

Risk management plans for meteo- tsunamis with proposal of improving actions to existing local RMPs

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Risk Management Plan Concerning Risks of Coastal Floods Caused by Extremely High Ocean Waves with a Proposal to Improve the Measures of Existing Local Management Plans

Kaštel Kambelovac pilot location

1. Introduction

Croatia is located in an area exposed to certain natural disturbances that can take on greater proportions and lead to natural disasters. Due to its geographical location, geomorphological and hydrographic features, this primarily refers to natural disasters such as earthquakes, floods, fires, tidal waves, hurricanes, and storms. That is why it is important to work on prevention systems, as well as measures to protect against certain natural disasters, and to find ways to mitigate their consequences. In this context, the project *Preventing, Managing and Overcoming Natural-Hazards Risks to mitiGATE economic and social impact* – **PMO-GATE** seeks to increase the safety of the program area from natural disasters, as well as disasters caused by human activity. The project also encompasses the development of a disaster management system and increasing recovery capacity in order to reduce potential damage. The project involves Italian and Croatian regions in order to jointly find new ways to raise the level of protection and resilience to natural disasters that are specific to the areas where the project is implemented, and this primarily refers to floods caused by extremely high ocean waves, floods caused by rising sea levels, and earthquakes. The PMO – GATE project is focused primarily on the local level, i.e. the Kaštel Kambelovac pilot location, which is located in an area exposed to floods and tidal waves. The hazards and risks identified in the *Risk Management Plan Concerning Risks of Coastal Floods Caused by Extremely High Ocean Waves* are analyzed in this document from the point of view of improving existing local management plans, providing a SWOT analysis with management objectives as a prerequisite for quality flood risk management.

2. Spatial coverage of the pilot location

The Town of Kaštela is part of the Split-Dalmatia County. It borders the municipalities of Klis, Prgomet and Lećevica to the north, the Town of Solin to the east, the Town of Trogir to the west, and the City of Split at sea. The surface area of the town is 56.9 km², and the length of the coast is 23 km. The Town of Kaštela administratively encompasses seven settlements: Kaštel Sućurac, Kaštel Gomilica, Kaštel Kambelovac, Kaštel Lukšić, Kaštel Stari, Kaštel Novi, and Kaštel Štafilić. According to the first official reports of the 2021 census, there are 37,951 inhabitants in the Town of Kaštela, while in the urban agglomeration area of Split, to which the Town of Kaštela belongs, there are slightly over 275 thousand inhabitants. The figure below shows the spatial coverage of the Town of Kaštela.



Source: www.google.com

Figure 1 Area of the Town of Kaštela

Kaštel Kambelovac is a pilot location for the development of the *Risk Management Plan Concerning Risks of Coastal Floods Caused by Extremely High Ocean Waves*. The settlement is located between Kaštel Lukšić and Kaštel Gomilica at the foot of the Kozjak hill. The area of Kaštel Kambelovac is suitable for this project since it is diverse enough to be a *test bed* for the entire area of the Town of Kaštela.



Source: www.geoportal.dgu.hr, processed by the creator

Figure 2 Spatial coverage of the Kaštel Kambelovac pilot location

3. SWOT analysis

The SWOT analysis (*Strengths, Weaknesses, Opportunities, and Threats*) is shown in the table below. It combines an analysis of the situation, an analysis of the risk exposure to floods caused by extremely high ocean waves, and key identified issues, elaborated in detail within the Delivery 5.1.2. *Risk Management Plan Concerning Risks of Floods Caused by Extremely High Ocean Waves*.

