Assessment of General Vulnerability of the Coastal Zone which represent additional arguments for expanding the coastal set back;
7. Due to a lack of sound data on river mouths/ estuaries, data on permanent and significant intermittent water flows (as prepared by the Institute for Hydrometeorology and Seismology of Montenegro – IHMS – for the purpose of Assessment of General Vulnerability) was used in an informative manner;
8. Due to a lack of sound data on wetlands, data on continuously flooded surfaces which indicate what are the areas of marshes and wetlands (e.g. along Bojana river) that should certainly be avoided for construction was used in an informative manner. Data prepared by the IHMS for the purpose of Assessment of General Vulnerability were used.

2.1 Habitats mapping for selected locations

Field work within the project "Biodiversity (habitats/vegetation) mapping at selected locations in the coastal area of Montenegro" was completed in October and November 2012. The main goal of the project was to provide for detailed mapping of habitats at selected locations: Velika plaža Ulcinj, Buljarica, Tivat Saltpans and Platamuni. These locations have been identified as particularly important from the aspect of preservation of species as well as habitats diversity. Data on vulnerability of the mentioned locations gained through the Assessment of General Vulnerability of the Coastal Zone of Montenegro was used as an input for this work. During the field work, data referring to floristic composition (with a special emphasis on invasive species, representativeness and anthropogenic impacts) was also recorded in addition to habitat types. After completion of the field work, mapping was done using Quantum GIS (version 1.8). Among others, the following were prepared: overview of habitats with vulnerability grades assigned for the purpose of vulnerability assessment of the narrow coastal zone, which have been harmonised with general vulnerability grades for the coastal region; list of species recorded during filed work with an overview of habitat types where they were found, protection status at national and international level as well as important remarks; overview of potential anthropogenic impacts; and integral report for each of the four locations which entails baselines (guidelines) that should be taken into account for urban planning in the coastal region.

For habitats vulnerability assessment, IUCN publication on conservation biology – "Establishing IUCN Red List Criteria for Threatened Ecosystems" – was used. Criteria C and D from this publication were applied as the most suitable for the mapped habitats, taking into account available data. Statuses defined according to IUCN categorisation have been translated into numeric grades in line with the following principles:

- critically endangered (CR) = 5;
- endangered (EN) = 4;
- vulnerable (VU) = 3.

Grades 1 and 2 have been assigned to habitats which do not meet any of the above criteria, i.e. to those which are not characterised by significant level of vulnerability.

In order to determine vulnerability of the selected locations, analysis of present anthropogenic impacts was performed (Illustration 1). In the area of Velika plaža and its hinterland, intensive anthropogenic impacts were identified leading to: decrease of surfaces under natural vegetation; habitats fragmentation; and changes in the floristic composition of habitats due to nitrification and spread of invasive species. For Tivat Saltpans, no major anthropogenic impacts were identified. Cattle grazing on the embankments contributes to nitrification in this zone but it does not represent serious threat for protected habitat types. At Buljarica, all the types of anthropogenic impacts recorded for Velika plaža were also evidenced. Urbanisation linked to tourism is the main negative anthropogenic impact at Platamuni. Vegetation of marine cliffs is protected due to inaccessibility of the terrain which is unsuitable for any type of urbanisation. However, planting of species that are potentially invasive on urbanised part of the beach represents a threat for this habitat type too. Overview of anthropogenic impacts, vulnerability grades for the observed sites and proposal of guidelines for elimination or mitigation of evidenced impacts and pressures is provided in the Annex 1 to the Vulnerability Assessment of the Narrow Coastal Zone titled "Habitats Mapping for Selected Localities and Assessment of Their Vulnerability".

Illustration 1: Habitats mapping at selected locations

2.2 Erosion map of the immediate coastline

Graphic presentation of erosion was done on 1:25000 maps for 13 selected watersheds and for the narrow coastal belt ranging from 500 to 1000 m in width. Erosion maps were generated based on a method where strength of erosion processes in a given watershed and watercourse bed is classified into five categories of destructiveness: I excessive, II strong, III moderate, IV weak, and V very weak erosion. For practical reasons, categories I ab and Ee have been differentiated/added to mark excessive erosion through abrasion (I ab) present along rocky sea shore and eolian erosion (Ee) on sandy beaches.

Narrow coastal belt is characterised by highly jagged shoreline with rich diversity of relief forms such as capes, coves, cliffs, *podkapine* (shelter-like recesses at the foot of the steep shores), bays and inlets. Dominant steep rocky shore with scattered parts of rocks and stones of different sizes and shapes has evolved due to the work of waves on limestone. In the bays, inlets and some coves, materials have been deposited through torrential watercourses and were then shaped by the sea waves. Development of beaches (sand, pebble and rocky) and their nowadays appearance are result of water and eolian erosion. Their length, width and surface vary on different locations from Igalo to Bojana.

Erosion of the immediate coastline is contained in the Annex 2 of this Vulnerability Assessment of the Narrow Coastal Zone, while Erosion map of the immediate coastline is also presented at the Illustration 2.

2.3
Seismic categorisation of space

Based on the content of seismic hazard maps and seismic micro-zoning, categorisation of space in the six coastal municipalities with a view to seismic impacts has been performed.

For the general regional seismic impact linked to the so called base rock, with high values for mechanic characteristics, categorisation has been performed on the basis of expected maximum horizontal ground acceleration during earthquake within standard (according to the European norms) return periods of 475 years. This type of categorisation has a significant role in the process of developing spatial planning documentation for the entire coastal region as an area with very high level of seismic hazard and consequent seismic risk.

General seismic vulnerability was then combined (convolved) with the content of the engineering-geological map on lithological characteristics of the terrain and of the map with categorisation of terrain's slopes, in accord with the level of their impact in evaluation of the basic seismic vulnerability. In this way general seismic vulnerability was determined and expressed through grades 1-5, whereas grade 4 stands for very high impact and grade 5 denotes impact that exceeds acceptable criteria and possibility to provide for safety (as indicated in the Annex 3 tables in more detail).

Adequate quantification of seismic effect of the local geotechnical environment is of significance for adequate and realistic categorisation of space given its possible contribution to the overall seismic vulnerability. For these reasons and in order to express cumulative vulnerability of space in the narrow (500 m) coastal zone, detailed categorisation and mapping of seismic vulnerability were performed based on the content of results of seismic micro-zoning of urban areas in the coastal towns which contains detailed elements of interaction between primary seismic movements (on the base rock) and local geotechnical environment. In this way, level of detail of the graphic model of coastal zone vulnerability was harmonised with its scale.

During intensive complex surveys in the coastal municipalities of Montenegro that were carried out in the period 1982-1985, a vast amount of diverse geological, geophysical, seismological and other types of data was recorded. These data were used to produce described regional seismological baselines (maps of seismic hazard and seismic micro-zoning maps) as well as other types of graphic and other products. In parallel with these surveys, the already mentioned procedure of seismic micro-zoning was conducted resulting in a detailed set of maps (scale of 1:5000 or 1:10000, depending on the municipality in question). Seismic micro-zoning maps as well as derived maps of suitability of terrains for urbanisation have integrated vast amount of all the survey results. For CAMP MNE needs and with consent of the public institution Institute for Geological Surveys of Montenegro, available set of maps on seismic micro-zoning for all the six coastal municipalities was scanned and geo-referenced in the original Gauss–Krüger projection. Total number of available maps in the sets for seismic micro-zoning for all the coastal municipalities was 103 (Table 4, Annex 3) while as five maps were not available.

Based on the analysis of seismic vulnerability for the coastal area in question, it is necessary to formulate specific recommendations for spatial planners as end-users of these information with the aim to treat the results of the analysis. In the course of developing spatial planning documents for the coastal belt and the entire territory of coastal municipalities of Montenegro, having in mind high levels of seismic hazard in the area and expected consequent levels of seismic risk, it is necessary to respect determined grades of seismic vulnerability of space to the future earthquake activities, especially vulnerability indexes derived by combining expected seismic activity and contents of engineering-geological and of seismic micro-zoning maps. **Given their exceptional vulnerability, zones that have been graded with index 5 (based on the described criteria) are absolutely not recommendable for construction of built objects or regional infrastructure elements.** Zones with index 4 should be also treated with special caution and appropriate special methodological measures of seismic protection should be implemented in them, as emphasised in the vulnerability tables in Annex 3.

It is also useful to highlight the fact that all the so far surveys on seismic risks, including this analysis, have indicated there is a highly pronounced need to meticulously determine damageability functions for all typical objects and infrastructural systems in Montenegro. Their key role in evaluation of specific seismic risk as well as in the process of organised approach of its control and lowering is especially emphasised, in particular for highly vulnerable elements of already built environment in all the coastal municipalities with exceptionally high level of real seismic hazard, making urgent seismic protection thus more required.

Detailed overview of the results of seismic micro-zoning in the coastal zone of Montenegro is provided in the Annex 3 to this Vulnerability Assessment of the Narrow Coastal Zone titled “Study of Seismic Categorisation of Space for the Coastal Municipalities of Montenegro” and there presentation is also given at illustration 3.

