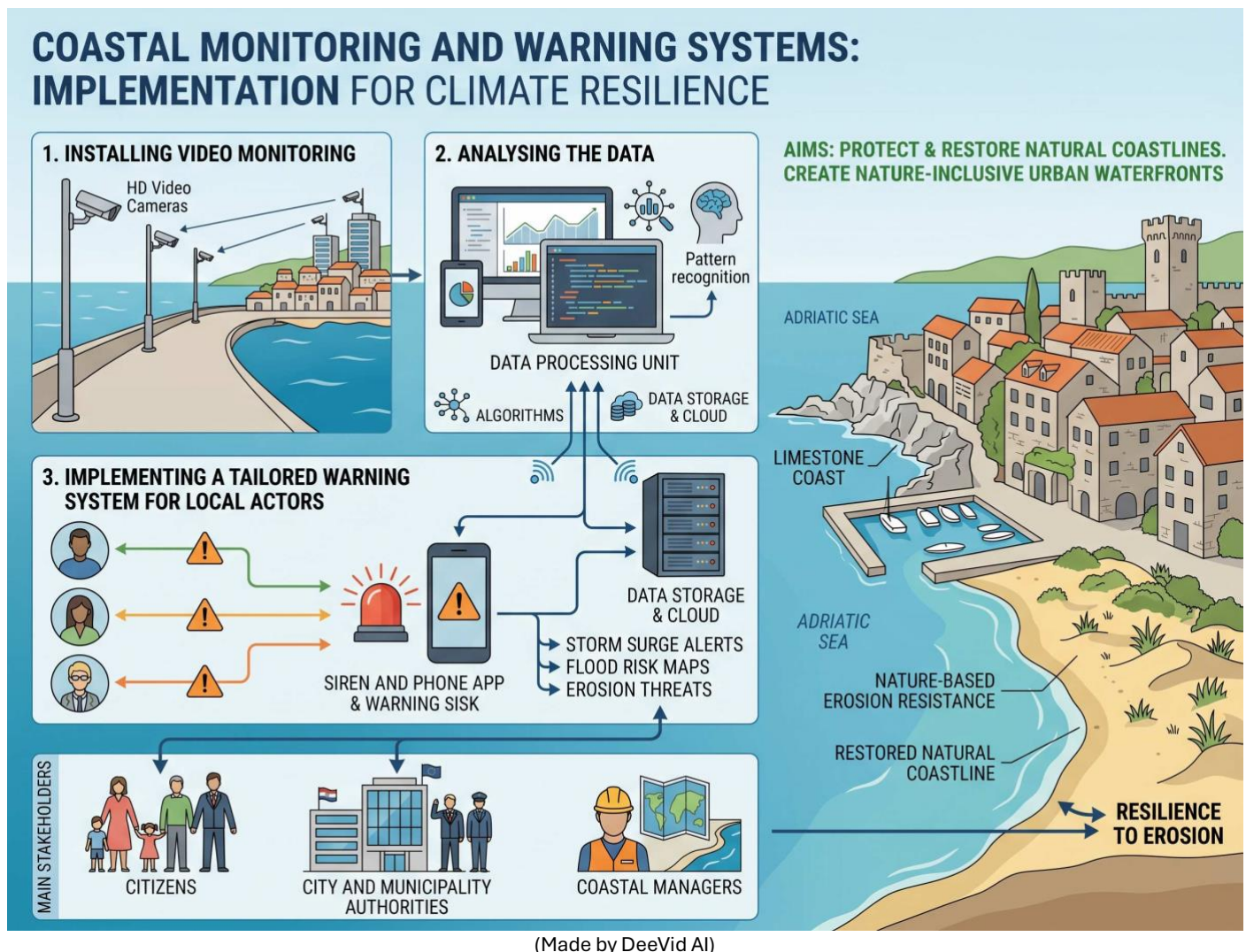


Split-Dalmatia County: Nature-inclusive and resilient coastal zones

Protecting and restoring natural coasts and creating nature-inclusive urban waterfronts resilient to erosion.



Key Message

- Anthropogenic pressures coupled with climate change impacts increase the risks of coastal erosion.
- Coastal monitoring systems are necessary to transform coastal zones into nature-inclusive and resilient.

