LocAll4Flood | Interreg Euro-MED | Co-funded by the European Union

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White Paper
LocAll4Flood

https://locall4flood.interreg-euro-med.eu

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List Of Abbreviations

CW	Co-creation Workshop
EWS	Early Warning Systems
FRMP	Flood Risk Management Plan
IMGM	Integrated Multi-stakeholder Governance Model
NbS	Nature-based Solutions
PSDM	Participatory System Dynamics Modelling
PSM	Problem Structuring Methods
SNA	Social Network Analysis
SOP	Standard Operating Procedure
SUDS	Sustainable Urban Drainage Systems

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1 Executive Summary

Floods are the costliest natural disasters in Europe, and flash floods in the Mediterranean are among the most dangerous, as they develop within hours, strike small and often unmonitored catchments, and leave little time for authorities or communities to react. Climate change is making these events more frequent and intense, while decades of urban expansion in floodplains, fragmented institutional responsibilities, and limited public preparedness continue to increase exposure. In this context, traditional approaches based mainly on grey infrastructure and top-down emergency management are no longer sufficient on their own.

LocAll4Flood was developed to address this gap. Co-funded by the European Union through the Interreg Euro-MED programme, the project tested an Integrated Multi-stakeholder Governance Model (IMGM) across nine pilot catchments in six Mediterranean regions: Catalonia and the Balearic Islands (Spain), Malta, Varna (Bulgaria), Puglia (Italy), and Central Macedonia (Greece). The model is based on the pillars of prevention, adaptation and mitigation, and combines three lines of action: Early Warning Systems (EWS), public awareness and education, and Nature-based Solutions (NbS).

The project demonstrated that integrated flash flood risk management is both technically viable and institutionally applicable across diverse territorial contexts. All pilot sites implemented operational Early Warning Systems integrating between three and eight real-time data sources. Three rounds of training sessions and co-creation workshops collected a total of 271 evaluations across all pilot regions, with training satisfaction rising from 80.4% in Session 1 to 94.3% in Session 3, and overall session satisfaction reaching 97.3% by the final round. Eight different materials were developed and implemented, with more than 18,000 copies distributed across the region, reaching over 5,000 exhibition visitors and 33 organisations directly receiving printed materials. Participatory System Dynamics Modelling (PSDM) processes co-produced NbS implementation pathways and concrete action frameworks across all pilot sites, overcoming governance barriers and generating shared priorities aligned with existing Flood Risk Management Plans (FRMP). Across all pilots, 91.8% of participants agreed that the project strengthened collaboration among flood risk management actors, and 97% expressed confidence in its positive long-term impact.

At the same time, the project highlighted key areas for further development. Strengthening the formal integration of Early Warning Systems into civil protection procedures, advancing Nature-based Solutions from planning to implementation, and reinforcing public awareness and trust through long-term engagement remain important priorities. Expanding the involvement of local authorities and emergency services will further support multi-actor governance, while scaling up the IMGM across the Mediterranean will require continued capacity building, policy uptake, and simplified tools adapted to different governance contexts.

This White Paper presents the project's main results, best case studies, and a set of concrete recommendations for practitioners and policymakers working on flash flood risk management across the Mediterranean. It is addressed to local, regional and national authorities, civil protection bodies, basin management organisations, environmental agencies, research institutions, and interregional cooperation networks seeking evidence-based, participatory, and transferable tools to strengthen flash flood resilience in their territories.

2 Context and background

Floods are the most frequent and among the costliest natural disasters in Europe[1]. Between 1980 and 2022, climate-related extreme events caused an estimated €650 billion in damages, with floods alone accounting for €279.5 billion, or 43% of the total[2]. As temperatures rise, heavy rainfall events are expected to become more frequent and intense, increasing flood risk across Europe, especially in the Mediterranean region[3],[4].

Flash floods are particularly dangerous because they develop very quickly, often within less than four to six hours after intense rainfall begins[5]. This leaves little time for authorities to issue warnings, organise evacuations, or deploy emergency measures. Nearly half of Europe's most damaging floods since 1870 were linked to these short and intense rainfall events[1].

The Mediterranean basin is especially vulnerable. Its climate is characterised by long dry periods followed by sudden, intense storms. Small catchments and temporary streams can react rapidly, generating severe flooding with little natural buffering capacity. At the same time, decades of urban growth and construction in floodplains have reduced wetlands and other natural areas that once absorbed excess water. More roads, buildings, and paved surfaces now increase runoff and place additional pressure on drainage systems. As a result, flood exposure is growing, which highlights the need for stronger prevention and preparedness measures.

Public authorities still face several important challenges. Many small catchments lack the monitoring networks needed for accurate forecasting. Early Warning Systems are often unavailable in the areas most exposed to flash floods [6]. Nature-Based Solutions, such as wetlands, retention areas, and green infrastructure, remain underused despite strong support from European policy. In addition, responsibilities are often fragmented across institutions, while citizen engagement and data sharing remain limited. Addressing flash flood risk therefore requires more than traditional thinking. It calls for better forecasting tools, stronger coordination between institutions, greater public participation, and wider use of Nature-Based Solutions adapted to local conditions.

The urgency of this challenge has intensified. The EU Floods Directive (2007/60/EC) is currently in its third cycle (2022–2027), requiring Member States to update their Flood Risk Management Plans with stronger ambitions on prevention, adaptation, and mitigation. At the same time, the European Green Deal, the Biodiversity Strategy for 2030, the Nature Restoration Law, and the EU Climate Adaptation Strategy are all pushing for a shift toward Nature-Based Solutions in flood risk management, yet implementation on the ground remains limited.

LocAll4Flood was created in response to these needs. The project operates in the Mediterranean regions of Spain (Catalonia and the Balearic Islands), Malta, Bulgaria, southern Italy, and Greece, where floods caused 793 deaths between 1980 and 2020[7]. The project develops and tests an Integrated Multi-stakeholder Governance Model (IMGM) that combines prevention, adaptation, and mitigation through a collaborative, participatory, and territorially tailored approach, while consistently fostering engagement

[1] European Environment Agency (EEA). 2024. Responding to climate change impacts on human health in Europe: focus on floods, droughts and water quality. EEA Report 3/2024. 2024.
[2] European Environment Agency. 2023. Economic losses from weather- and climate-related extremes in Europe.
[3] Moatti, J. P., & Thiébault, S. (Eds.). 2018. The Mediterranean region under climate change: A scientific update. IRD éditions.
[4] Ali, E., W. Cramer, J. Carnicer, E. Georgopoulou, N.J.M. Hilmi, G. Le Cozannet, and P. Lionello, 2022: Cross-Chapter Paper 4: Mediterranean Region. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2233–2272. doi:10.1017/9781009325844.021.
[5] WMO, 2006. Technical Regulations. Volume III: Hydrology, WMO-No. 49. World MeteorologicalOrganization (WMO).
[6] Krabbenhoft, C.A., Allen, G.H., Lin, P. et al. Assessing placement bias of the global river gauge network. Nat Sustain 5, 58å6–592 (2022). https://doi.org/10.1038/s41893-022-00873-0
[7] Petrucci, O., Aceto, L., Bianchi, C., Brázdil, R., Diakakis, M., et. al. 2022. FFEM-DB "Database of Flood Fatalities from the Euro- Mediterranean region". Version 3. 4TU.ResearchData. Dataset. https://doi.org/10.4121/14754999.v3

across local, regional, and national governance levels. Designed for small Mediterranean catchments, it also offers a model that can be replicated across the region. This White Paper presents the main results, best case studies, and recommendations generated by the LocAll4Flood project, with the aim of making them accessible and actionable for the widest possible range of practitioners, policymakers, and institutions working on flash flood risk management across the Mediterranean basin. Specifically, it seeks to demonstrate that an integrated, participatory, and evidence-based governance model for flash flood risk management can be designed, tested, and transferred across diverse Mediterranean contexts.

Section 2 of this White Paper introduces the LocAll4Flood project, including its context, partners, and methodology, meanwhile Section 3 presents the project results, organised around the Integrated Multi-stakeholder Governance Model that fostered collaboration among stakeholders across local, regional, and national governance levels as the overarching framework, and three thematic lines of work: prevention, adaptation, and mitigation. Section 4 highlights the selected best practices from the pilot sites, showcasing specific achievements and their potential for replication. Section 5 outlines the main recommendations for practitioners and policymakers, and finally, Section 6 presents the overall conclusions and remaining challenges.