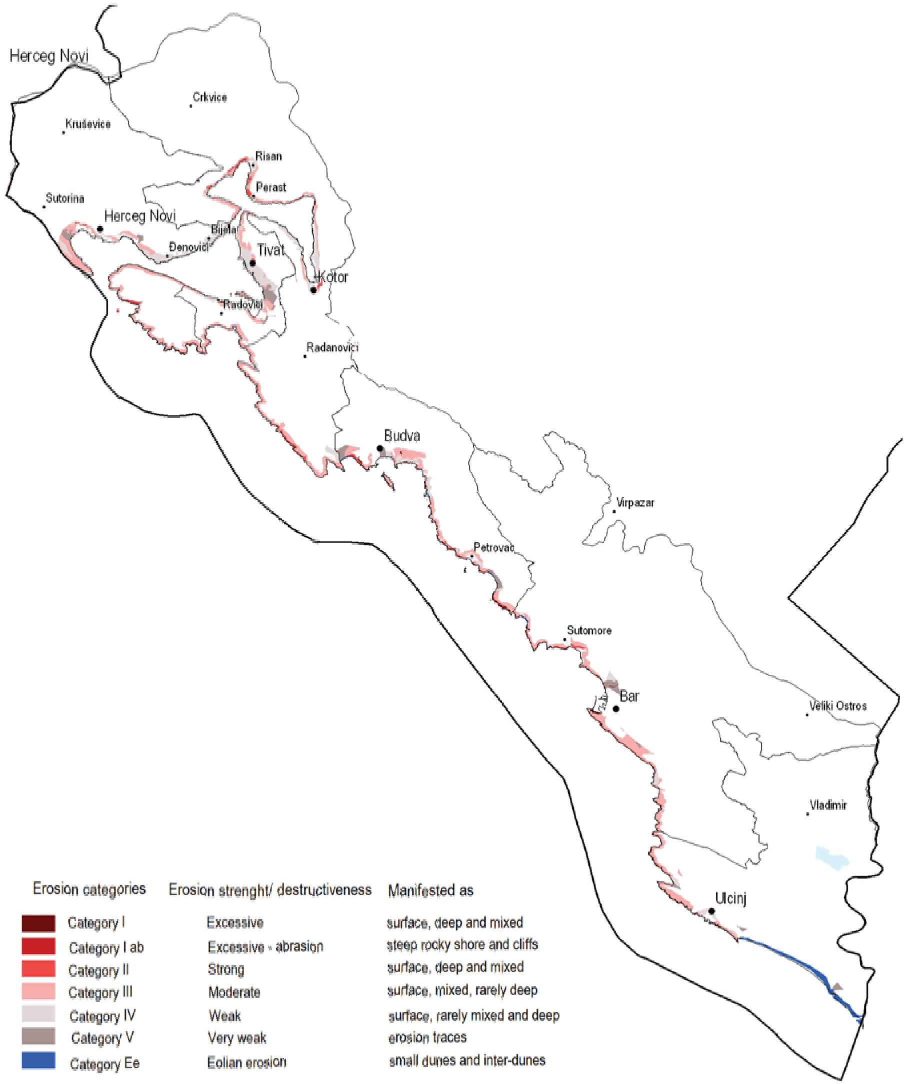

Illustration 2: Erosion map of the immediate coastline

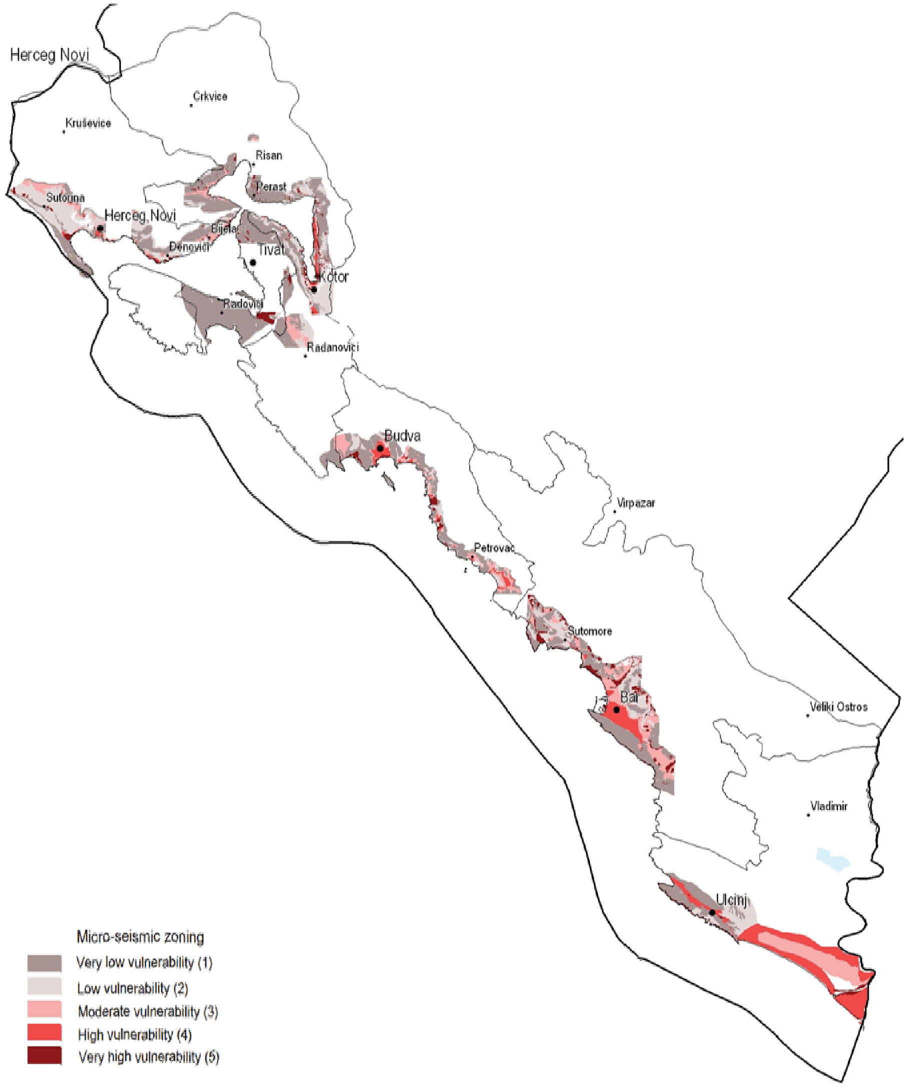

Illustration 3: Micro-seismic categorisation of space

2.4
Assessment of areas with high impact of storms

Data from the three main meteorological stations (availability of data and basic statistical analyses are presented in Annex 4) have been used for the analysis of storms and they show frequent occurrence of winds from second and third category. These are winds with maximum gusts that reach storm to hurricane speeds and are caused by passing of cyclones in the winter part of the year (October – April). As such, they can cause:

- lighter as well as more substantial damages on buildings, built structures, constructions, and overhead power transmission lines;
- storm waves on the sea, which cause flooding and erosion of the shore, damages on built infrastructure along the coast line, etc.

According to precipitation criteria, storms from categories 1 and 2 are the most frequent ones in the coastal region of Montenegro. This means strong precipitation with possible daily rainfall of up to 150 mm. This is why burden from heavy rainfall must be taken into account, especially when planning precipitation collection and discharge systems.

Analysis of waves generated by winds shows that Montenegrin coast towards the open sea does not have natural wave protection in the form of a chain of islands or reefs. That is why this entire part of the coast is exposed to destructive waves and highly vulnerable to them. Impact of waves in the most of Boka Bay is moderate, with the exception of Herceg Novi Bay and some locations where there are larger fetches. A common feature for these locations is that they have a low shore and are thus more vulnerable to flooding caused by storm waves.

Depending on how much is certain area exposed or sensitive to storms, and on its capacity to adapt (Illustration 4), vulnerability has been classified into 5 categories ranging from very low to very high. Each category has been associated with appropriate colour, as shown in the table 3.

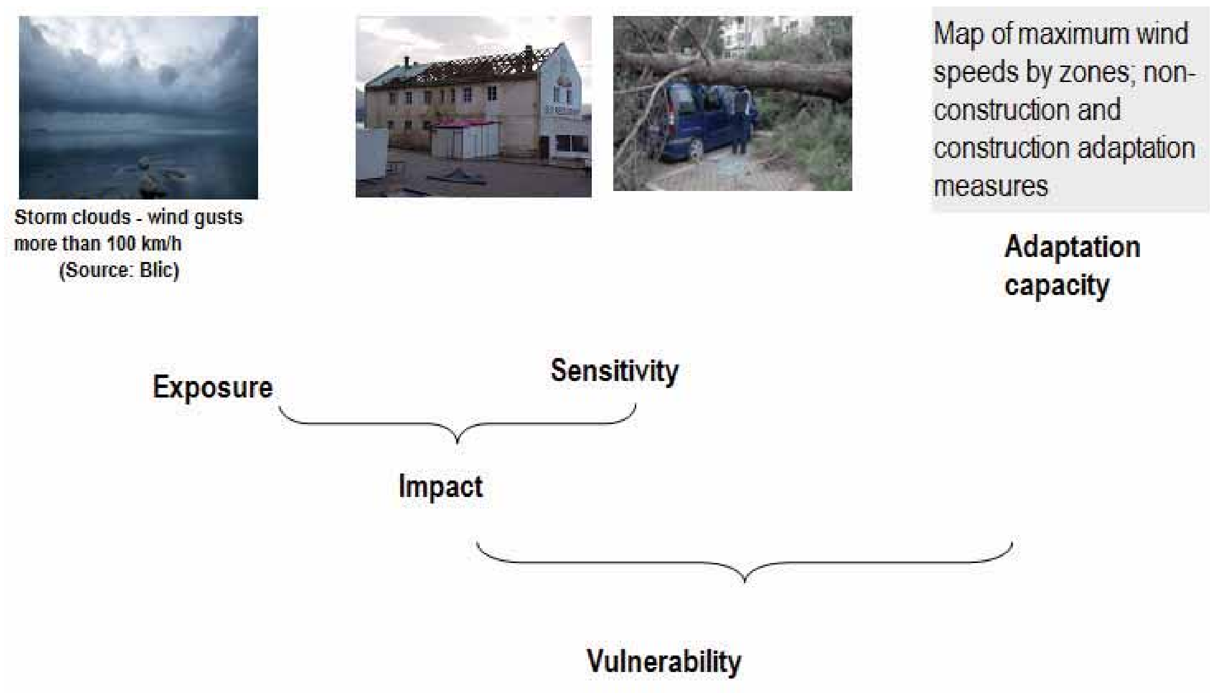

Illustration 4: Concept of the model of vulnerability to storms

Illustration 5: Areas with high impact of storms

Table 3: General potential impact of storms, capacity to adapt and vulnerability grade

Grade	General potential impact of storms	Adaptation capacity	Vulnerability
1	No or negligible impact	Very high	Very low
2	Moderate impact meaning a small/ moderate change of environmental elements, which is not especially determined as a quality; also meaning a small change in material assets that can be easily repaired	High	Low
3	Large impact meaning a significant change of environmental elements and widespread damages to material assets	Moderate	Moderate
4	Impact is very high meaning a large change or loss of environmental elements, which is recognised as a quality , and substantial/ extreme damages to material assets	Low	High
5	Impact is inadmissible/ unacceptable – it exceeds acceptability threshold and means a very large change or loss of environmental elements, which is especially determined as a quality; catastrophic damages and loss of material assets	Very low (low feasibility of adaptation measures)	Very high

Having in mind intensity of storms, their movements and consequences they can cause, as well as geometry of Montenegrin coast (at some points, slope of the shore is low, there are semi-closed coves and bays, and river mouths), the following areas could be singled out and assessed as moderately to highly vulnerable to storms (based on expert judgement):

- areas for which representative measurements on meteorological stations in Herceg Novi, Bar and Ulcinj are available – vulnerability 4 (Herceg Novi) and 3 (Bar, Ulcinj);
- Buljarica and Jaz coves, Sutorina river mouth, Saltpans and Kotor (especially its southern part), Canj cove, Ulcinj beach and mouth/ estuary of Bojana river up to the Porto Milena channel – vulnerability 4;
- coast of the Montenegrin open sea since it does not have natural protection from waves in the form of chains of islands od underwater reefs – vulnerability 4;
- major part of Boka Bay – vulnerability 3.

Several difficulties were faced in the process of mapping vulnerability to storms. Some of the most important ones included: insufficient amount of basic data and information, and complex terrain (for example, the area of Ulcinj Velika plaža is a large area with low topography with beech reefs, dunes and depressions behind the reefs). Because of these difficulties, coastal flooding was only mapped for six locations (Buljarica and Jaz coves, mouth of Sutorina and Bojana rivers, Saltpans and Canj) for which information could be retrieved from literature, maps and based on direct field observations. For the Velika plaža and Ada Bojana shore, analysis was done based on analogy with Buljarica cove as both have similar sand and pebble beaches with practically identical exposure to waves. Flooding areas for the Velika plaža and Ada Bojana were determined by applying the same distance field (so called offset) from the shore (85 m) as for Buljarica cove.

Flooding zones were defined based on the only available data on the shore line (MSDT, July 2012) which was also used for other analyses within CAMP MNE. For the purpose of defining coastal set back line and other spatial planning activities within SPSPCZ MNE, results acquired through CAMP MNE (vulnerability of the narrow coastal zone, guidelines for defining the coastal set back) and other spatial data linked to the shore line (e.g. bathymetry belts) need to be calibrated/ harmonised with the shore line data which is being prepared by the hydrographical department of the IHMS of Montenegro, in line with relevant regulations.

Annex 4 to the Vulnerability Assessment of the Narrow Coastal Zone titled "Study of Storms in the Coastal Region of Montenegro" contains detailed analysis of the Montenegrin coastal zone vulnerability due to the impact of storms.

2.5 Assessment of areas affected by the sea level rise

The open source programme GRASS GIS was used to map the sea level rise (GRASS stands for Geographic Resources Analysis Support System). This software is used to manage geographic spatial data, for spatial modelling and visualisation. GRASS GIS is used for scientific and commercial purposes worldwide as well as by numerous government and consulting agencies. It is produced by Open Source Geospatial Foundation (OSGeo 2013).

To make calculation of the sea level rise it is necessary to have information on the mean sea level (MSL) for the Adriatic. Mean sea level at the tide gauge station in Bar is +0.27 m (Jovanović 1978) above Trieste vertical datum, which used to represent a reference level for measuring heights on land in former Yugoslavia. The basis in the analysis of scope of the areas that will be affected by sea level rise is application of the latest set of LiDAR data of the digital terrain model (DTM) for the Montenegrin coastal zone with data provided in relation to Trieste vertical datum. In order to calibrate projections of the sea level rise in relation to Trieste vertical datum, a value of 0.27 m has been added to the projected values of the sea level rise, which represents value of the height expressed in the national system. This is how projection of the estimated sea level rise on the digital terrain model was done.

Sea level rise is a problem that is being researched in numerous scientific circles therefore a large number of various projections that can substantially differ among themselves is available. Sea level rise is a very complex process. Progress in studying this problem depends on a large number of factors (eustatic, glacial-hydro-isostatic, tectonic) which are indicated on different spatial and time scales and for which it is difficult to say with certainty whether they are a cause or consequence of changes in the environment.

Projections derived from climate models recommended by the International Panel on Climate Change (IPCC) as well as projections based on semi-empiric methods of certain authors have been taken into account in the analysis of the sea level rise in the Montenegrin coastal zone. Transference of the projected sea level rise for the Montenegrin coastal zone into space was done only through application of the digital terrain model (DTM), without using techniques to downscale global models to regional level and by taking into account changes of the sea level in the Adriatic basin. Effects caused by strong winds and waves have not been considered in the assessment of the seal level rise for Montenegro's coast.

As Montenegrin coastal zone is a part of the Mediterranean basin, possibility of divergence from global projections has been taken into account with a view to enclosed character of the Mediterranean sea basin in relation to the Atlantic ocean; the 'bottleneck" effect of the Gibraltar straits has been also taken into account. Recent studies have confirmed that the seal level rise in the Mediterranean will follow rise in the Atlantic ocean (differences are at the level of 5-10 cm during the next 100 years) (Jorda et al. 2011 in: Umgiesser et al. 2010). According to Bindoff (2007), differences in the sea level rise will not exceed ± 0.15 m in the XXI century, depending on the geographic position of the coast. Measurements of tide in the XX century (Klein and Lichter, 2009) also show that the sea level rise in the Mediterranean is very similar to the average sea level rise at global level of 0.5 – 2.5 mm per year. By observing this correlation and in the context of connectedness of the Mediterranean and Adriatic seas while also taking into account substantially lower physical separation of the two sea basins, it can be concluded that the trends in the Mediterranean are reproduced in the Adriatic sea.

Given the fact that the mean sea level at Montenegrin coasts was calculated based on data from Jovanović, 1978, a change in the sea level in the period 1978 – 2012 was factored in. According to the coastal data measured in Croatia and Italy, sea level in the XX century has increased on average by 1 – 2 mm per year. However, tidal measurements in the period between 1993 and 2012 show an increase in the sea level of 2.9 – 5.7 cm in the course of these 19 years (Umgiesser et al.). By extrapolating highest values registered at tide gauge stations and via satellite in the period 1978 – 2005 and by analysing the trend of growth, a value of 15 cm is derived as a possible sea level increase in the Adriatic by 2012.