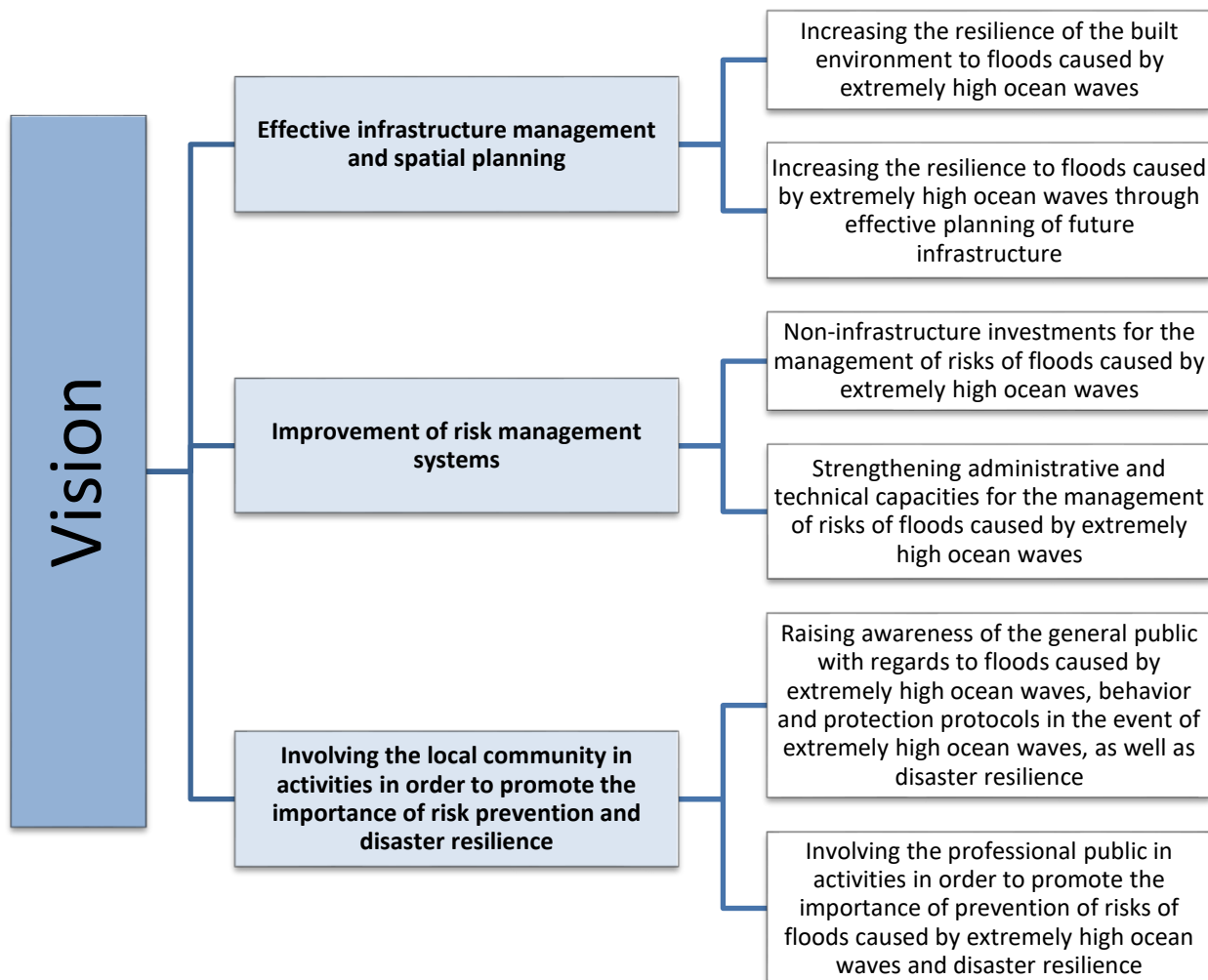
STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> ❖ existing documentation for planned management (the Action Plan in the field of natural disasters for 2021 for the Town of Kaštela and the Coastal Zone Management Plan of the Town of Kaštela) ❖ existence of the Risk assessment of major accidents for the Town of Kaštela ❖ existence of operational forces in the event of floods ❖ existence of infrastructure for the protection against waves such as breakwaters and groins ❖ existence of the system of civil protection ❖ length of the coast ❖ good transport connectivity 	<ul style="list-style-type: none"> ❖ unfavorable geographical location ❖ extreme population density in the area of the Town of Kaštela ❖ old infrastructure of insufficient quality ❖ unplanned and illegal construction ❖ poor capacity and condition of existing drainage systems ❖ pollution and devastation as a consequence of industrialization ❖ unsatisfactory state of roads and road infrastructure ❖ unsatisfactory level of protection of cultural heritage ❖ insufficient level of connection of the population to the public sewerage system ❖ lack of distance from the coast during construction ❖ collapse and sinking of the historic center ❖ ecological black spot – the ex-Jugovinil zone
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> ❖ reconstruction and strengthening of existing buildings for protection against floods ❖ existence of a legislative framework for the protection of cultural heritage, park architecture monuments, and natural monuments ❖ affiliation of the Town of Kaštela to the Split urban agglomeration area ❖ implementation of the <i>Improvement of water and municipal infrastructure of the Kaštela – Trogir agglomeration</i> project; reconstruction and improvement of water and municipal infrastructure by replacing pipelines and treatment systems ❖ development and improvement of flood management plans ❖ communication between services in the event of floods 	<ul style="list-style-type: none"> ❖ coastal erosion due to splashing of the waves ❖ climate change ❖ beach erosion caused by extremely high ocean waves ❖ erosion and collapse of roads and other transport infrastructure due to floods caused by extremely high ocean waves ❖ shortage of electricity and drinking water ❖ flooding of the coast and coastal infrastructure ❖ coast and sea pollution ❖ changes in the marine ecosystem and biodiversity ❖ destruction of animal habitats ❖ destruction of agricultural land