2.1 Introduction to the project LocAll4Flood

The project aims to reduce vulnerability to flash floods in small Mediterranean catchments through an integrated, participatory, and territorially adapted approach. Co-funded by the European Union through the Interreg Euro-MED programme, the project runs for 33 months from 2024 to 2026 and is implemented by a consortium of eight academic, technical, and regional organisations. The project is led by BETA Technological Center (UVIC-UCC) (Spain) partnering together with Euroregion Pyrenees-Mediterranean, Universitat de les Illes Balears (UIB) (Spain), the Energy and Water Agency (EWA) (Malta), the Black Sea - Danube Association for Research and Development (BDCA) (Bulgaria), Water Research Institute - Italian National Research Council (IRSA-CNR) (Italy), Hydrometeorological Innovative Solutions (HYDS) (Spain), and Aristotle University of Thessaloniki (AUTh) (Greece).

The project's central contribution lies in the design, testing, and transfer of an Integrated Multi-stakeholder Governance Model (IMGM) for flash flood risk management that fostered collaboration among stakeholders across local, regional, and national governance levels. The IMGM provides the overarching framework within which three complementary sets of tools are developed and validated: (i) Early Warning Systems, (ii) Public wareness and education, and (iii) Nature-Based Solutions.

The IMGM model was tested across nine pilot catchments across six Mediterranean regions. The pilot sites were selected to cover the all the topographical areas of land in the Mediterranean including: urban, rural/natural, industrial, and coastal. This diversity both validates the IMGM across different territorial conditions and supports its transferability across the wider Mediterranean basin.

Pilot Catchment	Region	Country	Type	Geographical Characteristics
Gurri	Catalonia	Spain	Urban/Rural	Catchment area covering the Vic Plain
Torrent Gros	Balearic Islands	Spain	Urban	Long stream running through the eastern part of the Palma metropolitan area
Torrent de na Bàrbara	Balearic Islands	Spain	Urban	Stream running through the city of Palma
Birkirkara- Msida	Malta	Malta	Urban	Low-lying catchment in the hearth of Valetta metropolitan area
Burmarrad	Malta	Malta	Rural	Low-lying catchment west of the island of Malta
Dalgopol	Varna	Bulgaria	Urban	Town on the banks of the Kamchia River
Kamchia-Varna	Varna	Bulgaria	Coastal/Natural	Kamchia River-estuary system on the bank of the Black Sea
Bari	Puglia	Italy	Industrial/Urban	Large city crossed by seasonal streams
Anthemountas	Central Macedonia	Greece	Rural/Coastal	Catchment bounded by mountain ranges and located near the coastal city of Thessaloniki

Table 1 Pilot catchments accross the Mediterranean regions where the IMGM model was tested

The project adopts a collaborative approach throughout, ensuring that tools were co-developed with local actors rather than imposed from outside and that the resulting methodology is grounded in the specific governance, institutional, and territorial realities of each pilot territory. The results and methodology are intended to be directly replicable by national, regional and local authorities across the Mediterranean

region, providing practical and evidence-based tools for improving flash flood resilience beyond the project duration.

2.2 LocAll4Flood Project Results

The LocAll4Flood project has generated results through co-creation and iterative validation across nine pilot territories in six Mediterranean regions. All outputs are organised within the overarching framework of an Integrated Multi-stakeholder Governance Model (IMGM), which structures flash flood risk management across three phases: prevention, adaptation, and mitigation. Within this framework, three complementary lines of work were developed and tested: Early Warning Systems, public awareness and education, and Nature-Based Solutions. Together, these form an integrated approach, designed from the outset not merely as a set of project deliverables, but as a transferable and evidence-based methodology for sustainable flash flood risk management across the Mediterranean region.

2.2.1 Integrated Multi-stakeholder Governance Model

Getting the right people to work together

Flash flood risk in the Mediterranean is not primarily a data or modelling problem: it is consistently exacerbated by a structural disconnect between the emergency management mandates of Civil Protection bodies and the long-term spatial and flood-risk planning functions of basin authorities, water agencies, and land-use planners. The IMGM bridges these two spheres by fostering coordinated engagement among quadruple helix stakeholders (i.e. public authorities, the private sector, academia, and civil society), and promoting collaboration across local, regional, and national governance levels (Figure 1). This approach ensured that responses extend beyond purely technical solutions to incorporate inclusive decision-making, shared responsibility, and long-term sustainability.

Figure 1. Governance levels of the IMGM approach

For each pilot catchment, a deep stakeholder analysis was conducted prior to the co-creation activities, combining Social Network Analysis (SNA) to map governance networks and identify key actors, with Problem Structuring Methods (PSM) to elicit stakeholder perceptions of risk, governance challenges, and solution pathways. This analysis revealed the structural patterns of each governance system and informed the design of targeted, context-specific engagement strategies.

Co-Creation Activities

Three rounds of co-creation workshops (CW) were carried out across all pilot regions, each focusing on different aspects of flash flood risk reduction addressed by the IMGM. CW1 explored EWS, CW2, Education Materials (design and implementation) and CW3, participatory process for NBS. In addition to the CW training sessions were combined, where the first focused on FRMP, the second on flood risk perception and survey results, and the third on NBS for flood regulation. Each round followed a Quadruple Helix approach, engaging four categories of actors: (1) public authorities, including local and regional administrations, civil protection bodies, and technical services; (2) knowledge institutions and research organisations; (3) private sector actors; and (4) civil society organisations, NGOs, and community representatives.

CW1 – Prevention	CW2 – Adaptation	CW3 – Mitigation
Focus:	**Focus:**	**Focus:**
Flood Risk Management and EWS	Public awareness and preparedness	NbS, applying a PSDM
Outputs:	**Outputs:**	**Outputs:**
• Collective assessment of existing FRMPs and associated measures • Identification of vulnerable elements and critical infrastructure • Clarification of institutional roles and responsibilities • EWS operational considerations Complete EWS versions were implemented across all six pilot regions after CW1	• Tailored educational materials and awareness-raising activities were implemented across all six pilot regions in collaboration with different stakeholders • Stakeholder identification and validation • Role definition across adaptation activities • Mapping of synergies • Educational and awareness materials review	• A list of potential NbS for each site was compiled and agreed upon with stakeholders. • The workshop combined scientific and local knowledge with qualitative stakeholder perceptions and quantitative data to co-design NbS intervention scenarios in two structured phases: a) Identification of co-benefits, trade-offs, and barriers b) Scenario building using Causal Loop Diagrams and Behaviour Over Time analysis

Table 2 Co-creation Workshops (CW) summary

Three interconnected training-and-workshop modules were delivered across all pilot regions, forming a progressive capacity-building programme. Each module combined a training session to build technical knowledge with a co-creation workshop to foster stakeholder coordination and support the collaborative design and implementation of locally adapted solutions.

Training 1 – Prevention	Training 2 – Adaptation	Training 3 – Mitigation
Focus:	**Focus:**	**Focus:**
Flood Risk Management and EWS	Public awareness and preparedness	NbS
Introduced participants to the EU Floods Directive framework, FRMP structure, flood hazard mapping, and EWS technical	Focused on the challenge of shifting from hierarchical governance to a collaborative approach, introducing the	Contrasted conventional grey infrastructure with Nature-Based Solutions, presented the NBS catalogue organised by

foundations including the Argos platform.	IMGM approach, risk perception dynamics, and community engagement strategies. It also introduced hands-on educational tools designed to strengthen community resilience.	topographical area, and introduced the PSDM approach.

Table 3 Summary of interconnected training-and-workshop modules

The three training sessions and co-creation sessions achieved consistently high and progressively improving satisfaction levels, with participants across all regions consistently highlighting the relevance of the sessions for strengthening preparedness, improving inter-institutional collaboration, and supporting the implementation of local flood risk management strategies.

Transferability across the Mediterranean

The IMGM has been designed not only as a project methodology but as a transferable approach applicable to Mediterranean territories beyond the project's scope. The model is particularly relevant for territories undergoing an update of their Flood Risk Management Plans within the third cycle of the EU Floods Directive (2022–2027), as it provides a structured methodology for multi-stakeholder engagement, governance gap analysis, and the co-design of prevention, adaptation, and mitigation measures directly applicable within the FRMP update process.

To maximise its uptake, the IMGM is being actively positioned for replication in the Euro-Mediterranean Region. Primary targets include regional Civil Protection coordination bodies, river basin management authorities, and municipal planning departments, which are the institutional actors best placed to integrate the model into binding territorial planning frameworks.