Having in mind the above, four scenarios with projections of the sea level rise by 2100 were proposed in the analysis of the seal level rise in the coastal zone of Montenegro.

Scenarios take into account the following factors:

1. **First scenario (in line with IPCC projections from 2007):**
   a. Thermic expansion of the sea
   b. Glacier melting, excluding gradual melting of ice from Greenland and Antarctica
2. **Second, third and fourth scenario:**
   a. Thermic expansion of the sea
   b. Glacier melting, including gradual melting of ice from Greenland and Antarctica
   c. The highest local sea level rise in the period 1978 – 2013

Even though second, third and fourth scenario are based on application of the same factors, they take into account different projections of the sea level rise – from lowest to highest – that are based on semi-empirical methods. Impact of storms is not taken into account. There were no special attempts to validate scenarios, nevertheless they are based on the application of existing data some of which have been validated within specific projects implemented earlier.

First scenario: 0.62 m in DTM = 0.27 m (height correction) + 0.35 m (sea level rise by 2100), which is based on IPCC projections estimating global sea level rise by the year 2100 at 35 cm, which gives projection of 0.62 m in the digital terrain model in the context of illustrating extent of flooding zones due to sea level rise. Areas marked with red colour on illustration 6 show the extent of flooding in case of the sea level rise according to this projection. Impact of winds on the sea level rise in the period 1978 to 2012 has not been taken into account and is a subject of a distinct analysis (impact of strong winds).

Second scenario: 0.96 m in DTM = 0.27 m (height correction) + 0.15 m (sea level rise in the period 1978-2012) + 0.54 m (sea level rise by 2100), which takes into account the sea level rise in the Adriatic of 0.15 m between 1978 and 2012 and projections of the global sea level rise of 54 cm (which corresponds well with moderate to high projections in line with IPCC recommended climate models for scenarios A1B and A2 (these include impacts from gradual ice melt) as well as with the lowest projections of semi-empirical methods of previous studies based on the analysis of sea level rise in the past and average global temperature increase). In relation to this, a scale of sea level rise has been proposed corresponding to temperature increases compared to pre-industrial period from the aspect of registered level of impact of relevant anthropogenic impacts (Rahmstorf 2007). Based on these premises, projection of 0.96 m in the digital terrain model was obtained with a view to illustrating the extent of flooding zones due to sea level rise. This scenario also does not take into account impact of winds on sea level rise between 1978 and 2012 (this is subject of separate analysis). Areas marked with orange colour on illustration 6 denote areas that will be threatened in case projections of the sea level rise according to the second scenario materialise.

Together with the first scenario, this projection can be also considered as realistic in present as well as in near future given the fact that already now, according to the data of the Institute of Hydrometeorology and Seismology of Montenegro (data acquired over a longer period of time on tide gauge stations along Montenegrin coast and estimations of the existing impacts of tide, as well as data that refer to meteorological factors), sea level rise of 0.69 m is happening during storms (0.69 m is value without calibration of the sea level in relation to Trieste vertical datum – 0.27 m). It is necessary to emphasise that projections of impacts of the sea level rise during storms are of empirical nature and local character, and that they are taking place within timeframe of several hours, while as projections of climate change impacts are long-term and based on conversion of global projections to local level. Previous comparison was made in order to point out how justified it is to consider expected impacts of sea level rise at present. **That is why second scenario should be treated as a minimum safety level also in the processes of short-term planning of urban development.**

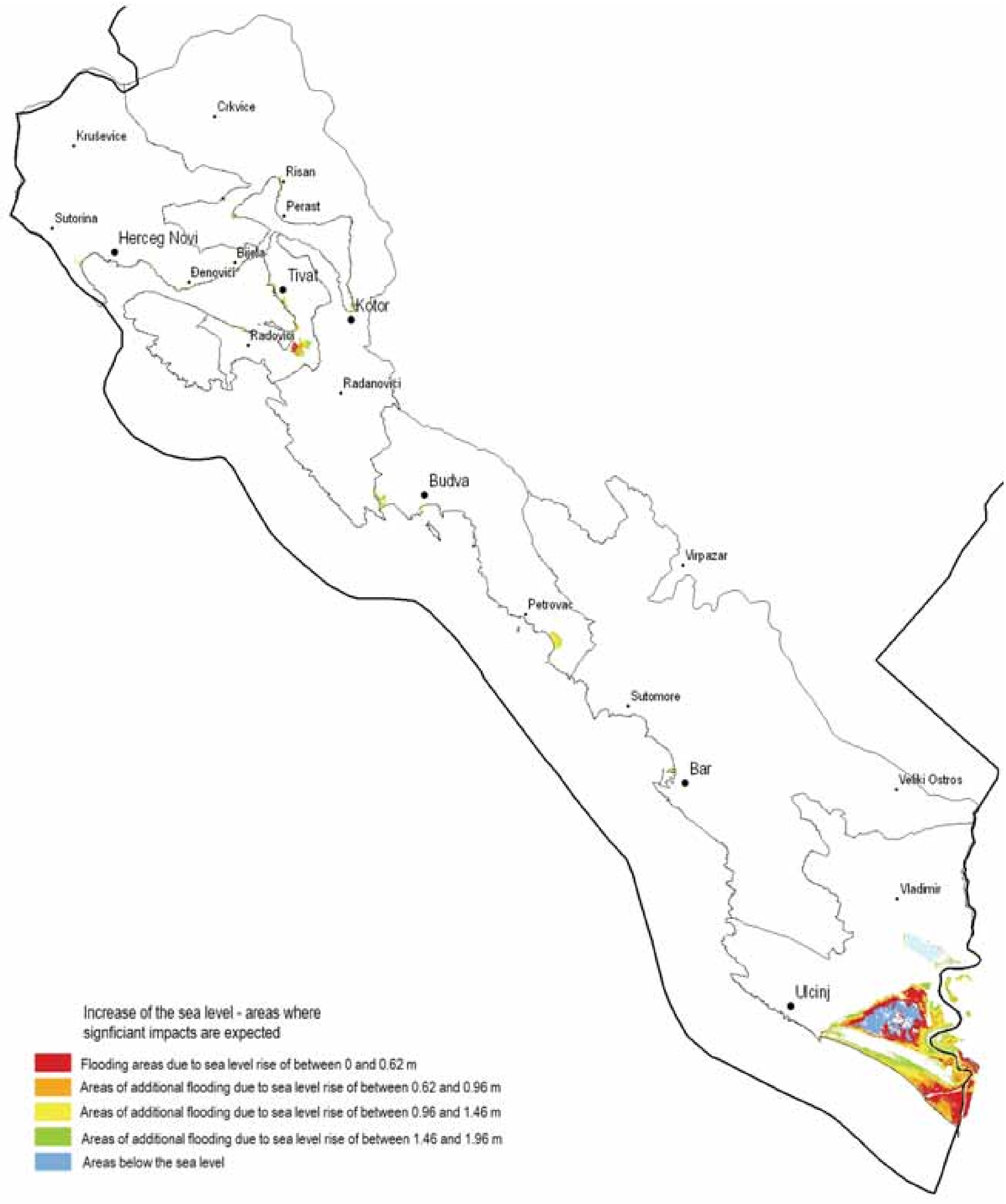

Illustration 6: Sea level rise

Third scenario: 1.46 m in DTM = 0.27 m (height correction) + 0.15 m (sea level rise in the period 1978-2012) + 1.04 m (sea level rise by 2100), is based on cumulative impact of the sea level rise in the Adriatic in the period between 1978 and 2012 and projection of the global sea level rise of 1.04 m. Most of the semi-empirical calculation methods of moderate to high projections shows that projected sea level rise of 1 m by 2100 is highly likely. According to

Vermeer and Rahmstorf's (2009) semi-empirical method that links variations of the global sea level on a time scale with changes in global mean temperature by 2100, sea level rise of slightly less than 1 m is expected, but under the lowest projections for scenarios A1B and A2. Impact of winds on sea level rise in the period between 1978 and 2012 is not taken into account, as it is subject to distinct analysis; impact of gradual ice melt is taken into account. This scenario is based on the projection of global sea level rise of 1.04 m and matches projection of 1.46 m in the digital terrain model in the context of illustration of flooding zones due to sea level rise impacts (areas marked with yellow colour on the map in illustration 6).

Fourth scenario: 1.96 m in DTM = 0.27 m (height correction) + 0.15 m (sea level rise in the period 1978-2012) + 1.54 m (sea level rise by 2100), takes into account sea level rise in the Adriatic in the period between 1978 and 2012 and projection of the global sea level rise of 1.54 m. Projection of the sea level rise above 1 m cannot be considered as unrealistic since it is based on linear dependence of higher temperature increase (warming) and sea level rise. Such phenomena have already been registered in the XX century, therefore it is realistic to expect they could continue in the XXI century too (Rahmstorf 2007). Projection based on the highest values of the sea level rise under A1B and A2 scenarios up to 2100 exceed projections of 1.5 m sea level rise by few centimetres (Vermeer i Rahmstorf 2009). This scenario is based on **projection of the global sea level rise of 1.54 m** and it corresponds to projection of 1.96 m in the digital terrain model in the context of illustrating flooding zones due to sea level rise impacts (areas marked with green colour on the map in illustration 6).

Blue colour on the map in illustration 6 marks the areas where flooding **projections due to sea level rise have been calculated for sections lying below 0 m in the digital terrain model.** This especially refers to hinterland of Bojana river mouth/ estuary given the fact this is one of the lowest and therefore most vulnerable parts of terrain; for these reasons, the area will be endangered under any of the mentioned scenarios.

For the purpose of vulnerability assessment of different areas with a view to expanding the coastal set back zone, the first scenario has been chosen as the most realistic and probable one in the vulnerability assessment of the narrow coastal zone. This conclusion has been drawn based on sea level rise projections for the Montenegrin coastal zone from previously presented scenarios and their comparison with actual situations recorded through hydrographical and tide gauge monitoring along the coast. The scenario is based on IPCC projections estimating global sea level rise by 2100 at 0.35 m which gives projection of 0.62 m in the digital terrain model in the context of illustrating the extent of flooding zones due to sea level rise (taking into account height correction of 0.27 m in reference to Trieste vertical datum). As previously discussed, the projection is considered realistic at present as well as in near future

Since none of the four scenarios take into account daily oscillations of the sea level and sea level oscillations caused by weather, **it is recommended that at present and in the near future second scenario on the sea level rise above mean sea level** – i.e. **projection of 0.96 m in the digital terrain model – is applied in the context of illustrating the extent of flooding zones due to sea level rise.** This especially having in mind that second scenario projection corresponds fully with the data of the Institute of Hydrometeorology and Seismology of Montenegro recorded at the tide gauge station in Bar, which show that sea level rise of 0.69 m is taking place already now during storms (when sea level calibration of 0.27 m in relation to Trieste vertical datum is taken into account, the sea level rise is 0.96 m). **The recommendation needs to be applied in all spatial plans,**

including short-term planning, particularly because of the fact that the highest level of pressures on the environment is relevant for planning further urbanisation. It is also assessed that both locations of the areas where flooding occur and evaluation of the flooding intensity correspond with results of the analysis on impacts from strong winds given in real time, by applying real data.

Considerations and conclusions pertaining to the application of the four sea level rise scenarios (which are based on the analysis of literature data in line with IPCC projections and relevant semi-empirical methods) for the Montenegrin coastal zone have been mapped with precision through the use of high resolution LiDAR data and an estimation of the sea level rise implications for space has been made. Given the fact that sea level rise estimates are of long-term nature (they refer to the year 2100), an assessment of probability of their realisation at present and in the near future was made, based on application of assumptions presented in the previous part of the analysis. With these in mind, each future spatial plan should take into account results of the first (sea level rise of +0.62 m in the DTM) as well as of the second scenario (sea level rise of +0.96 m in the DTM), which correspond with maximum sea level rises in the current, still rare, emergency situations of coastal zone flooding due to impacts of strong winds. This is especially important in the context of application of data on projected impacts of sea level rise in the Montenegrin coastal zone within the time horizon of developing the Special Purpose Spatial Plan for the Coastal Zone of Montenegro.

Moreover, it is possible to obtain values of the sea level rise in a shorter time period by using linear interpolation method, taking current sea level rise data as a starting point i.e. by getting the end values depending on the chosen scenario. It is important to mention that scenarios refer to a period from 2010 to 2100 – a long-term period where projections are usually based on functions of exponential growth. That is why simple linear interpolation was applied for shorter time segments of the long-term interval, whereas for a part of the interval outside the short-term period certain deviations of the growth function were included in the calculation in order to calibrate difference occurring due to simplified presentation of exponential growth of the seal level rise until the end of the century by the means of simple function of linear growth.

Graphic presentation of all the four scenarios is provided on illustration 7.

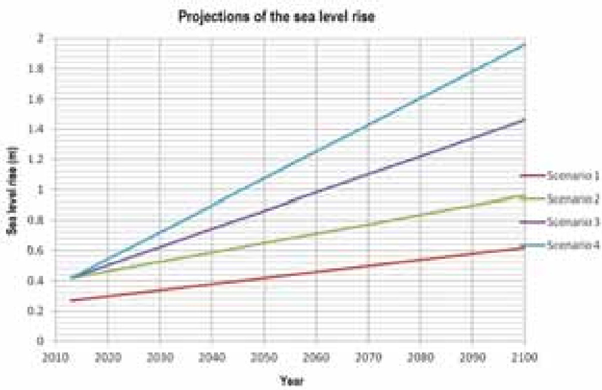

Illustration 7: Linear interpolation of the sea level rise projections under scenarios 1 – 4

Orthophotos were used to provide for better visual presentation of the final results of this analysis (Annex 5).