Policy Relevance

International policy:

- **E.U. Strategy on Adaptation to Climate Change (2021):** The strategy calls on Member States to incorporate climate adaptation into flood risk management plans and to use NbS to reduce vulnerability and enhance ecosystem health.
- **E.U. Floods Directive (2007/60/EC):** Real-time monitoring, early warning systems, and community literacy aligns with the directive's requirements for proactive risk assessment and public engagement. The use of video monitoring and deep learning for shoreline detection is a direct response to the need for data-driven, adaptive flood and erosion management
- **E.U. Biodiversity Strategy for 2030:** Nature literacy, ecosystem-based solutions, and community involvement in coastal restoration mirrors the strategy's goals. The strategy supports projects that

integrate scientific monitoring with public participation, much like the beach profiling and citizen engagement campaigns detailed here.

National policy:

- **Climate Change Adaptation Strategy in the Republic of Croatia for the period until 2040 with a view to 2070 (2020):** The strategy outlines priority measures across 10 vulnerable sectors—including agriculture, tourism, and coastal resources—to build resilience and reduce weather-related economic losses.
- **Disaster Risk Assessment for the Republic of Croatia (2024):** The assessment identifies 15 priority hazards, prioritising earthquakes, river and flash floods, wildfires and climate change-related hazards.

What is the Challenge

Split-Dalmatia County is a Mediterranean area with ca. 450.000 citizens, mostly oriented towards tourism, which causes strong pressures on the narrowest coastal strip. The climate change impacts: storm surges, flash floods and compound floods, cause additional pressures and together result in coastal erosion that directly influences the environment, economy, policy and social sector. Natural coasts should be further protected and restored. To create nature-inclusive urban waterfronts resilient to erosion, innovative nature-based solutions must be coupled with engineering ones.

Insufficient knowledge and “proof of solution” for nature-inclusive solutions, together with a general lack of coastal erosion data, are among the challenges to implementing climate-resilience actions. Citizens, along with coastal authorities and managers, should be informed about the causes of change and potential measures, all grounded in scientific evidence and expert knowledge.

An Innovative Solution

The core component of the solution is an advanced video-based monitoring system designed to enable real-time shoreline detection and tracking. This system records high-resolution footage and collects valuable data on coastal changes, which can subsequently be used for comprehensive scientific and engineering analyses of coastal erosion. Using these insights, targeted mitigation strategies and protective measures can be developed to address erosion effectively. Citizens, coastal authorities, and managers are empowered to use this information to better understand erosion dynamics and implement appropriate protective actions for themselves and their communities. Furthermore, alert systems can be integrated with the monitoring platform to deliver prompt notifications of significant shoreline changes or imminent threats, thereby enhancing disaster preparedness and response.

The Benefits the solution produces

- ✓ • **A more comprehensive, fact-based understanding of the changes that occur during coastal erosion**, including the thresholds at which these changes are considered extreme enough to necessitate management intervention, as well as the predictive and response capacities involved.
- ✓ • **Scientifically validated information on current management interventions**, assessing whether they contribute to or mitigate the erosion issues that have emerged.
- ✓ • **Advanced coastal erosion warning systems** designed to support timely, pre-emptive management responses, incorporating detailed monitoring techniques and early detection signals.

How developed is the solution

This solution is being tested at small scale in real-world contexts in Ireland and Portugal. The coupling of video monitoring into a coastal warning system has a first prototype already implemented in the Praia de Mira (NW Portuguese Coast) and the implemented algorithms being validated.

Where could also be applied to?

Area Characteristics	Intention for applying the solution
Coastal areas with beaches that are filled up annually due to ongoing coastal erosion.	A monitoring system will provide detailed evidence of coastal erosion and support a comprehensive understanding of its causes. This knowledge will inform the development of effective, nature-inclusive measures to prevent or mitigate coastal erosion, emphasising natural solutions such as vegetation restoration and the deployment of undersea reefs.
River mouths that are regulated disrupt natural processes.	Maintaining river regulation and future management strategies should incorporate more nature-based solutions, including the renaturalization of riverbanks, to better restore natural dynamics.
Urban coastal zones feature a combination of promenades, waterfronts, and ports.	Video documentation of storm impacts will provide vital evidence, enabling citizens, coastal authorities, and managers to plan more effective mitigation strategies.
Coastal nature reserves, especially wetlands.	A detailed understanding of coastal processes, measurement of erosion, correlation with other natural phenomena, and the formulation of comprehensive measures for nature conservation and protection.