2.2.2 Early Warning Systems

Giving authorities the appropriate data

Flash floods are difficult to monitor and predict because they develop quickly and affect small, localised areas. Traditional rainfall and river monitoring networks often lack the spatial or temporal resolution needed to detect them accurately, especially in small catchments and non-perennial streams, which are widespread and highly vulnerable across the Mediterranean basin. Early Warning Systems are recognised by the European Environment Agency as an effective tool for disaster prevention and climate adaptation, capable of extending the anticipation horizon for flash floods events. Yet such systems have rarely been available for small catchments, and even where they exist, their outputs are seldom integrated into daily emergency management procedures, limiting their operational value for civil protection operators and first responders. LocAll4Flood directly addressed this gap by developing and testing a customised EWS across all six pilot regions, combining technical deployment with participatory co-creation to ensure the tools were genuinely embedded in local flood risk management practice.

System design and deployment

The LocAll4Flood EWS was built around six core principles:

01 **Consolidation** of all flood-relevant information into a single comprehensive platform;

02 **Seamless integration** of data from multiple organisations through a fully collaborative architecture

03 **Proactive risk management** through monitoring tools and protocol integration

04 **Technological** accessibility via a unified mobile and desktop application

05 A **modular architecture** enabling adaptation to specific users, datasets, and vulnerable elements, including the reuse of existing studies and models

06 **Continuous interaction with end users** and local stakeholders as an essential condition for the system to evolve into a genuinely operational tool.

Figure 2 Core principles of the LocAll4Flood EWS

The EWS is built on the ARGOS platform, a cloud-based system for the monitoring and management of weather-induced emergencies, selected for its flexibility to adapt to diverse territorial contexts and multiple data sources. Two versions of Argos were deployed according to territorial characteristics and governance structure. The regional/national version integrates sensor networks (river levels, reservoirs, meteorological radar), forecast models (ECMWF, GFS, Harmonie), and official warnings at the regional scale, generating high-resolution forecasted alerts oriented to supervision based on predefined thresholds. The city version is designed for localised, urban-catchment management and is distinguished by its capacity to manage risk at the level of individual critical points, with tailored alert rules and the ability to activate and monitor response plans directly from the platform.

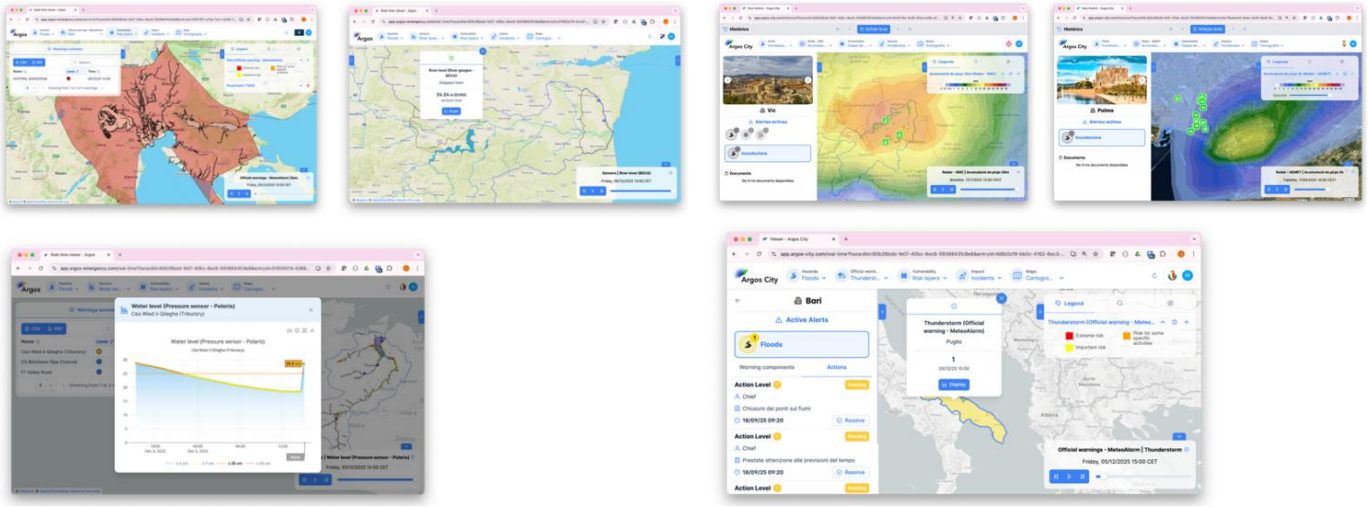


Figure 3. The two versions of ARGOS used in LocAll4Flood: regional/national version (left image) and Argos City version (right image)

Local implementation

Local implementation followed an iterative co-creation process. Each EWS was first presented to relevant local stakeholders (i.e. civil protection services, local and regional authorities, and emergency management agencies) who provided input on data needs, alert logic, and vulnerable elements to be incorporated. A structured testing phase then allowed the systems to be used in real rainfall events, with feedback collected from pilot leaders and stakeholders feeding into technical refinements and recommendations for formal integration into standard operating procedures. The table below summarises the key characteristics of each local deployment.

Catalonia (Spain)

Location:
Vic-Gurb area

How it was implemented:

Integrating a rich set of data sources: rain gauges from SMC and AEMET, local river gauges and a humidity sensor from PRODAISA, weather radar from SMC, and ECMWF precipitation forecasts. An additional sensor was installed on the intermittent Torrent de l'Esperança. Flood inundation maps from the Catalan Water Agency were integrated for three local streams.

Tested with:

Gurb and Vic City Council civil protection staff.

Argos Version Used:
Argos City

Balearic Islands (Spain)

Location:
Palma and Marratxí

How it was implemented:

Integrating AEMET rain gauges, weather radar, ECMWF forecasts, and ARPSI flood mapping for Torrent Gros and Torrent de na Bàrbara, with 15 vulnerable elements identified. Efforts to integrate the Balearic Government's raingauge network were made but could not be completed due to technical infrastructure limitations.

Tested with:

Palma Firefighters and the Balearic Islands Water Resources Department.

Argos Version Used:
Argos City

Varna (Bulgaria)

Location:
Kamchia catchment (Dalgopol and Kamchia Estuary)

How it was implemented:

Integrating three water level sensors provided by the pilot leader (TeleControlNet), GFS precipitation forecasts, MeteoAlarm official warnings, and on-site cameras. Access to national data sources proved limited, constraining the system's resolution.

Tested with:

Varna regional administration and civil protection authorities.

Argos Version Used:
Regional

Malta

Location:
Birkirkara and Burmarrad catchments (Malta)

How it was implemented:

Building on Malta's existing EU-funded hydrological monitoring infrastructure: 5 automatic weather stations and 7 stream level sensors. Official warnings via MeteoAlarm and GFS forecasts were integrated, along with flood area maps for the Birkirkara and Burmarrad catchments. Pre-existing threshold values were incorporated, strengthening alert meaningfulness. Weather radar data was not accessible during the project.

Tested with:

The Energy and Water Agency.

Argos Version Used:
National level

Puglia (Italy) **Location:** Bari	**How it was implemented:** Integrating a dense local raingauge network (from three CFD–Civil Protection providers: Bari Hydrographic, Observatory, and Campus), weather radar products from the National Civil Protection, and official MeteoAlarm warnings. Water level data could not be accessed due to administrative barriers.	**Tested with:** The Technical Office of the Metropolitan City of Bari. **Argos Version Used:** Argos City
Central Macedonia (Greece) **Location:** Anthemountas River basin east of Thessaloniki	**How it was implemented:** Integrating official MeteoAlarm warnings, GFS forecasts, and two local weather stations (NOA/meteo.gr and AUTH). Distinctively, AUTH provided very high-resolution real-time model outputs covering both meteorological variables (rainfall, pressure) and coastal flood parameters (sea-surface height, coastal flood height). 158 alert subscribers registered, the highest uptake across all pilots.	**Tested with:** Municipalities of Thermi and the Delta, and AUTH researchers. **Argos Version Used:** Regional

Figure 4 Key charactersitics of each local deployment

User engagement and operational usability

For each pilot region, the responsible partner identified the appropriate operational users of the EWS within the local emergency management chain. Three transversal features were developed across all pilot deployments to improve usability and daily engagement:

Newsletter: sending daily email notifications of official warnings when intense rainfall is forecast for the next three days.

Dashboard: summarising key information in simple cards without requiring users to interact with the full map interface.

Historical Viewer: allowing users to access and reproduce past episodes through a calendar interface showing exactly what data was available in the system at any given moment.