3.
Assessment of areas where conditions for expanding the coastal set back zone exist

In line with chosen method of work, the following vulnerable areas have been prioritised for further analysis in order to determine sections where conditions for expanding the coastal set back exist:

- mouth of Sutorina river;
- Kostajnica – Risan;
- north-western part of Vrmac;
- Tivat Saltpans;
- Jaz beach and part of Mrčevo field;
- Buljarica;
- Čanj;
- Velika plaža;
- Ada Bojana.

Analysis of individual areas assessed as vulnerable in terms of formulating proposal for the coastal set back expansion is presented in the tables in subsequent sections. Coastal set back line will be detailed in the analysis for defining the coastal set back. The tables include the most significant vulnerability aspects that have been covered in detail in the Assessment of General Vulnerability of the Coastal Zone and in individual analyses and studies prepared for the Vulnerability Assessment of the Narrow Coastal Zone.

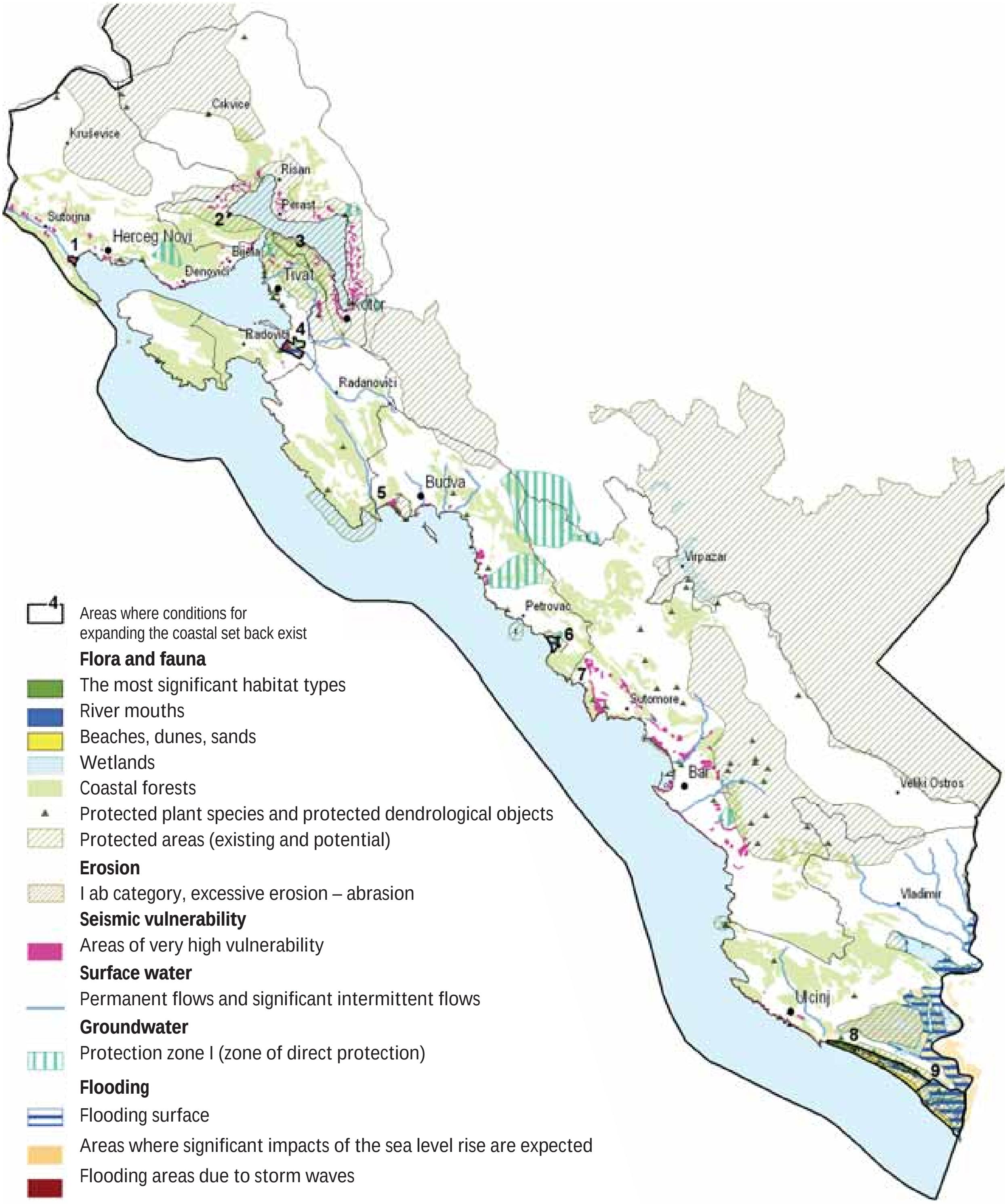

Illustration 8: Locations of proposals for expanding the coastal set back with the most significant segments/data used to define the coastal set back expansion proposal

3.1
Mouth of Sutorina river

Coastal ecosystem:	No
Nature protected area:	No
Erosion:	No
Seismic vulnerability:	Yes, very high seismic vulnerability
Groundwater:	No
Impact of storms and sea level rise:	Yes, area of flooding due to impacts of storm waves, and a probable impact of sea level rise upstream Sutorina: mouth of Sutorina river, even though located in the Bay of Boka, is exposed to the activity of high waves coming from southern direction through the Bay's entrance; coast at river mouth is low, partly flooded, whereas larger areas can be flooded in case of cumulative impact of sea level rise.
Non-built areas:	Area between the coastline and walking corridor is partly developed (built); a small non-built area designated for development is located along the very river
Location specificity:	Yes, zone of peloid deposits in the hinterland
Proposal for expanding coastal set back:	Yes, expansion of the coastal set back is proposed – it is sensible to limit construction in order to preserve peloid deposits (area's surface is 32.17 ha)

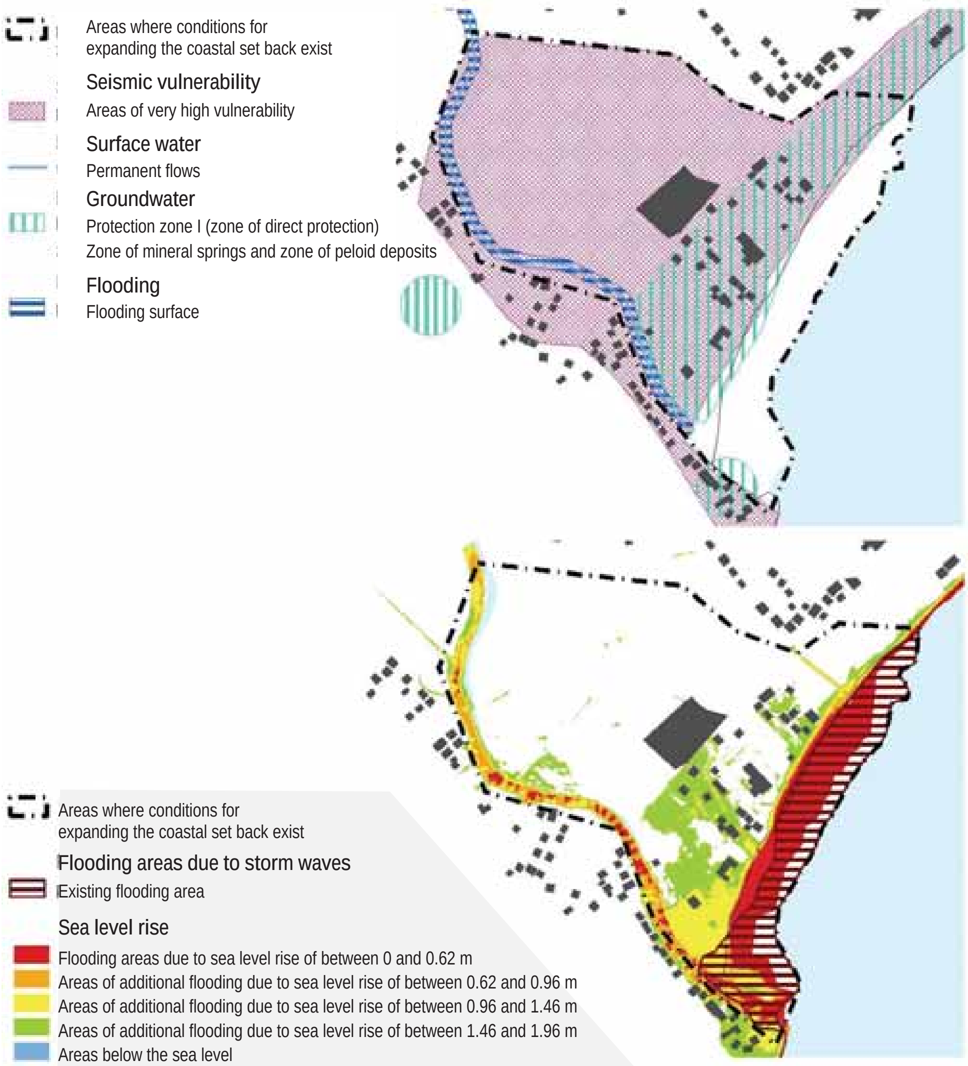

Illustration 9: Mouth of Sutorina river

3.2
Kostanjica – Risan

Coastal ecosystem:	Yes, coastal holm oak forest – black oak (Orno-Quercetum Ilicis) community especially important for biodiversity of the Mediterranean coastal zones
Nature protected area:	Yes, Kotor-Risan Bay is protected under municipal decision and also an area listed as UNESCO's natural and cultural heritage
Erosion:	Yes, from place to place moderate to strong erosion (illustration 2)
Seismic vulnerability:	Yes, from place to place very high seismic vulnerability
Groundwater:	No
Impact of storms and sea level rise:	Yes, sea level rise impact at the mouth of Morinjska river
Non-built areas:	Partly developed area, with smaller settlements located along the shore
Proposal for expanding coastal set back:	No, due to steep slopes, expansion of the coastal set back is not sensible – construction should be directed towards completion of the existing settlements; expansion is proposed at the mouth of Morinjska river where significant impact of the sea level rise is expected (surface of the area: 3.61 ha)

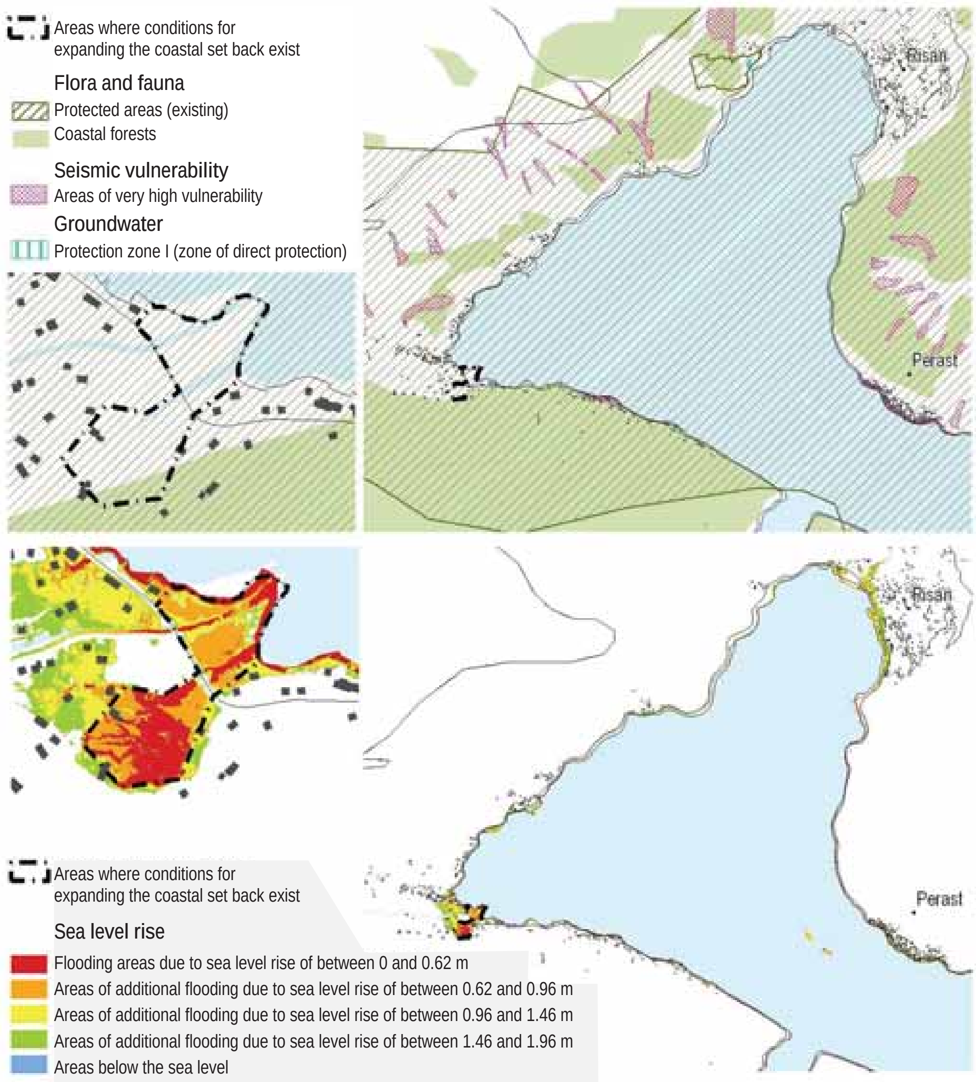

Illustration 10: Kostanjica – Risan

Illustration 11: Mouth of Morinj river

Illustration 12: North-western part of Vrmac

3.3
North-western part of Vrmac

Coastal ecosystem:	Yes, coastal holm oak forest – black oak (Orno-Quercetum Ilicis) community is present, especially important for biodiversity of the Mediterranean coastal zones
Nature protected area:	Yes, Kotor-Risan Bay is protected under municipal decision and also an area listed as UNESCO's natural and cultural heritage
Erosion:	Yes, from place to place moderate erosion (illustration 2)
Seismic vulnerability:	Yes, from place to place very high seismic vulnerability
Groundwater:	Yes, protection zone I (Lepetane)
Impact of storms and sea level rise:	No
Non-built areas:	Partly developed area, with smaller settlements located along the shore
Proposal for expanding coastal set back:	No, due to steep slopes, expansion of the coastal set back is not sensible – construction should be directed towards completion of the existing settlements