4. Management vision and goals

The vision of the desired future condition in the management of risks of floods caused by extremely high ocean waves and local plans until 2030, as well as measures to improve local plans derive from the previously conducted situation analysis, risk analysis, and SWOT analysis. Therefore, the vision is as follows:

The pilot location in Kaštel Kambelovac is an area of enhanced resistance to the risks of floods caused by extremely high ocean waves, where measures of efficient infrastructure management and spatial planning and improvement of the risk management system are continuously implemented, along with the involvement of the local community in decision-making processes.

Activities that help achieve set goals in the management of risks of floods caused by extremely high ocean waves at the pilot location have been designed in the form of management measures. The set goals can be achieved through one or more measures. The diagram below summarizes the goals and measures from Delivery 5.1.2. *Risk Management Plan Concerning Risks of Coastal Floods Caused by Extremely High Ocean Waves.*



5. Management measures

Various management measures contribute to the achievement of goals, as well as the vision, stated in the previous Delivery 5.1.2. *Risk Management Plan Concerning Risks of Floods Caused by Extremely High Ocean Waves*. Each management measure contains a description, i.e. its relevance in relation to the set goal, time frame, project developers, stakeholders involved and activities. The table below provides a summary of the goals and accompanying measures and activities.

Goals	Measures	Activities
Effective infrastructure management and spatial planning	Increasing the resilience of the built environment to floods caused by extremely high ocean waves	Investments in adapting and increasing the resilience of critical infrastructure according to the coastal flood vulnerability zones
		Investments in adapting and increasing the resilience of buildings for public and social purposes to floods caused by extremely high ocean waves and mitigating their effects
	Increasing the resilience to floods caused by extremely high ocean waves through effective planning of future infrastructure	Infrastructure operations on buildings along the coast aimed at reducing the risk of floods caused by extremely high ocean waves
		Investments in adapting and increasing the resilience of the new water and municipal, electricity, telecommunications, and transport infrastructure with regards to the risks of floods caused by extremely high ocean waves
Improvement of risk management systems	Non-infrastructure investments for the management of risks of floods caused by extremely high ocean waves	Spatial planning of alternative traffic routes with regards to coastal flood zones
		Development and modernization of the civil protection information and communication system
	Strengthening administrative and technical capacities for the management of risks of floods caused by extremely high ocean waves	Development and modernization of the public alert information and communication system
		Integration of adaptation measures to risks of floods caused by extremely high ocean waves in the spatial planning documentation
		Organization of trainings to strengthen the capacity of decision-makers with regards to the dangers of floods caused by extremely high ocean waves and ways to mitigate their consequences
		Development of rescue and evacuation plans with regards to the coastal flood zones
		Improvement of the training system for operational forces and frequent emergency rescue drills
Performance of regular checks on the correctness of technical equipment of operational forces		
Involving the local community in activities in order to promote the importance of risk prevention	Raising awareness of the general public with regards to floods caused by extremely high ocean waves, behavior and protection protocols in the event of extremely high	Organizing public campaigns in order to raise awareness of the general public in cooperation with the academic community and experts in the field of management of risks of floods caused by extremely high ocean waves and disaster resilience and their consequences for people, society, infrastructure, and the environment
		Organizing public campaigns in order to raise awareness of the general public on the protocol of behavior of the population in the event of floods caused by extremely high ocean waves and other natural disasters