Figure 5 Transversal features developed to improve usability and daily engagement

User adoption varied across territories. Greece recorded high alert subscription rates, with 16 registered users, demonstrating that targeted communication strategies can significantly accelerate operational uptake. Users expressed general satisfaction with the tools developed across the pilots.

The project's implementation experience has been distilled into **an EWS Operational Integration Package**, a practitioner-ready onboarding resource documenting data access conditions, alerting logic, integration steps into existing emergency standard operating procedures (SOPs), and structured lessons learned on institutional readiness. The package is designed to enable new territories to adopt the EWS

approach without requiring bespoke technical development, and serves as the primary transfer vehicle for scaling the LocAll4Flood EWS beyond the pilot regions.

2.2.3 Public awareness and education

Helping society understand and prepare

Risk perception and community preparedness are not direct outcomes of hazard exposure, rather, they are shaped by prior flood experience, trust in authorities, level of education, and the quality of risk communication. In the Mediterranean context, where flash floods can develop within minutes, the gap between objective and perceived risk can have serious consequences for individual and collective behaviour. Addressing this gap requires targeted, evidence-based engagement strategies grounded in an understanding of what specific communities know, fear, and are willing to do in relation to flood risk. LocAll4Flood approached public awareness and education as an integral component of flash flood risk management, not a supplementary communication activity.

Prior to designing any educational or communication materials, the project conducted an evidence-based **baseline diagnosis** through a face-to-face survey assessing social awareness and risk perception of flash floods. Co-designed by all project partners and implemented across six pilot sites, the survey obtained a total of 2,822 responses. These street-level surveys identified gaps in risk awareness, preparedness levels, and knowledge of local flood dynamics, with awareness levels closely reflecting direct flood experience across sites, ensuring that the educational resources developed were directly responsive to identified community needs at local level.

Building directly on these findings, **eight educational and communication materials**[8] were developed through a participatory co-design process (CW2) involving different stakeholders from each pilot region. Translated into six languages, the materials are structured around four target audiences:

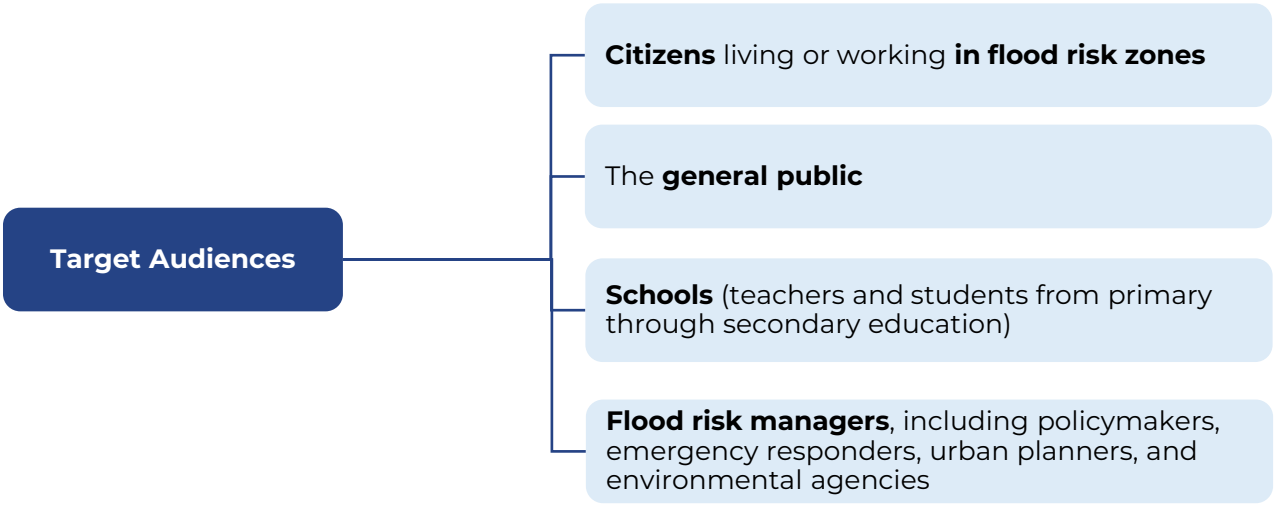


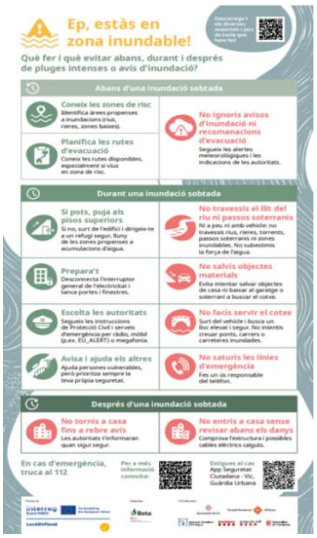
Figure 6 Target audiences for educational and communication materials

This audience segmentation ensures that content and communication approaches are tailored to the specific knowledge gaps, risk profiles, and decision-making roles identified through the baseline diagnosis.

[8] https://locall4flood.interreg-euro-med.eu/what-we-achieve/

Materials 1 to 8:

M1. Large-format emergency infographic



Target audience:
General public

Description:
Designed for display in buildings, businesses, and educational spaces for quick reference in flood-prone areas

Purpose:
Enable rapid access to essential safety information and reinforce awareness

M2. Household preparedness magnet

Target audience:
Households in flood-prone areas

Description:
A practical everyday reminder for homes in flood-prone areas

Purpose:
Maintain constant awareness, preparedness, and vigilance

M3. Awareness-raising informational brochure

Target audience:
General public (16+)

Description:
Explains flood origins and the impact of climate change on their frequency

Purpose:
Raise awareness and improve understanding of flood risk

M4. Travelling exhibition "Before the water arrives"

Target audience:
General public (16+)

Description:
Nine thematic sections guiding visitors from flood science to participatory governance, including testimonials from multiple sectors

Purpose:
Promote community preparedness and comprehensive understanding of flood risk management

M5. Flut Island online decision-making game

Target audience:
Secondary students and general public (11+)

Description:
Simulation where players act as decision-makers managing flood risk under climate pressure

Purpose:
Develop critical thinking and decision-making skills in complex contexts

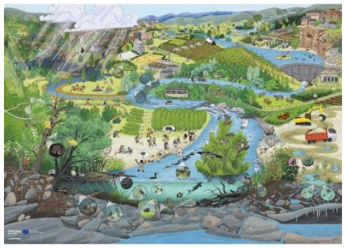
M6. Flut Island Print and Play board game (including a teaching guide)

Target audience:
Secondary students and general public (11+)

Description:
Narrative-based learning tool where players act as environmental investigators after a catastrophic storm

Purpose:
Foster experiential learning and understanding of flood causes and solutions

M7. Giant river basin puzzle (including a teaching guide)



Target audience:
Primary and secondary students

Description:
Physical tool to explore river systems and human– environment interactions

Purpose:
Enhance understanding of river ecosystem and flood resilience

M8. Flood Risk Management Plan card game

Target audience:
Diverse stakeholders (education, workshops, training)

Description:
Participatory simulation where players develop a Flood Risk Management Plan under increasing flood risks

Purpose:
Strengthen strategic planning, collaboration, and evidence-based decision-making in flood governance

Table 4 Educational and communication materials developed

Local implementation

In all pilot regions, implementation combined direct physical distribution, institutional partnerships, travelling exhibitions, school-based activities, digital downloads, and social media dissemination. Across all pilot sites:

+18,000

More than 18,000 **printed materials** were distributed: 11,355 magnets and infographics, and 6,750 brochures

15

15 **travelling exhibitions** were displayed in municipalities, universities, schools, research centres, and civil protection facilities.

+5,000

The exhibitions reached more than 5,000 **visitors**, including students, teachers, technical staff, older adults, and the general public.

33

33 **organisations** directly received printed materials, such as local authorities, emergency services, police, environmental agencies, research institutions, and schools.

263

263 **stakeholders** were contacted through targeted email campaigns.

20

Educational resources were republished on 20 **external institutional websites**, helping ensure long-term visibility and access.

Figure 7 Summary of local implementation across all pilot sites

2.2.4 Nature-based Solutions

Working with nature to reduce flood risk

Nature-based Solutions represent a paradigm shift in flood management: moving from a reliance on grey infrastructure, such as dams, levees, engineered drainage, toward interventions that work with natural processes to absorb, slow, and store floodwaters. NbS are increasingly recognised by EU policy frameworks as providing multiple co-benefits beyond flood mitigation, including carbon sequestration, habitat restoration, improved water quality, and enhanced quality of life. Yet their implementation remains limited in Mediterranean Flood Risk Management Plans, not primarily due to a lack of awareness, but because the pathway from conceptual interest to investment-ready project often remains undocumented and administratively opaque. LocAll4Flood set out to close this gap through participatory co-design and a transferable, evidence-grounded methodology.