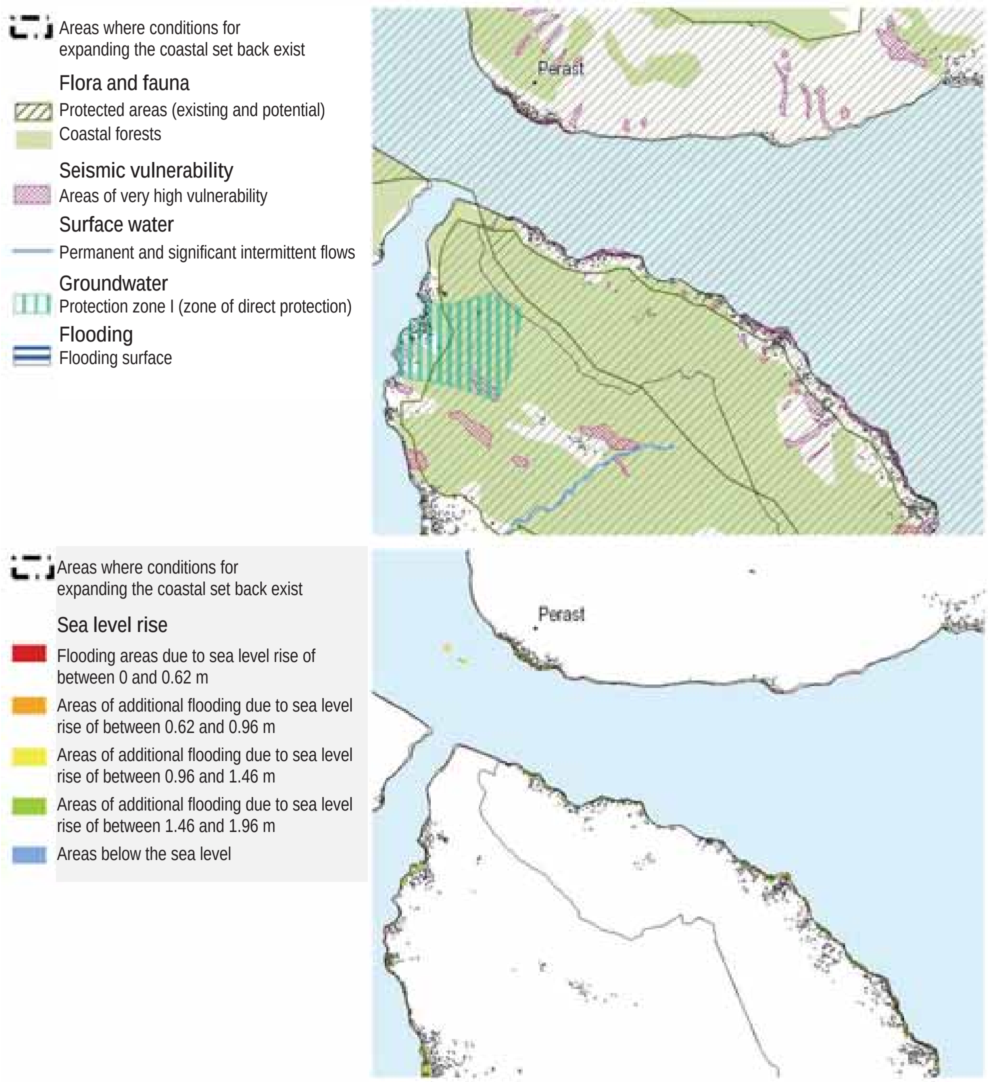

Illustration 13: North-western part of Vrmac

3.4
Tivat Saltpans

Coastal ecosystem:	Yes, wetland area and at the same time mouth of Kološun stream
Nature protected area:	Yes, special nature reserve
Erosion:	No
Seismic vulnerability:	Yes, very high seismic vulnerability
Groundwater:	No
Impact of storms and sea level rise:	Yes, flooding area due to a small difference between the sea and saltpans' level; high impact of the sea level rise is expected – Saltpans are saline, occasionally flooded wetland area. Even though the cove itself is in the protected Bay of Boka, it has a fetch in the north-western direction of 9.5 km so a strong and long-lasting wind from that direction causes waves that flood coastal belt in the cove
Non-built areas:	Partly developed area, with smaller settlements located along the shore
Proposal for expanding coastal set back:	Yes, expansion of the set back is proposed. Tivat Saltpans are typical area protected under the ICZM Protocol (surface of the area: 161.20 ha)

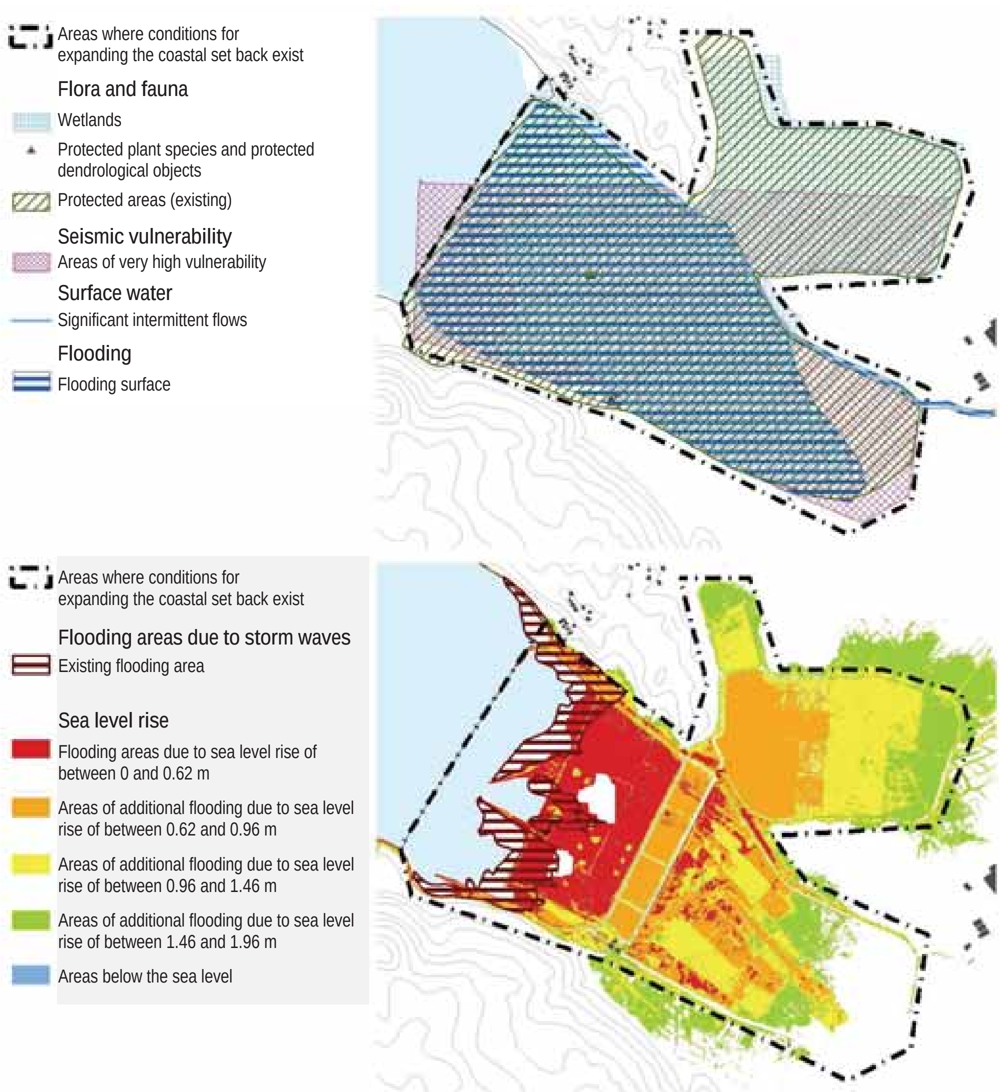

Illustration 14: Tivat Saltpans

Illustration 15: Tivat Saltpans

Illustration 16: Jaz beach and part of Mrčevo field

3.5
Jaz beach and part of Mrčevo field

Coastal ecosystem:	No
Nature protected area:	No
Erosion:	Yes, eolian erosion (illustrations 2 and 16)
Seismic vulnerability:	Yes, from place to place very high seismic vulnerability
Groundwater:	No
Impact of storms and sea level rise:	Yes, flooding area due to impact of storm waves as well as due to expected sea level rise: Jaz cove is on the open sea coastline and its low shore is exposed to wave activity from south-eastern direction (scirocco) with the longest fetch in the Adriatic and with record wave heights; impact of the sea level rise due to thermal expansion combined with other metrological and oceanographic parameters (wind and precipitation, storm and tide surges) could lead to flooding of significant land areas in the cove's hinterland
Non-built areas:	Individual tourism facilities
Proposal for expanding coastal set back:	No, impacts of the sea level rise and storms remain limited to 100 m belt; because of impacts, adaptation (decrease) of the set back is not possible. It should be kept in mind that Mrčevo field is agricultural land of exceptional importance, which questions whether construction in this area is justifiable

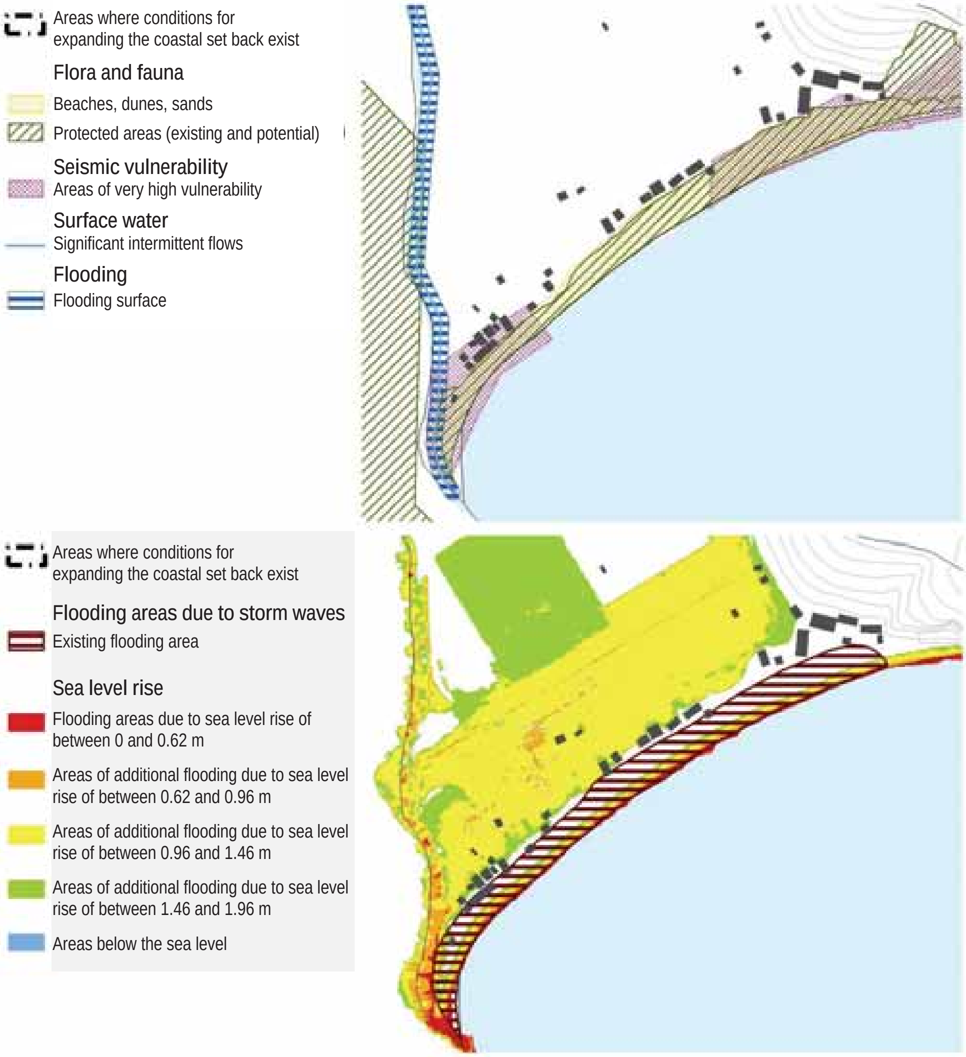

Illustration 17: Jaz Beach

3.6
Buljarica

Coastal ecosystem:	Yes, zone of halophyte vegetation, wetland habitat of exceptional importance for birds (IBA)
Nature protected area:	Yes, monument of nature
Erosion:	Yes, eolian erosion (illustration 2)
Seismic vulnerability:	No
Groundwater:	No
Impact of storms and sea level rise:	Yes, flooding area; large impact of the sea level rise is expected: Buljarica cove is on the open sea coastline and is directly exposed to high waves activity from southern, south-western and western direction. Soil along the shore is low and marshy. If possible projection of a more significant sea level rise due to thermal expansion is taken into account, cumulative impact could have catastrophic effects on specific ecosystem in the cove's hinterland
Non-built areas:	Yes, settlements are located in the background of the field
Proposal for expanding coastal set back:	Yes, protected area of exceptional importance for biodiversity preservation as typical coastal wetland area and specific coastal ecosystem the protection of which is required under the ICZM Protocol; in case of new tourism capacities development, extent is questionable and the need to preserve the most significant natural characteristics should be kept in mind (area's surface: 72.40 ha)