Goals	Measures	Activities
and disaster resilience	ocean waves, as well as disaster resilience	Production of promotional materials and their distribution to the local population along with ways to contribute to the sustainability of the coastal area
	Involving the professional public in activities in order to promote the importance of prevention of risks of floods caused by extremely high ocean waves and disaster resilience	Organization of scientific conferences in cooperation with the academic community Implementation of activities in order to improve the system of prediction and monitoring of floods caused by extremely high ocean waves based on the input of experts in the field Implementation of applied research activities in cooperation with public administration and scientific organizations Strengthening the capacity of SMEs and business support organizations, with emphasis on activities in the field of construction, spatial planning, water supply, energy and environmental protection

6. Proposal to improve the measures of existing local management plans

Measures to improve local management plans relate primarily to the development of a management structure in order to manage flood risks caused by extremely high ocean waves, as well as to strengthen resilience to climate change. The list of coastal zone management measures from the *Coastal Zone Management Plan of the Town of Kaštela* with data on competent bodies and holders of measures listed in the *Action Plan in the field of natural disasters for 2021 of the Town of Kaštela* are systematized and adapted to the management of floods caused by extremely high ocean waves. Their overview is provided in the tables below.

Chapter:	4 Policies and management measures
Subchapter:	4.1 Implementation of an integrated approach to the management of the coastal area of the Town of Kaštela in the light of climate change
Priority:	1.1 Development of a management structure for the implementation of an integrated approach to the management of the coastal area of the Split-Dalmatia County
Measures:	<ul style="list-style-type: none"> 1.1.1 Establishment of a Coordination Committee for an integrated coastal and marine management of the Split-Dalmatia County 1.1.2 Defining the boundaries of the maritime domain 1.1.3 Implementation of a system for monitoring the situation and processes in the coastal area
Priority:	1.2 Strengthening resilience to climate change
Measures:	<ul style="list-style-type: none"> 1.2.2 Introduction of innovative tools for managing the coastal area of the Kaštela Bay and the Split-Dalmatia County with regards to climate variability and climate change 1.2.3 Establishment of an early warning system for the coastal area 1.2.4 Strengthening resilience and risk management of floods, droughts, and fires 1.2.5 Raising awareness of sustainable coastal development and the necessity of adaptation to climate change 1.2.6 Strengthening resilience of the coastal economy
Priority:	2.2 Preservation and improvement of the built environment
Measures:	<ul style="list-style-type: none"> 2.2.2 Protection and renovation of the architectural heritage 2.2.3 Improvement of the quality of the built environment
Priority:	2.3 Improvement of the quality of space usage
Measures:	<ul style="list-style-type: none"> 2.3.1 Reduction of land consumption 2.3.2 Promotion of sustainable construction

In the context of risks of flood caused by extremely high ocean waves, the measures set out within the framework of the Priority 1.1., which relate to the development of the management structure for the implementation of the integrated approach to the management of the coastal area of the Split-Dalmatia County, can be adjusted in such a way that the establishment of the coordination committee for integrated management of coastal and marine areas of the Split-Dalmatia County encompasses disaster

risk management, especially risks related to coastal flooding. Additionally, the potential risk of coastal flooding caused by extremely high ocean waves must be taken into account when determining the boundaries of maritime domain in order to prevent threats to population and infrastructure and reduce long-term consequences. Also, the implementation of a system for monitoring the situation and processes in the coastal area may encompass monitoring the process of management of risks of floods caused by extremely high ocean waves in order for it to be able to be improved in the future.

Measures from the Priority 1.2. Strengthening resilience to climate change, such as the introduction of innovative tools for managing the coastal area of the Kaštela Bay and the Split-Dalmatia County with regards to climate variability and climate change, and the establishment of early warning systems for the coastal area are also applicable to risks of floods caused by extremely high ocean waves and can be improved in such a way to encompass that type of risk as well. It is important to consider smart technologies and forecasting systems that can help in avoiding major disasters following the floods caused by extremely high ocean waves.

Measures 1.2.4., 1.2.5., and 1.2.6., which relate to strengthening the resilience of the coastal economy and to disasters in general, as well as to the awareness of climate change, are also applicable to the risks of extremely high ocean waves. The improvement of these measures is expressed in the involvement of the media and the wider community in strengthening the resilience, taking into consideration the risks of extremely high ocean waves.