NbS catalogue for flash flood risk management

As a foundation for all subsequent work, the project developed a structured NbS catalogue for flood risk management through: (i) a literature review of 40 European NbS initiatives from 2015 to 2024; (ii) an in-

depth analysis of 34 EU funded NbS projects from 2015 to 2020; and (iii) a qualitative effectiveness assessment conducted through individual meetings with 8 experts.

The NbS catalogue for flood risk management includes a specific sheet for each NBS typology, with a technical description, the most suitable topographical areas for deployment, the benefits and barriers to implementation, and the effectiveness domain.

The catalogue organises NbS around four topographical contexts that reflect the dominant land-use and vulnerability profiles of the Mediterranean region:

			
Urban Areas	**Rural and Natural Areas**	**Coastal Areas**	**Industrial Areas**
Rain gardens, green roofs, permeable pavements, Sponge City design principles, and Sustainable Urban Drainage Systems (SuDS), addressing surface runoff concentration and reduced infiltration capacity in built environments.	Reforestation, floodplain restoration, and wetland creation, targeting runoff generation, sediment dynamics, and natural water retention at the catchment scale.	Dune restoration, addressing the specific vulnerability profile of coastal flash flood exposure combined with sea-level and storm surge dynamics.	Constructed wetlands and hybrid grey-green engineering, providing solutions adapted to contexts where land-use constraints or contamination risks limit purely nature-based approaches.

Table 5 Topographical contexts of the Mediterranean region

This typological structure allows practitioners in a new territory to navigate the catalogue according to their specific catchment context, rather than facing an undifferentiated list of measures requiring expert interpretation.

Participatory Modelling Approach

The translation of catalogue knowledge into locally grounded NbS scenarios was achieved through a two-step process. First, building on the NbS catalogue, a technical hydraulic study was conducted at each pilot site to identify which solutions could effectively reduce flood risk from a hydrological and engineering perspective. This technical baseline then informed a Participatory System Dynamics Modelling (PSDM) approach, applied across all nine pilot catchments. This methodology was deliberately chosen to move beyond expert-led planning and embed local knowledge, institutional perspectives, and community priorities into the scenario development process from the outset.

The PSDM process was structured in two sequential phases:

Phase 01	Phase 02
Stakeholders collectively identified the benefits, trade-offs, and barriers associated with NbS implementation in their specific territorial context, producing a shared understanding of the governance, financial, and technical constraints that typically prevent NbS from advancing beyond the conceptual stage.	Stakeholders used this shared understanding as the basis for co-designing NbS scenarios tailored to their catchment's hydrological, land-use, and institutional conditions.

Figure 8 Sequential phases of the PSDM process

Pilot testing

The PSDM approach was applied across several Mediterranean pilot sites, proving flexible enough to work across diverse physical, institutional, and governance settings. Stakeholders, including local and regional authorities, water management agencies, civil protection authorities, technical experts, environmental organisations, and researchers, were engaged through structured workshops (CW3) combining small-group work and plenary discussions. Participants followed a step-by-step process to identify relevant NbS for their context, discuss co-benefits, barriers and trade-offs, build cause-effect relationships, and compare future scenarios (business-as-usual versus NbS implementation).

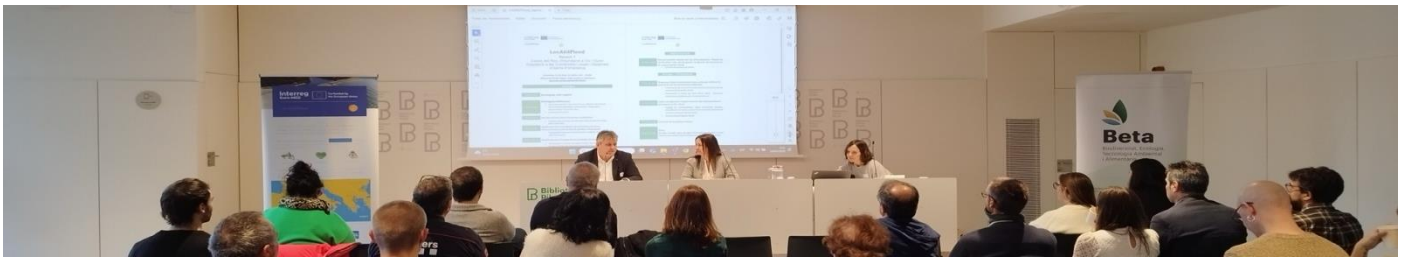
Across all pilots, the comparison between scenarios consistently showed that without systemic NbS adoption, flood risk, infrastructure stress, and socio-economic losses tend to increase over time, whereas coordinated NbS pathways improve water retention, reduce runoff and damage, enhance biodiversity, and contribute to broader resilience objectives.

3 Best Case Studies

CASE A:
Vic-Gurb (Catalonia, Spain) | Multi-actor governance and integrated IMGM

Description

Mixed urban-rural catchment with pre-existing institutional maturity. A Municipal Civil Protection Document (DUPROCIM) approved since 2019 with two water level sensors on the Mèder and Gurri rivers, and NbS investment included in Catalan Water Agency's (ACA) FRMP/PMH 2022–2027. The IMGM was tested here under conditions of relative governance readiness across two adjacent municipalities.



Achievements:

- Broadest civil society engagement of any pilot (30 civil society organisations mapped, including neighbourhood associations, schools, and civic centres)
- Highest EWS data integration (8 sources)
- Highest public awareness outreach (12,000 printed materials distributed; exhibition hosted across 4 locations for up to 150 days attracting over 2,000 visitors)
- 3 NbS actions identified via PSDM: basin-scale coordination, integrated urban-agricultural NbS strategies, monitoring mechanisms.

Impacts:

- Both municipalities formally adopted educational materials on their institutional websites
- The Consell Comarcal d'Osona identified as a supra-municipal EWS operator for small municipalities lacking civil protection capacity
- 4 governance barriers overcome through PSDM (urban-rural policy disconnect, sectoral silos, limited monitoring culture, resistance to long-term measures).

Replication potential:

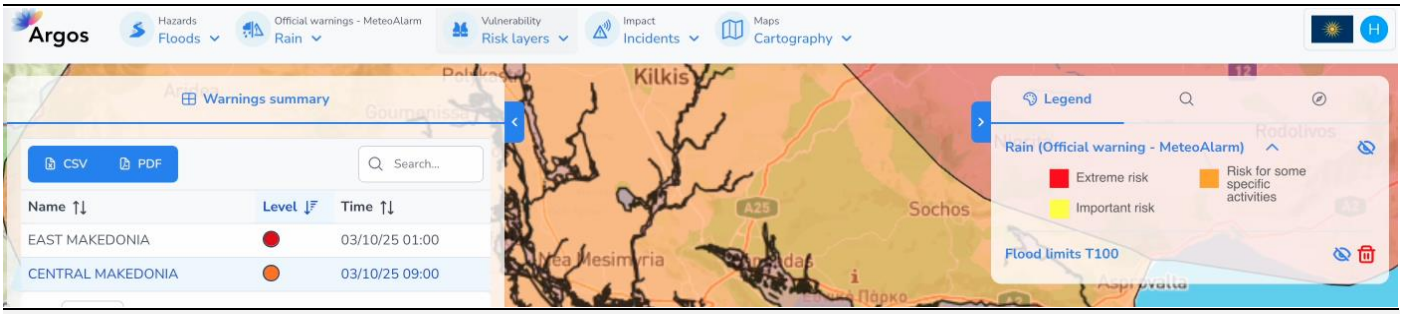
High.

Demonstrates the full IMGM functioning in a mixed catchment. The supra-municipal EWS governance model is directly transferable to any region with small municipalities sharing a river system. The PSDM approach for integrating urban and agricultural NbS at basin scale is applicable across the many Mediterranean catchments that cross both land uses. The Catalan regulatory context (with ACA's FRMP investment programme and existing civil protection documentation structures) also provides a blueprint for how the IMGM can be anchored in national planning instruments.