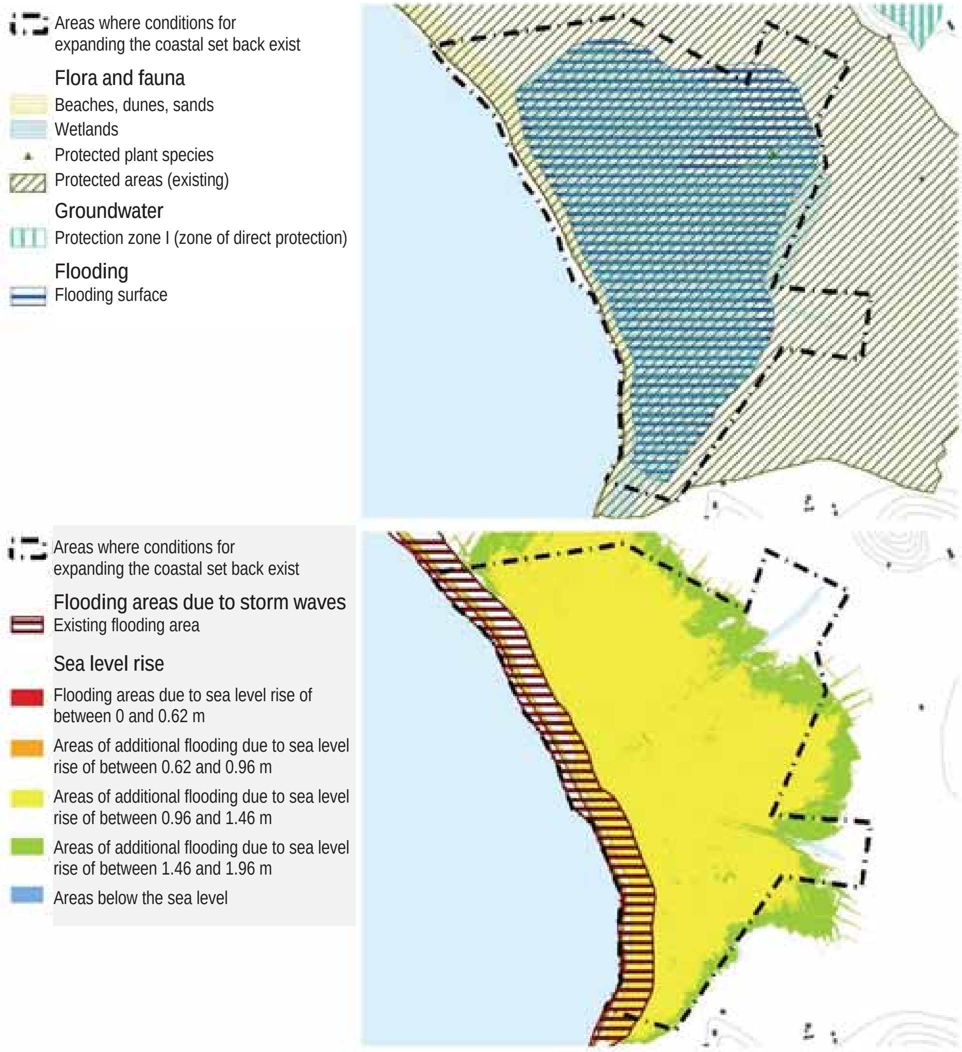

Illustration 18: Buljarica

Illustration 19: Buljarica

Illustration 20: Čanj

3.7
Čanj

Coastal ecosystem:	No
Nature protected area:	No
Erosion:	Yes, eolian erosion (illustrations 2 and 20)
Seismic vulnerability:	No
Groundwater:	No
Impact of storms and sea level rise:	Yes, very high impact of storms is expected: the cove lies on the open coastline and is directly exposed to wave activity, the stretch from Black to Sapavica capes being an exception as it is protected from direct wave strikes from southern and south-eastern directions. However, waves from south-western and western directions to which the cove is directly exposed have a fetch spreading over the entire width of the Adriatic. For this reason, they reach heights and destructive power close to those of fully blown *jugo*
Non-built areas:	Settlement
Proposal for expanding coastal set back:	No, impacts of the sea level rise and storms remain limited to 100 m belt; because of impacts, adaptation (decrease) of the set back is not possible. Future construction should be adapted to expected impacts of storms combined with sea level rise. Integrity of the (protected) beach and of its immediate hinterland should be maintained

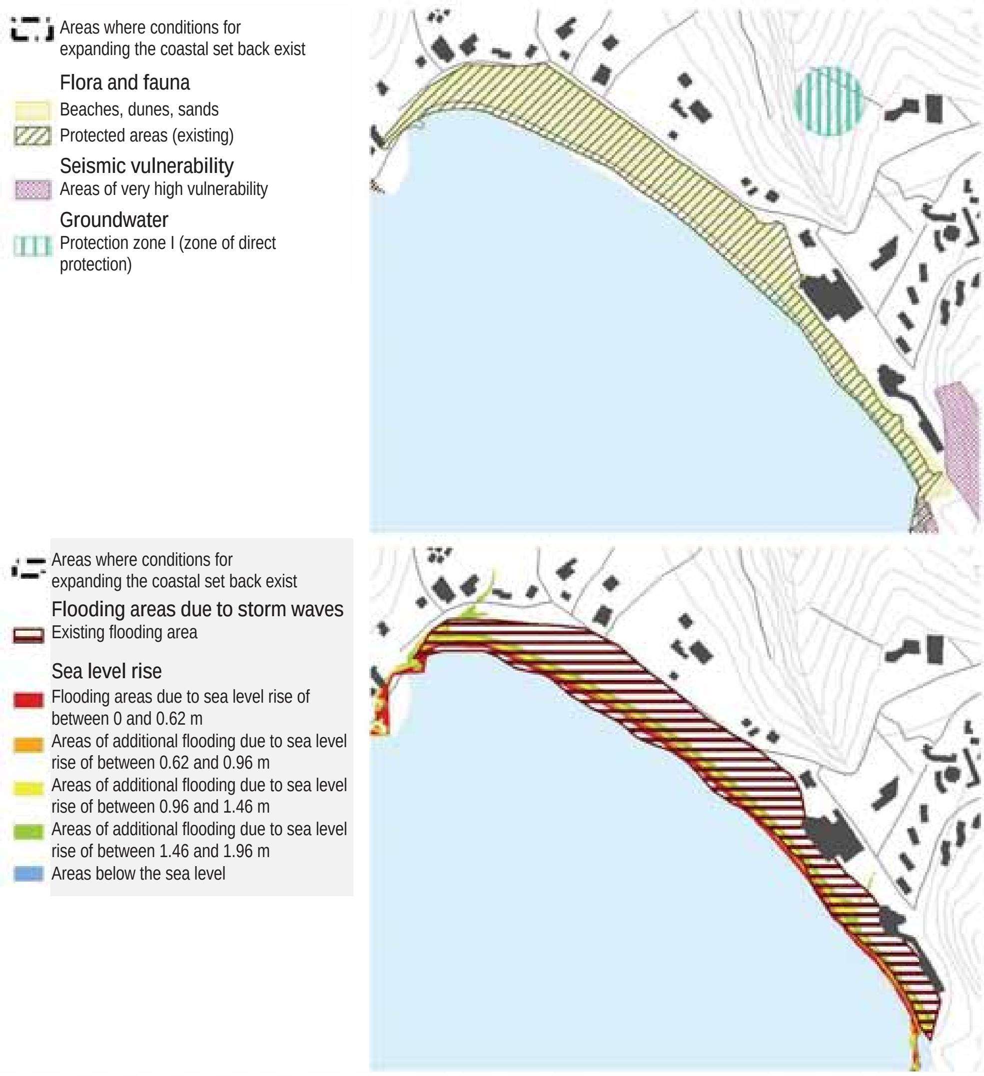

Illustration 21: Čanj

3.8
Velika plaža

Coastal ecosystem:	Yes, dunes with halophyte vegetation, grassland and coastal forests habitats
Nature protected area:	Yes, monument of nature
Erosion:	Yes, eolian erosion (illustrations 2 and 23)
Seismic vulnerability:	Yes, near shore area is a zone of high seismic vulnerability, covered with thick soft untied sandy sediment; during 1979 earthquake, this zone manifested pronounced dynamic instability (illustration 3)
Groundwater:	No
Impact of storms and sea level rise:	Yes, minor impact of the sea level rise is expected in the middle and very high on the eastern part of the beach (see elaboration on page 40.
Non-built areas:	Yes, except for tourism settlement on the north-western part of the coast
Proposal for expanding coastal set back:	Yes, expansion of the coastal set back is proposed as the area in question is of exceptional importance for preservation of complex coastal biodiversity, the protection of which is required under the ICZM Protocol. Related to this, planned extent and manner in case of construction of new tourism capacities is questionable, whereas necessity of preserving the most significant natural and landscape characteristics should be kept in mind (area's surface: 650.25 ha)

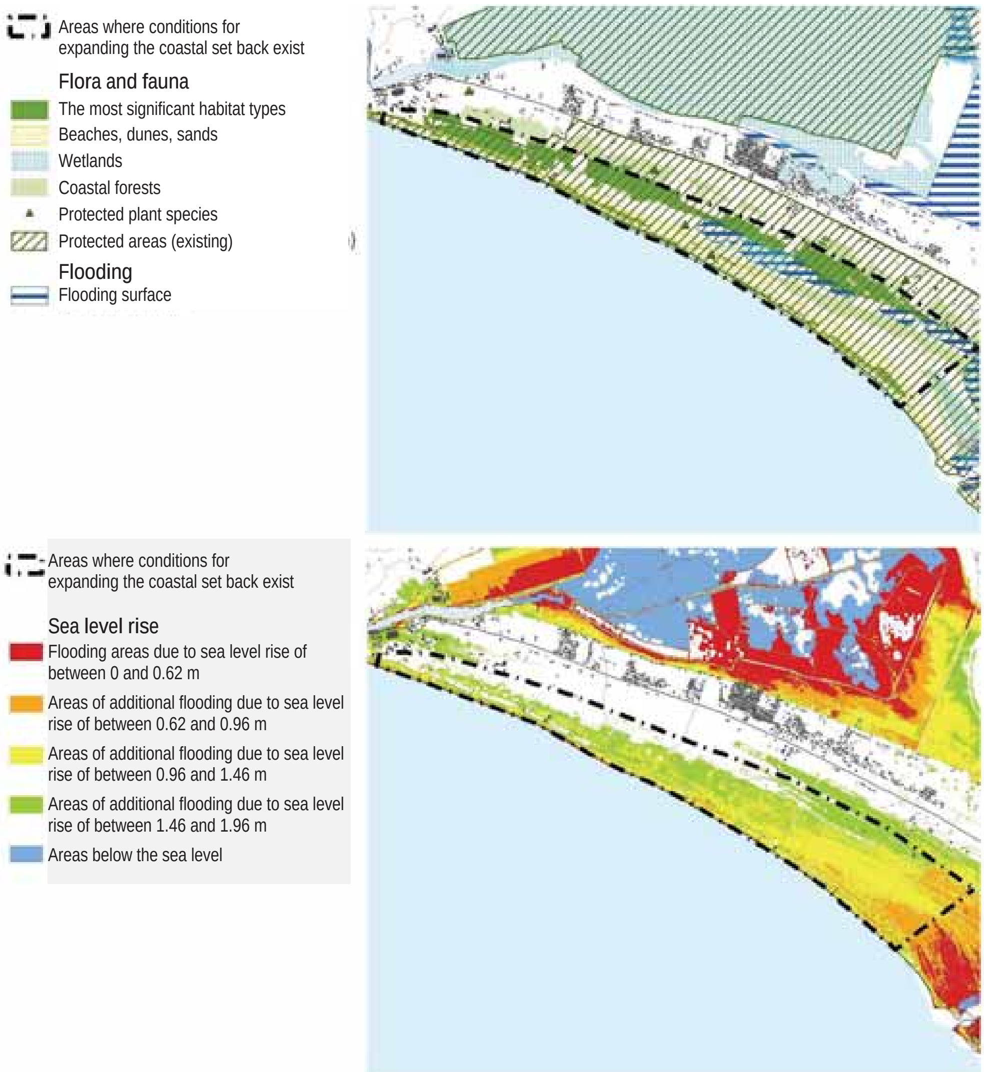

Illustration 22: Velika plaža

Illustration 23: Velika plaža

3.9 Ada Bojana

Coastal ecosystem:	Yes, dunes with halophyte vegetation, marshy grassland and coastal forest habitats; biodiversity of fresh, brackish and marine habitats at Bojana mouth/ estuary
Nature protected area:	Yes, recognised as potential nature protected area – monument of nature
Erosion:	Yes, eolian erosion (illustration 2
Seismic vulnerability:	Yes, near shore area is a zone of high seismic vulnerability, covered with thick soft untied sandy sediment; during 1979 earthquake, this zone manifested pronounced dynamic instability (illustration 3)
Groundwater:	No
Impact of storms and sea level rise:	Yes, Bojana flooding area, very high impact of the sea level rise is expected (see elaboration on page 44
Non-built areas:	Yes, except for the tourism settlement on the north-western part
Proposal for expanding coastal set back:	Yes, expansion of the coastal set back is proposed as the area has exceptional importance for preservation of complex coastal biodiversity i.e. it is typically valuable complex coastal natural area the preservation of which is required under the ICZM Protocol (surface of the area: 956.95 ha)