In the context of the risk of extremely high ocean waves, the measures from the Priority 2.2., which relate to the preservation and improvement of the built environment, can be improved by taking into consideration the increase of resilience to extremely high ocean waves during the process of protection and renovation of the architectural heritage according to the relevant rules of the profession. The above-mentioned recommendation also refers to the future improvement of the built environment, ensuring that the construction is carried out according to contemporary standards and taking into consideration all of the risk parameters of extremely high ocean waves. Additionally, measures from the Priority 2.3., which encompass the improvement of the quality of the area, can influence the reduction of consequences that floods caused by extremely high ocean waves may cause. Measures that concern reduction of land consumption and the promotion of sustainable construction must also include the risks of extremely high

ocean waves in order to prevent further settlement in high-risk areas and to ensure that all of the new buildings are compliant with the contemporary standards, i.e. in line with the risk of extremely high ocean waves.

The list of measures and holders of measures in the event of backwaters is provided in Chapter 6.9, or subchapter 6.9.1. *Action Plan in the field of natural disasters for 2021 of the Town of Kaštela*. The plan also prescribes other measures that concern cooperation in the event of breakwaters with the competent bodies and various institutions in the subchapter 6.9.2. The list of said measures in relation to breakwaters, which are subject to improvement and protection against floods caused by extremely high ocean waves, is given in the table below.

Chapter:	6.9 Backwaters
Subchapter:	6.9.1 List of measures and holders of measures in the event of backwaters
Measures:	<ul style="list-style-type: none"> • 6.9.1.1 Informing on the occurrence of hazards and collecting information on the consequences of backwaters • 6.9.1.2 Organization of other civil protection measures during the response of the civil protection system in the event of backwaters (including evacuation and provision of care) • 6.9.1.3 Regulating traffic and security during interventions
Project developers:	The holders of measures are the mayor, the operational forces of the civil protection system, health workers and the Ministry of the Interior, and following the declaration of a natural disaster, in order to allocate funds for partial remediation of damages caused by natural disasters, the competent bodies referred to in Article 5 of the Act on Mitigation and Elimination of the Consequences of Natural Disasters (OG 16/19) take appropriate actions.
Subchapter:	6.9.2 Other measures that concern cooperation in the event of breakwaters with the competent bodies and various institutions
Measures:	<ul style="list-style-type: none"> • 6.9.2.1 Coverage of the endangered area with devices for alerting citizens • 6.9.2.2 Measures and evacuation routes in the endangered area • 6.9.2.3 Protective structures (embankments, retention systems, flood-relief channels, culverts etc.)

Informing on the occurrence of hazards and collecting information on the consequences of backwaters as one of the measures discussed in subchapter 6.9.1., which contains a list of measures and holders of measures in the event of backwaters, should, in the future, take into account the systematization and linking of collected information of all stakeholders involved in the event of backwaters. Information must be collected and published so that it can be accessed by any of the relevant stakeholders at any time, which greatly facilitates the whole process of communication between stakeholders. On the other hand, it also affects the facilitation of the organization of other civil protection measures during the response of the civil protection system in the event of backwaters (including evacuation and provision of care). This type of improvement of these measures can be accomplished by creating a database that will consolidate

all the relevant information that has been collected. A similar interactive solution is applicable to another measure covered by this subchapter, which refers to the regulation of traffic and security during interventions. The implementation of an interactive online application that would provide insight into the condition of roads would facilitate traffic regulation, traffic on non-endangered roads, as well as security during interventions of floods caused by extremely high ocean waves.

As part of other measures related to cooperation in the event of backwaters with the competent bodies and various institutions, which are listed in subchapter 6.9.2., the coverage of the endangered area with devices for alerting citizens was presented. In the context of floods caused by extremely high ocean waves, these devices can be connected to forecasting devices in order to alert the population in a timely manner and to have more time for evacuation. The system could also encompass measures and evacuation routes in the endangered area and display them in real time, which would render the entire process of alert and evacuation of the population uninterrupted and run smoothly. Other measures related to the construction of protective structures (embankments, retention systems, flood-relief channels, culverts etc.) can be improved with the construction according to the highest standards and the application of smart technologies, where possible. Also, there are wave breaker systems that can be activated using the parameters that would announce the occurrence of extremely high ocean waves and that can be implemented in order to mitigate the consequences of floods caused by extremely high ocean waves.

In conclusion, in the context of managing the risks of floods caused by extremely high ocean waves, it is recommended to integrate the measures and activities presented in Chapter 5 into existing and future local management plans.