CASE B:
Central Macedonia (Greece) | EWS real storm performance and high user adoption

Description

Rural/coastal pilot in the Anthemountas River basin east of Thessaloniki. The EWS (ARGOS platform) integrated 6 data sources including MeteoAlarm warnings, AUTh high-resolution rainfall forecasts, and coastal metocean outputs, and was tested operationally during an active Mediterranean storm season (Sep–Dec 2025), providing real-event validation against named storms Adel and Byron (100–120 mm cumulative rainfall, documented flooding in Thessaloniki).



Achievements:

- 62 alert subscriptions, the highest population-level EWS adoption in the project
- 28 alerts of levels 1–3 recorded during the testing period, with strong agreement between ARGOS warnings and documented storm impacts
- 15 registered users
- 11 active monitoring days
- Automated SMS/email alerts confirmed as operationally useful during named storms

Impacts:

- Cross-sectoral uptake demonstrated, with users spanning civil protection, state insurance, environmental management, and academia
- Real-storm validation (rather than simulation) provides a publishable and transferable evidence base for EWS adoption decisions.

Replication potential:

High.

The Greek case demonstrates that high user adoption is achievable when the EWS is embedded in an academic-operational partnership. Real-storm testing during the project lifecycle provides qualitatively stronger evidence for decision-makers than simulations alone.

CASE C:
Central Macedonia (Greece) | Public awareness

Description

The Greece pilot combined targeted school-based outreach with strong institutional and digital dissemination across the Anthemountas River catchment, standing out among all pilots for depth of educational engagement rather than volume of printed materials.

Achievements:

- Educational materials distributed directly to 4 schools (primary, gymnasium, lyceum levels), reaching over 300 students and 40 educators
- Exhibition displayed across 5 locations for 106 days, reaching over 2,000 visitors
- 3 external institutional websites republished the materials (municipalities of Thermi and Thermaikos, plus a civil protection post)
- Schools independently published posts and blogs informing families about the activities.

Impacts:

- Autonomous amplification by schools beyond the project's direct activities demonstrates self-sustaining dissemination
- Materials reached diverse age groups, including intergenerational transfer (children engaging parents and grandparents)
- Strong social media reach with Greece-specific posts generating over 2,500 impressions and 62 reactions in a single post.

Replication potential:

High.

The school-centred model creates ripple effects beyond the project cycle without requiring ongoing resources. The combination of in-person facilitated sessions with interactive games and take-home materials is easily transferable to other Mediterranean municipalities with school networks.

CASE D
Bulgaria (Dalgopol and Kamchia-Varna) | NbS co-design in a policy-ready context

Baseline Description

The Bulgarian pilot sites of Dalgopol and Kamchia-Varna already had NbS and hybrid measures allocated in the national Flood Risk Management Plans with public funding committed at the time the project began. The IMGM was tested where policy commitment existed, but participatory governance capacity was lacking.

Achievements:

- The PSDM process achieved strong knowledge integration. Around 80% of model variables were identified through semi-structured stakeholder interviews and 20% through workshops
- The CLD was validated by workshop participants without requiring structural changes, indicating shared understanding of system dynamics
- 4 concrete NbS actions identified
- 5 barriers were overcome through the process: policy misalignment, uncertainty about NBS effectiveness, limited municipal maintenance capacity, space competition and fragmented implementation
- Awareness-raising materials were distributed through public institutions, schools, and municipal facilities, and all materials were published in both English and Bulgarian on to ensure wide accessibility.

Impacts:

- Strengthened inter-institutional coordination between the Regional Administration, Dalgopol Municipality, Civil Protection, and the River Basin Directorate
- Stakeholders achieved a shared understanding of system dynamics that clarified roles and created a foundation for coordinated NbS implementation aligned with existing FRMP measures.

Replication potential:

High.

The IMGM is most effective where policy commitments exist but participatory governance is lacking, which is a common condition across EU member states in the current FRMP 2022–2027 cycle. The PSDM methodology provides a structured pathway to close that gap without requiring new policy frameworks.

CASE E
Malta (Birkirkara–Msida and Burmarrad) | Multi-Stakeholder Governance for Flash Flood Risk Management

Baseline Description

The Malta pilot encompasses two catchments both designated as areas with Potential Significant Flood Risk under Malta's national Flood Risk Management Plan. The islands' dense urbanisation of naturally flood-prone dry valleys, combined with widespread impervious surfaces, makes flash floods a recurring hazard, with significant events recorded as recently as 2023 (142.9mm daily rainfall). Flood risk governance was characterised by fragmented institutional responsibilities across multiple ministries, agencies, and regional councils, with limited coordination mechanisms and low community awareness outside areas with direct flood experience.

Achievements:

- Three training and co-creation workshops engaged four stakeholder categories: public administration, private sector, civil society and academia.
- A Social Network Analysis identified the Energy and Water Agency and Civil Protection Department as the most central actors in the governance network, supporting formalisation of coordination roles.
- A PSDM was developed with 80% of variables drawn from stakeholder interviews, producing two intervention scenarios and three concrete governance actions.
- Educational materials were deployed through Regjun Tramuntana and the Ghajn National Water Conservation Centre, with the Flood Risk Management Plan card game integrated into teaching at the University of Malta.

Impacts:

- Four structural governance barriers were addressed: (i) land-use and ownership conflicts, (ii) administrative capacity gaps, (iii) long-term maintenance uncertainty, and (iv) fragmented institutional responsibilities.
- Community awareness and NbS implementation were confirmed as the most strategically central variables in the Malta flood risk system.
- Flood risk awareness was the highest across all pilot sites, with 62.3% of survey respondents having directly experienced flooding, validating the urgency and local receptiveness.

Replication potential:

High.

Malta's context as a small archipelago state with nationally managed flood risk governance and no large river systems, offers a distinct replication model for other coastal and island territories in the Mediterranean where dispersed institutional responsibilities and coordination gaps are the primary barriers to effective flood risk management. The multi-stakeholder governance framework, combined with the embedding of educational tools into academic curricula and alignment with ongoing national NBS policy initiatives (LIFE IP, GIFLUID), strengthens long-term institutional anchoring and transferability.

4 Recommendations

Based on the knowledge and experience generated during the project, a set of specific recommendations are proposed to support replication, scaling-up, and long-term sustainability of flash flood risk management measures in Mediterranean contexts.

Implementation Level: **Implementation Timeframe:**

	Local Level		Regional Level	S	Short (0-2 years)	M	Medium (2-5 years)	L	Long Term (+5 years)

4.1 Integrated planning and multi-stakeholder governance

1 S

Use governance mapping and participatory methods to identify coordination gaps

Social Network Analysis and Problem Structuring Methods proved effective for identifying key actors, governance bottlenecks, coordination gaps, and stakeholder perceptions before designing engagement strategies. These tools should be used to precede the design of any engagement strategy to support more targeted, evidence-based governance interventions.

2 S

Clearly define governance responsibilities across levels:

Explicit local vs. regional/national division of roles before implementation of EWS, NbS, or awareness measures begins to target the appropriate audience.

3 S

Use and apply the IMGM as the overarching integration framework:

Addressing flash flood risk requires moving from isolated management toward a comprehensive and integrated response. The IMGM provides this framework, connecting EWS, NBS, and awareness-raising actions within coordinated governance structures supported by institutional capacity and community participation. Demonstrated across the main Mediterranean territorial configurations, it should be actively promoted as a transferable model, with simplified versions developed for territories with lower governance maturity.

4 S/M

Strengthen the bridging role of technical and environmental agencies

Meteorological services, basin authorities, and environmental agencies play a critical role in connecting technical knowledge with operational decision-making. The links between these actors and emergency managers, and local planners should be strengthened to improve coordination, information flow, and the practical use of risk data.

5 S/M

Invest in institutional capacity-building

Many authorities face technical and administrative gaps that limit implementation despite political commitment. Continuous training, applied guidance, and governance support should be implemented to strengthen operational capacity at local and regional levels.

6 M

Strengthen Multi-stakeholder and cross-sector coordination

Effective flood governance should be enhanced through stronger coordination between local, regional, and national authorities, together with closer collaboration across water management, civil protection, spatial planning, environmental agencies, research institutions, civil society, and the private sector. The Quadruple-Helix approach is essential for building ownership, relevance, and long-term institutional uptake. Sustained co-creation processes and joint awareness activities are therefore essential to embed flood-risk tools and strengthen long-term governance capacity.

4.2 Early Warning Systems

1 S

Use real-event testing as a standard evaluation requirement for EWS adoption

Retain a structured log of alerts, observed rainfall, media/field impacts and user feedback after each significant storm, following the specific pilot experience with identification of multiple warnings and named-storm validations.