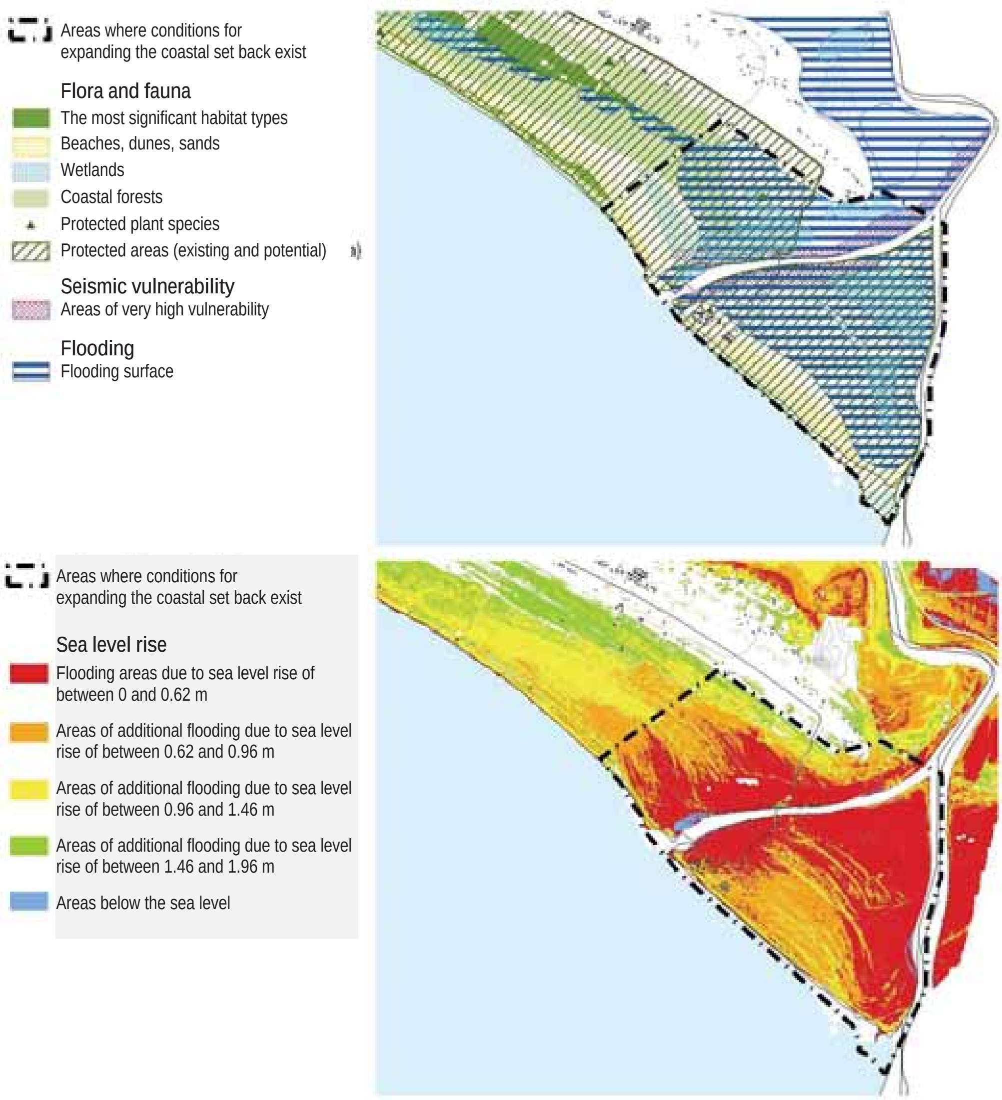

Illustration 24: Ada Bojana

Elaboration of storms and sea level rise impacts – Velika plaža – Ada Bojana

Bojana river mouth/estuary is specific for its unstable coastline and unstable topography of the sea bottom in the near shore area. For this reason, the coastline all the way to Porto Milena channel is shown as unstable. Topography of the bottom in this area, up to the 20 m isobaths, is not at all shown as it is constantly changing due to movements of sand dunes (Illustration 25).

This area is also erodible, as can be seen on illustration 25 where coastline from the official topographic maps issued by the VGI (Military Geographic Institute) Belgrade in the 1970s and the most recent satellite images have been overlapped. As depicted on the illustration, coastline has moved for more than a kilometre into the sea at some points due to sediments depositions to the east from the mouth on the Albanian part of the coast, while as one small island in the eastern arm of Bojana river disappeared altogether and the other decreased significantly due to erosion. By emergence of a new coastline profile, sea level rise will strengthen erosion processes in the river mouth area/estuary.

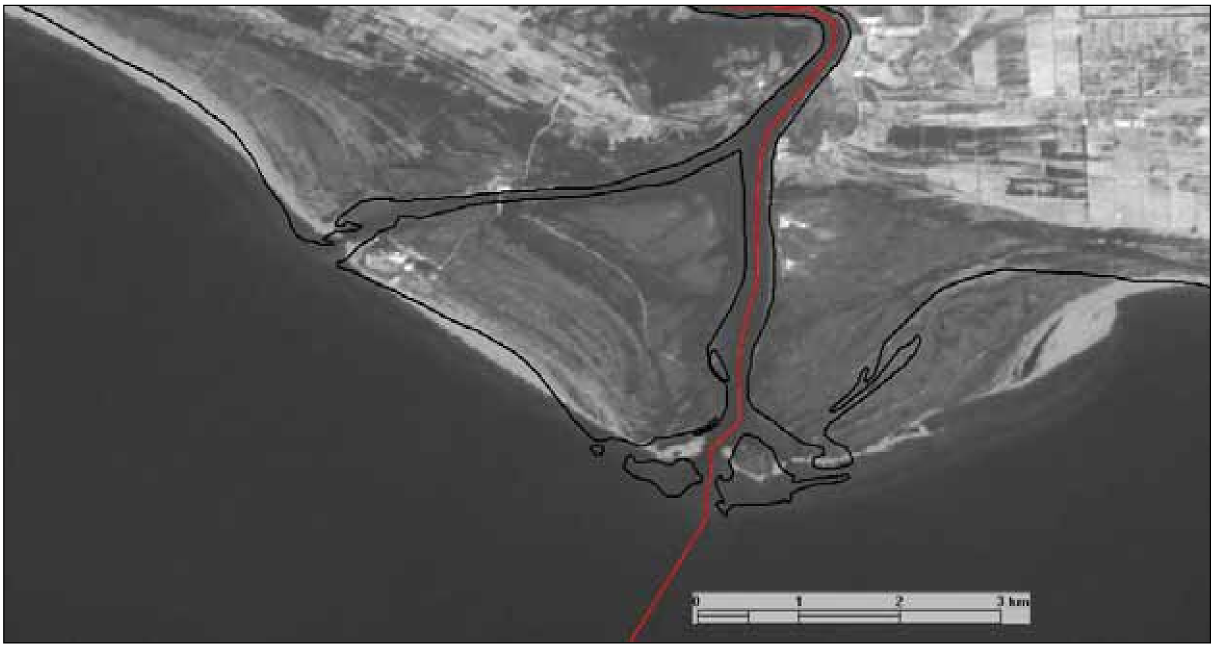

Illustration 25: Bojana river mouth (changes of the coastline due to erosion)

Due to a low gradient of Bojana riverbed (only 5 m over the 40 km of the river's length), storm cause additional slowdown of the river flow which can increase threats from flooding of the surrounding area.

In the analysis of impact of strong winds for Velika plaža and Ada Bojana, an approach analogue to the one applied for Buljarica cove was used. Since these are similar sand and pebble beaches with almost identical exposure to waves, similar advancement of waves on the beaches is expected. In other words, waves are expected to create similar beach profile on all these locations. That is why it can be assumed that during storms, waves will flood areas within the same distances from the coastline.

4.
Amendment to the general vulnerability assessment

Data used in the analysis of areas where conditions for expanding the coastal set back exist will be used in the Analysis for Defining the Coastal Set Back Zone, especially in the context of determining the areas where adaptation leading to decrease of the coastal set back is not possible due to high environmental vulnerability i.e. to pronounced impacts on the environment.

The following have been prepared for the Analysis for Defining the Coastal Set Back Zone:

1. **Amendment of the model of pronounced protection of the most significant environmental elements/segments** (illustration 26) which has been applied in the Assessment of General Vulnerability of the Coastal Zone for the narrow coastal belt within the distance of 1000 m from the coastline. Namely, the model was amended with results acquired through individual analyses and studies carried out for vulnerability assessment in the narrow coastal zone including:
   - Habitats mapping for selected locations (Velika plaža Ulcinj, Buljarica, Platamuni, Tivat Saltpans) and assessment of their vulnerability (Annex 1);
   - Erosion map for the immediate coastline (Annex 2);
   - Study of seismic categorisation of space for coastal municipalities of Montenegro (Annex 3);
   - Study of storms in the Montenegrin coastal region (Annex 4);
   - Study of sea level rise (Annex 5).
2. **Model according to the principle of maximum value** (illustration 27) where categories for determining vulnerability of the narrow coastal zone from the matrix presented on page 5 of this report have been associated in such a way that the most vulnerable categories (grade 5) have been particularly distinguished:
   - wetlands and river estuaries, dunes (valuable ecosystems significant according to the ICZM Protocol),
   - coastal forests (category significant according to the ICZM Protocol),
   - other ICZM categories representing additional arguments for defining the coastal set back.
3. **Model according to the principle of frequency** (illustration 28) which shows the rate of simultaneous occurrence and overlapping of categories according to which vulnerability of the narrow coastal zone has been assessed (matrix on page 5 of this report) in the observed area; 1 category denotes the lowest occurrence of vulnerability given the fact that vulnerability of the observed space is caused by one vulnerability category, while as 8 categories mean that vulnerability in the observed area is caused by simultaneous presence of eight vulnerability categories.