Who is this relevant to?

- County Authorities
- Local Authorities (coastal cities and municipalities)
- Port Authorities
- Croatian Water Company
- The Public Institution for Nature Protection in the Split-Dalmatia County
- Community Associations (involved in tourism, recreation)
- Nature Conservation or Environmental NGOs

What do you need to have in place:

- ✓ **Strategy, permissions and resources** to implement the coastal erosion monitoring system
- ✓ **Expertise in: science-public and science-policy communications, data analysis, coastal processes, GPS surveying and geoinformatics, local coastal processes and communities.**
- ✓ **Resources** to implement interventions such as beach nourishment and nature-based interventions.
- ✓ **Coastal warning system components:** Video monitoring cameras, local infrastructures (master with electric power and internet connection).
- ✓ **A public policy framework** that allows for activities such as artificial beach nourishment, more subtle coastal restoration interventions, hard infrastructure removal (to restore coastal processes), and decision-making based on data gathered using new monitoring techniques and analysis systems.

Key components of implementation:

- **Coastal warning systems in erosion hotspots** use video monitoring combined with deep learning to provide real-time indicators of shoreline position, beach width, and erosion thresholds. Key factors include wave attack limits on coastline and overtopping risks. The systems offer graphical alerts and historical data to aid decision-making, such as artificial beach nourishment.
 - Coastal Warning Systems - Installing video monitoring
 - Coastal Warning Systems - Analysing the data
 - Coastal Warning Systems - Implementing a tailored warning system for local actors

- **Engagement:** Engagement requires working with different sectors, including local authorities and coastal managers, to promote literacy and involvement. Collaborating with decision-makers provides valuable guidance and helps identify key issues. Local authorities gather citizens' concerns and can offer guidance, while all levels of decision-makers can benefit from coastal warning systems to manage erosion hotspots.



(AI generated image of installed Coastal monitoring system in Kaštel Gomilica, made by DeeVid AI)

Monitoring your success:

What to monitor	What to monitor?
Evidence of the scientific integration into decision-making.	Coastal erosion measures planned and implemented. Interviews and periodic surveys.

Levels of citizen awareness of coastal erosion as a natural process, which requires nature-inclusive solutions.	Education and cultural events involving the topics. Media evidence. Interviews and periodic surveys
Number of community associations and NGO involved in the coastal erosion monitoring.	Evidence of activities. Interviews and periodic surveys.

The challenges you may encounter

Activity	Challenge 1	Challenge 2
Implementing Coastal Warning Systems in erosion hotspots.	Lack of interest and disagreement among stakeholders about the justification of the system.	Obtaining the necessary permits for system installation, ownership and management (overlapping jurisdiction on the maritime domain).
Engagement of citizens, coastal authorities and managers.	Lack of understanding of the need for monitoring and the value that scientific data will provide for the purposes of mitigation and prevention.	Limited availability of stakeholders due to their other duties and their long-term participation.

Key Contact – who to talk to about your application idea

Martin Bućan (Split-Dalmatia County)

Martina Baučić (University of Split, Faculty of Civil Engineering and Architecture)

Further information (reading/resources box)

- Sloterdijk et al. (2025) A-AAGORA: Report of Toolbox "Learning and Evaluation methods". Deliverable 2.3 under the Horizon Europe A-AAGORA project, Grant Agreement no. 101093956. Available at: [www/ldkfjlskdjffj.com](http://www.ldkfjlskdjffj.com).
- Santos, F., Cunha, T.R. Baptista, P. Deep learning-based semantic Segmentation for Automatic shoreline extraction in coastal video monitoring systems. Remote Sensing. <https://www.mdpi.com/2072-4292/17/23/3865>
- Santos, D., Abreu, T., Bernardes, C., Baptista, P. Coastal flood susceptibility assessment along the Northern coast of Portugal. International Journal of Disaster Risk Reduction, 108, 104556. <https://doi.org/10.1016/j.ijdr.2024.104556>.