2 S/M

Maximise data integration and secure open data access

EWS maturity depends primarily on access to real-time observational, nowcasting, and high-resolution forecast data. New adopting territories should prioritise formal data-sharing agreements with meteorological, hydrological, and civil protection agencies from the outset. Crucially, data should be made openly accessible, most Euro-Mediterranean countries use weather radar for meteorological purposes but do not make this data publicly available, limiting EWS effectiveness. Coupling open radar and meteorological forecasts with basin-scale rainfall-runoff and inundation models further enhances precision, enabling localised impact warnings for specific vulnerable elements.

3 S/M

Adapt EWS to small catchments

Flash floods evolve within minutes to hours, requiring high temporal resolution in monitoring, forecasting, and alert dissemination. EWS should be specifically tailored to small catchments rather than adapted from large-basin systems, and should be continuously calibrated with local experts and tested against real events. Before building from scratch, territories should identify existing resources (e.g. universities with hydraulic models, local hydrometeorological data, previous studies, and people with knowledge of vulnerable elements) as these provide a strong foundation that reduces implementation time and cost.

4 S/M

Design around user needs and communication strategies

User preferences and operational needs varied significantly across catchments, reflecting differences in institutional roles and cultures. Alert settings, dashboards, and communication methods should therefore be co-designed with intended users, while warning messages should remain simple, actionable, and role-specific. Strong communication, onboarding, and training strategies are equally important to secure institutional buy-in, increase user registration, and ensure sustained operational use.

5 | M

Embed EWS into operational procedures and institutions

EWS effectiveness depends not only on technical deployment but on institutional integration. EWS should be formally embedded into civil protection Standard Operating Procedures (SOPs), emergency management frameworks, and civil protection protocols, clearly defining who receives alerts, who validates them, who triggers local actions, and how warnings translate into operational measures for roads, schools, municipal services, and critical infrastructure. Operational actors, therefore, should be involved early as it is essential for long-term adoption and effectiveness.

6 | L

Upgrade the local/regional EWS

The EWS should evolve from a mainly meteorological alerting tool into a compound-flood decision-support service that couples meteorological information with high-resolution forecasts, data from local meteorological stations, radar observations where available, rainfall-runoff and hydraulic modelling outputs, and coastal-flood forecasting products for flood-prone zones.

4.3 Public awareness and education

1 | S

Ground awareness materials on evidence and local needs

Flood-risk education should begin with a baseline assessment of risk perception, knowledge gaps, and misconceptions, to ensure materials respond to actual community needs rather than assumed ones.

2 | S

Tailor materials to different audiences and learning contexts

Awareness materials should be adapted to the needs of different audiences. Participatory and gamified tools proved especially effective for younger and non-technical audiences, while governance-oriented materials worked better for institutional users. Integrating flood-risk education into both formal curricula and informal learning spaces, such as community centres and exhibitions, helps build long-term awareness and strengthen the Human–River Connection.

3 | S/M

Address misconceptions about flood protection through targeted public communication

Explain why indiscriminate vegetation clearing and purely structural solutions may reduce ecological resilience, while well-designed riparian vegetation, floodplain reconnection and retention areas can reduce peak flows and provide co-benefits.

4 M

Embed awareness and promote transferability in activities for long-term institutional frameworks

Awareness raising should be treated as a continuous programme rather than a one-off campaign. Materials should be formally integrated into school curricula, municipal communication strategies, and civil protection training through agreements with schools, municipalities, and regional authorities to ensure long-term impact. Scaling up requires active dissemination through municipal, educational, and civil protection networks, as well as policy and interregional cooperation platforms, supported by digital monitoring and feedback surveys to evaluate effectiveness and refine materials over time.

4.4 Nature-based Solutions

1 S

Use the NbS catalogue as a starting point

It is recommended that the LocAll4Flood NbS catalogue be used as a strong evidence base for selecting measures across urban, rural, industrial, and coastal contexts. However, successful adoption depends on adapting these options through structured stakeholder engagement to reflect local priorities, constraints, and governance conditions.

2 S

Prioritise low-regret, policy-aligned NbS already supported by the RBMP/FRMP framework

NbS already recognised within existing River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs) offer the fastest pathway to implementation, facing fewer regulatory, institutional, and financial barriers. These 'low-regret' measures deliver flood risk reduction across a wide range of climate scenarios while generating ecological and social co-benefits. In the LocAll4Flood pilot areas, priority measures include riverbed demarcation, floodplain restoration and channel naturalisation, riparian buffer zones and bioengineering techniques, natural inland wetland restoration, and Natural Water Retention Measures in flood-prone corridors. Targeting these first builds institutional confidence and creates the enabling conditions for more ambitious NbS interventions over time

3 S

Protect and prioritise critical exposure hotspots in the pilots

Through combined EWS-triggered operational measures with targeted NbS and retention intervention strategies, protect the critical exposure hotspots, especially in the downstream and coastal areas which contain airports, road crossings, and flood-prone settlements.

4 S/M

Create a shared geospatial evidence base for authorities

Combining FRMP hazard/risk maps, field-survey locations, planned flood-protection works, NBS suitability areas, critical infrastructure and EWS/model outputs, so that decisions are transparent, updateable and transferable to other Mediterranean basins.

5 S/M

Treat participatory processes as a core implementation tool

Stakeholder participation should be embedded throughout NbS planning and design, ensuring early-stage participation and not treated as a consultation exercise. The PSDM process showed that co-creation improves local relevance, reveals implementation trade-offs, builds institutional ownership, and supports the transition from concepts to actionable plans.

6	S/M		

Prioritise NbS that maximise co-benefits

NbS should be selected not only for their contribution to flood risk reduction but also for their ability to deliver additional environmental, social, and economic benefits, including biodiversity enhancement, water quality improvement, climate adaptation, carbon sequestration, recreational opportunities, and human well-being. Prioritising multi-functional interventions can increase stakeholder support, improve cost-effectiveness, and strengthen long-term sustainability.

7	S/M		

Align NbS with EU policy and funding frameworks

Positioning NbS within EU frameworks such as the European Green Deal, the Biodiversity Strategy for 2030, and the Climate Adaptation Strategy strengthens policy legitimacy and improves access to funding opportunities. It is recommended to link local interventions to these frameworks to help secure long-term institutional and financial support.

8	M		

Design integrated, hybrid, and phased NbS portfolios

NbS are most effective when implemented as coordinated portfolios rather than isolated measures, combining grey and green approaches to reduce over-reliance on hard engineering. Small-scale measures such as green roofs, rain gardens, and permeable pavements can deliver early results and build support, while larger interventions wetland restoration, reforestation, and river re-naturalisation, should be planned as longer-term actions requiring greater coordination and resources.

9	M/L		

Embed NbS into planning, governance, and financing frameworks at all levels, treating flood prevention as an integral part of land-use planning rather than a standalone hydraulic intervention.

NbS should be incorporated into Flood Risk Management Plans, climate adaptation strategies, regional and municipal land and urban planning, environmental licensing, and civil protection frameworks. Before implementation, clear responsibilities must be established for long-term maintenance, financing, and monitoring — covering vegetation management, sediment removal, hydraulic capacity assessments, and periodic performance review.

10	L		

Expand NbS application to industrial and coastal areas

Most existing EU research and current FRMP measures concentrate on urban and natural contexts. Industrial and coastal areas are significantly underrepresented despite presenting equally relevant flash flood risk and significant opportunities for innovative NbS application. Future adoption planning should explicitly address these contexts.

5 Conclusions

The Mediterranean region faces a growing flash flood risk driven by climate change, urbanisation, and territorial vulnerability. The LocAll4Flood has demonstrated across nine pilot catchments in six Mediterranean countries, that a more integrated and preventive flood risk management is both necessary and achievable. By combining Early Warning Systems, Nature-based Solutions, and public awareness actions within a participatory Integrated Multi-stakeholder Governance Model, the project has developed practical, locally adapted tools that strengthen coordination, preparedness, and long-term resilience.

All pilot sites successfully implemented functional EWS integrating between 3 and 8 data sources. Three training and co-creation workshop cycles engaged hundreds of stakeholders with satisfaction levels increasing from approximately 85% in the first session to over 97% in the third, confirming the value of combining technical content with participatory methodologies. More than 18,000 educational materials were distributed across the Mediterranean, reaching over 5,000 exhibition visitors and 33 institutional entities. Participatory System Dynamics Modelling processes co-produced NbS action plans in all pilot sites, overcoming governance barriers and generating shared implementation pathways aligned with existing Flood Risk Management Plans. Across all pilots, 91.8% of participants agreed that the project strengthened collaboration among flood risk management actors, and nearly 96% expressed confidence in its positive long-term impact.