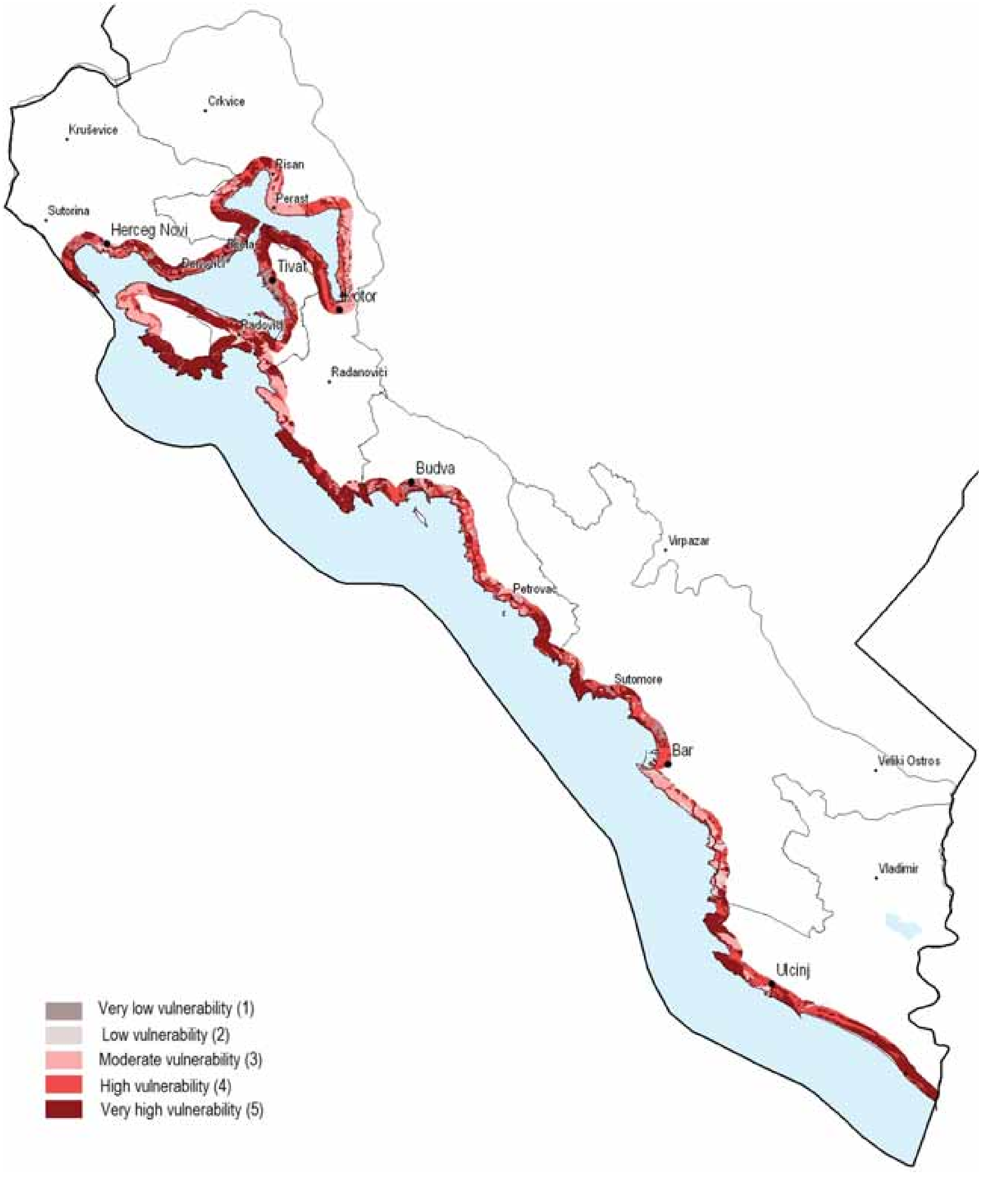

Illustration 26: Model of general vulnerability – model of pronounced protection of the most significant environmental elements/ segments amended with results of additional analyses (in the 1000 m belt)

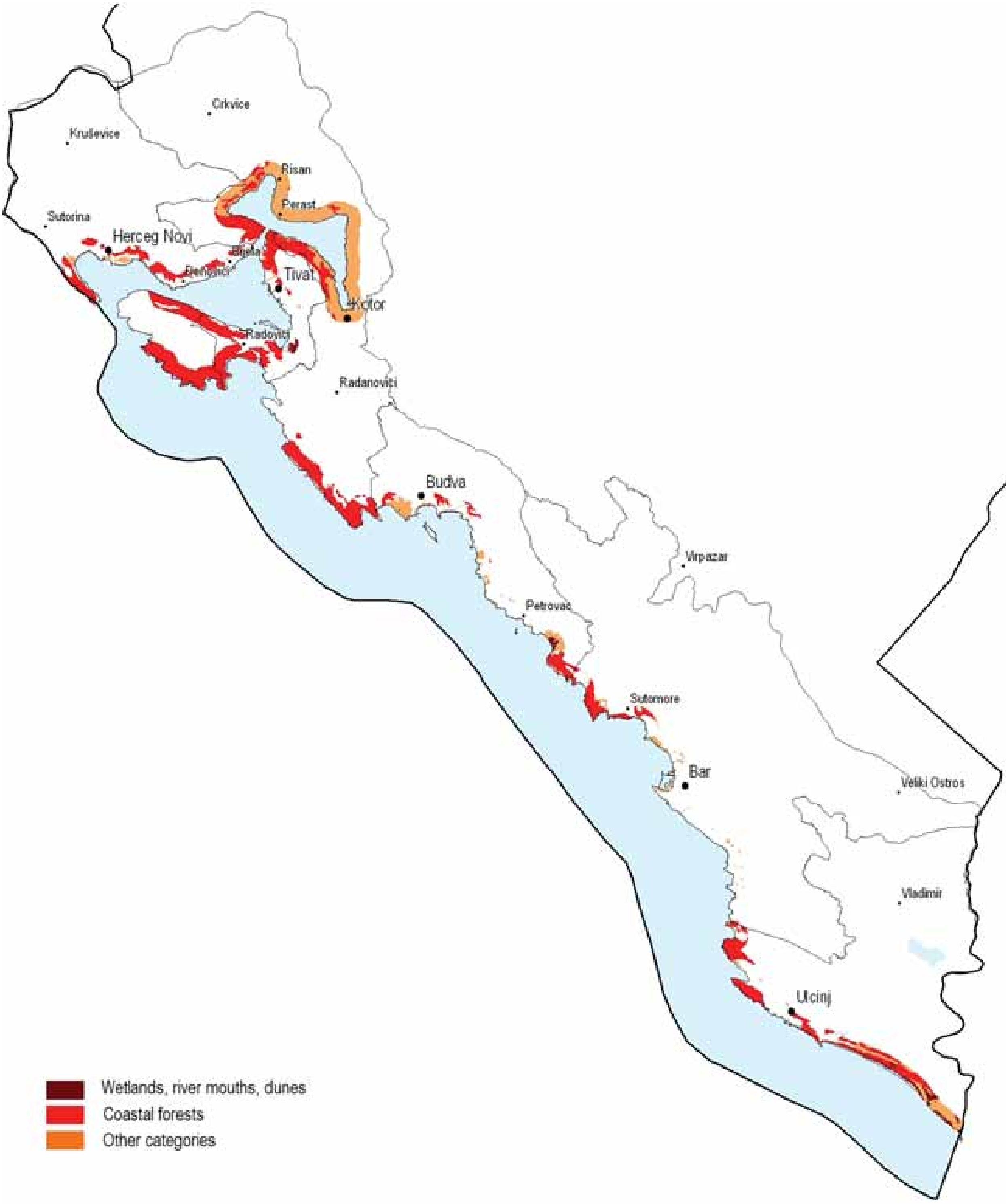

Illustration 27: Vulnerability model of the narrow coastal zone according to the principle of maximum value

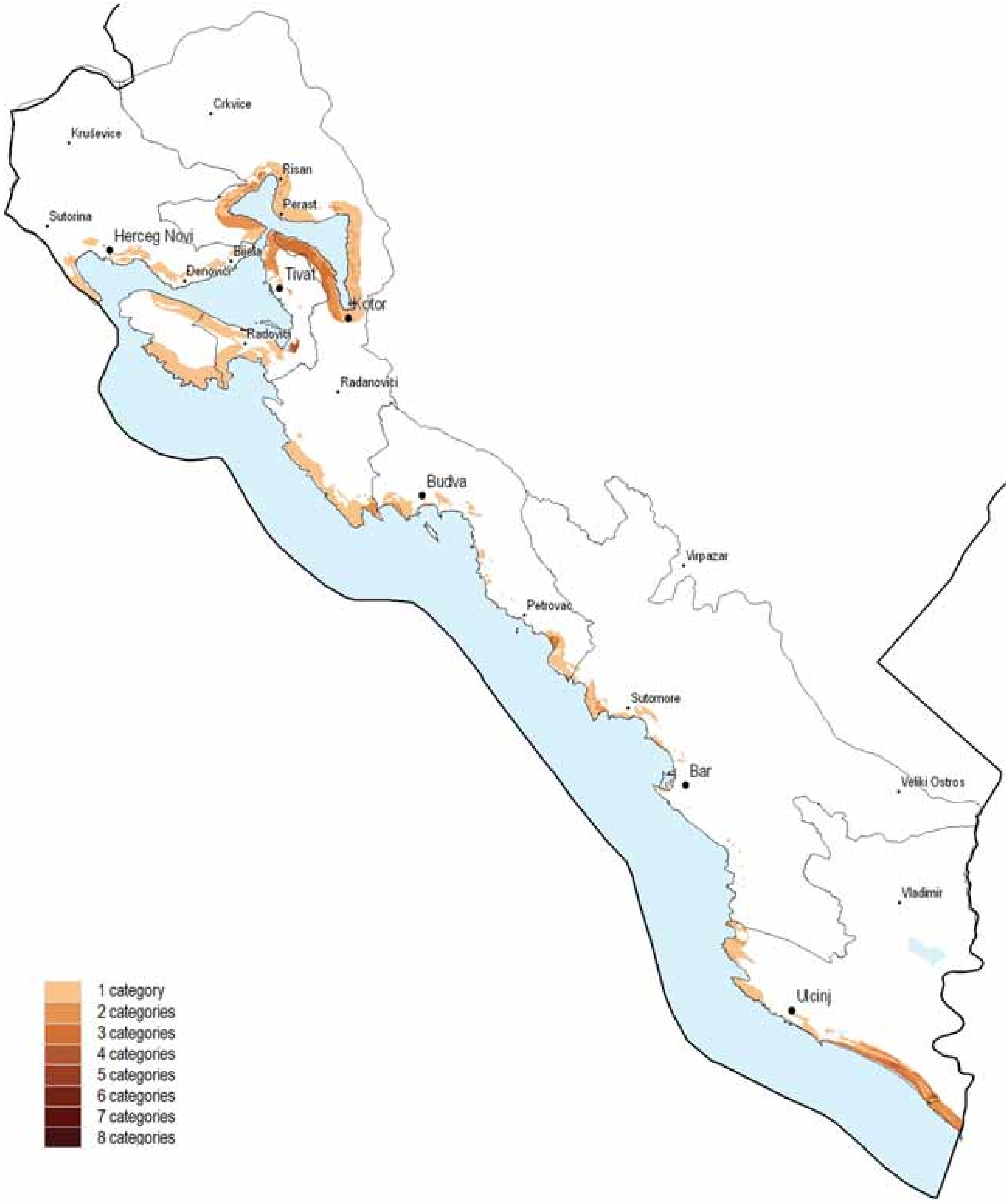

Illustration 28: Vulnerability model of the narrow coastal zone according the frequency principle

5.
Conclusion

In line with the results of analysis from chapter 3, the following are the areas where expansion of the coastal set back zone is proposed i.e. where construction along the shore should be restricted or prohibited, in accordance with the Barcelona Convention Protocol on Integrated Coastal Zone Management in the Mediterranean (ICZM Protocol):

- mouth of Sutorina river;
- mouth of Morinjska river;
- Tivat Saltpans;
- Buljarica;
- Velika plaža; and
- Ada Bojana.

As it can be seen from previously presented results of the conducted analyses, expansion of the set back is proposed for a smaller number of locations taking primarily into account the fact that they host the most significant environmental elements the protection of which is defined in the article 10 of the ICZM Protocol; the article explicitly provides for protection of specific coastal ecosystems: wetlands and estuaries, marine habitats, coastal forests and dunes.

Table 4: Scope of the zones where expansion of the coastal set back is proposed in relation to total surfaces, construction areas and share of developed (built) surfaces

Municipality	Surface in 1,000 m (ha)	Construction areas/ total surface (%)	Developed/total surface (%)	Vulnerability (4 and 5)*		Conditions for expansion	
				ha	% from total	ha	% from total
Bar	3,103	72.7	45.3	1,791	57.7	-	-
Budva	2,676	54.9	16.4	1,923	71.8	72.40	2.7
Herceg Novi	4,256	63.1	15.9	1,977	46.5	32.17	0.8
Kotor	5,721	23.4	6.9	3,342	58.4	3.61	0.1
Tivat	2,727	39.3	16.0	1,242	45.5	161.20	5.9
Ulcinj	2,908	37.3	7.5	2,320	79.8	1,607.20	55.2
Total	**21,391**	**46.3**	**13.8**	**12,595**	**58.9**	**1,876.58**	**8.8**

* Taking into account assessment of general vulnerability - model of pronounced protection of the most significant elements

Proposal for expanding the coastal set back must not be understood as a development limitation but rather as:

- Implementation of the principles of sustainable development of Montenegro;
- Implementation of the Protocol on Integrated Coastal Zone Management in the Mediterranean;
- Support for the spatial planning concept based on spatial diversity, existence of various spatial units along the coast (the goal is to prevent uniform and linear urbanisation along the entire coastline);
- A way to ensure safety of investments since the areas proposed for expanding the coastal set back coincide with the zones of high seismic vulnerability and existing/ potential flooding areas as well as with areas where significant impacts of the sea level rise are expected, or, in other words, they coincide with areas where construction is not justifiable and sensible anyway.

July 2013

CAMP Montenegro is a programme implemented jointly by United Nations Environment Programme Mediterranean Action Plan (UNEP/MAP) and the Montenegrin Ministry of Sustainable Development and Tourism (MSDT), with the involvement of local governments from the project area and of other relevant institutions.

The main objectives of the CAMP Montenegro include:

- creation of necessary mechanisms that can help achieve sustainable development of the coastal area;
- support for the implementation of national policies and the ICZM Protocol of the Barcelona Convention;
- promotion of integrated and participatory planning and management in the coastal area;
- development of national and local capacities for ICZM and raising awareness of the importance of the coastal area, complexity and fragility of its ecosystems and of the need for integrated approaches in managing them;
- facilitation of the transfer of knowledge on ICZM tools and approaches.

The main output of the programme is the ICZM Strategy and the Plan for Montenegro.