Despite these achievements, the project also highlighted several persistent structural challenges that still need to be addressed to ensure the long-term effectiveness, institutional uptake, and wider transferability of integrated flash flood risk management approaches. These challenges are translated into the recommendations presented within this White Paper which are structured around three key lines of work of EWS, NbS and public awareness and education.

EWS adoption remains uneven and is not yet fully integrated into emergency management procedures. User uptake varied significantly across pilot sites, with Greece recording 65 alert subscriptions while other regions showed lower engagement. This difference was linked less to technical capacity than to limited communication strategies, weak institutional integration, and the absence of formal incorporation into civil protection procedures. In addition, restricted access to weather radar data in many Euro-Mediterranean countries continues to limit forecasting capacity and creates inequalities between territories. Formalising EWS within emergency management frameworks and improving data-sharing between administrations will be essential to ensure the long-term operational effectiveness of EWS.

NbS face persistent economic, governance, and maintenance barriers. Across all pilot sites, stakeholders consistently identified high upfront costs, long-term maintenance uncertainty, fragmented institutional responsibilities, and limited political commitment as the main obstacles to NbS implementation. The PSDM processes have produced shared understanding and action plans, but these remain preparatory: actual NbS implementation is still pending in most sites. Where policy commitments already exist, as in Bulgaria's FRMP-funded measures, the path to implementation is clearer, but administrative capacity gaps and unclear maintenance responsibilities continue to delay progress. Closing this gap requires stable funding mechanisms, defined governance structures, and public-private management models to be established before implementation begins, not after.

Public risk perception and trust in authorities remain low across most pilot areas. The baseline survey showed that many residents do not expect floods to occur, are unsure how to respond in emergencies, and have limited confidence in authorities' ability to manage flood risks and communicate effectively. These findings highlight that building a strong risk culture requires long-term, continuous engagement beyond short-term awareness campaigns. While the autonomous republishing of project materials by Greek schools is a promising example of local ownership, such initiatives remain limited.

Institutional integration of project outputs remains partial. Although educational materials have been widely distributed and adopted by some municipalities, their incorporation into school curricula, civil protection training, and regular municipal communication strategies is still limited. In addition, 41.2% of workshop assessments identified local authorities and emergency services as missing from stakeholder networks, highlighting gaps between the project's multi-actor governance ambitions and actual practice. Without formal mechanisms embedding these tools into institutional processes, there is a risk that outputs remain project-based rather than long-term resources.

Transferability requires more than documentation. Although the IMGM has been validated across four topographical areas and six governance contexts, showing strong adaptability, scaling it across the Mediterranean will require continued investment in capacity building, stronger promotion through regional networks and policy platforms, and simplified entry-level versions for territories with lower governance capacity. The project has established a solid evidence base, but systematic dissemination and uptake remain key next steps.

The LocAll4Flood experience shows that flash flood resilience in the Mediterranean is fundamentally a governance and societal challenge, not only a technical one. Solutions are effective only when institutions, communities, and maintenance systems are aligned. The project has highlighted both the potential of integrated approaches and the gaps future flood risk policies should address.

6 Bibliography

Black Sea. Danube Association for Research and Development (BDCA). (2024). *D1.5.1: LocAll4Flood Integrated Multistakeholder Governance Model – training programme* (Deliverable D1.5.1, LocAll4Flood, Interreg Euro-MED). Available at: https://locall4flood.interreg-euro-med.eu/wp-content/uploads/sites/80/d.1.5.1_locall4flood-integrated-multistakeholder-governance-model---training-programme.pdf

Black Sea. Danube Association for Research and Development (BDCA). (2024). *D2.1.1: Identification form of each of the pilot sites* (Deliverable D2.1.1, LocAll4Flood, Interreg Euro-MED). Not publicly available.

BETA Technological Centre (Uvic-UCC). (2024). *D1.1.1: Definition of the 4 topographical areas of the Mediterranean most commonly affected by flash floods* (Deliverable D1.1.1, LocAll4Flood, Interreg Euro-MED). Available at: https://locall4flood.interreg-euro-med.eu/wp-content/uploads/sites/80/l4f_d1.1.1-definition-of-4-different-topographical-areas-of-the-mediterranean-most-commonly-affected-by-flash-floods.pdf

BETA Technological Centre (Uvic-UCC). (2026). *D2.3.1: Report on the testing outcomes of the adaptation solutions in the pilot sites* (Deliverable D2.3.1, LocAll4Flood, Interreg Euro-MED). Not publicly available.

BETA Technological Centre (Uvic-UCC). (2026). *Output 2.1: Catalogue of prevention, mitigation and adaptation solutions to reduce flash flood impact in the 4 different topographical areas* (Output 2.1, LocAll4Flood, Interreg Euro-MED). Not publicly available.

Consiglio Nazionale delle Ricerche (CNR). (2024). *D1.4.1: Catalogue of the mitigation solutions available in the 4 different topographical areas* (Deliverable D1.4.1, LocAll4Flood, Interreg Euro-MED). Available at: https://locall4flood.interreg-euro-med.eu/wp-content/uploads/sites/80/d.1.4.1_catalogue-of-the-mitigation-solutions-available-in-the-topographical-areas-2.pdf

Consiglio Nazionale delle Ricerche (CNR). (2025). *D2.4.1: Report on the testing outcomes of the mitigation solutions in the pilot sites* (Deliverable D2.4.1, LocAll4Flood, Interreg Euro-MED). Available at: https://locall4flood.interreg-euro-med.eu/wp-content/uploads/sites/80/d.2.4.1_report-on-the-testing-outcomes-of-the-mitigation-solutions-in-the-pilot-sites.pdf

Consiglio Nazionale delle Ricerche (CNR). (2026). *D2.6: Multi-stakeholders engagement* (Deliverable D2.6, LocAll4Flood, Interreg Euro-MED). Not publicly available.

Eurorégion Pyrénées-Méditerranée. (2024). *D3.2.1: Communication strategy* (Deliverable D3.2.1, LocAll4Flood, Interreg Euro-MED). Available at: https://locall4flood.interreg-euro-med.eu/wp-content/uploads/sites/80/d.2.3.-report-on-the-testing-outcomes-of-the-adaptation-solutions-in-the-pilot-sites.pdf

Eurorégion Pyrénées-Méditerranée. (2026). *D3.5.1: LocAll4Flood project exploitation strategy (transfer and mainstream)* (Deliverable D3.5.1, LocAll4Flood, Interreg Euro-MED). Not publicly available.

Hydrometeorological Innovative Solutions (HYDS). (2024). *D1.2.1: Report on the Early Warning System [EWS] to be implemented in the pilot sites* (Deliverable D1.2.1, LocAll4Flood, Interreg Euro-MED). Not publicly available.

Hydrometeorological Innovative Solutions (HYDS). (2025). *D2.2.1: Report on the testing outcomes of the Early Warning System [EWS]* (Deliverable D2.2.1, LocAll4Flood, Interreg Euro-MED). Available at: https://locall4flood.interreg-euro-med.eu/wp-content/uploads/sites/80/d.2.2.1_report-on-the-testing-outcomes-of-the-early-warning-system-ews.pdf

LocAll4Flood. (n.d.). *LocAll4Flood: Flash flood risk prevention & resilience in Mediterranean area through an integrated multi-stakeholder governance model*. Interreg Euro-MED Programme. https://locall4flood.interreg-euro-med.eu/

GLOWATER. University of Balearic Islands (UIB). (2024). *D1.3.1: Flash flood awareness and risk perception evaluation as a basis to design adaptation solutions in the 4 different topographical areas* (Deliverable D1.3.1, LocAll4Flood, Interreg Euro-MED). Available at: https://locall4flood.interreg-euro-med.eu/wp-content/uploads/sites/80/l4f_d.1.3_flash-flood-awareness-and-risk-perception-evaluation-as-a-basis-to-design-adaptation-solutions-in-the-4-topographical-areas-2.pdf

GLOWATER. University of Balearic Islands (UIB). (2025). *D2.5.1: Methodology of monitoring including battery of indicators* (Deliverable D2.5.1, LocAll4Flood, Interreg Euro-MED). Not publicly available.

GLOWATER. University of Balearic Islands (UIB). (2026). *D2.5.2: Monitoring: Assess the efficiency of the LocAll4Flood IMGM to reduce flash flood risks also through citizen science activities* (Deliverable D2.5.2, LocAll4Flood, Interreg Euro-MED). Not publicly available.