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Deliverable Phase 3 – Climate risk management

Methodical Climate Risk Assessment for the Cluj Metropolitan Area (MECRA-Cluj)

Cluj Metropolitan Area

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Abbreviations and acronyms

Abbreviation / acronym	Description
ABA	River Basin Administration (Someș-Tisa)
ADP	Public Domain Administration
AM	Managing Authority (for European funds)
ANM	National Meteorological Administration
APSFR	Areas with Potential Significant Flood Risk
ASF	Financial Supervisory Authority
CCC	Climate City Contract
CFD	Computational Fluid Dynamics
CIIC	Center for Innovation and Civic Imagination (Cluj-Napoca)
CLIMAAX	CLIMAte Risk and Vulnerability Assessment Framework and Toolbox
CMA	Cluj Metropolitan Area (ZMC)
CRA	Climate Risk Assessment
CRM	Climate Risk Management
CTP	Cluj-Napoca Public Transportation Company
DALI	Documentation for Approval of Intervention Works

IGSU	General Inspectorate for Emergency Situations (General Inspectorate for Emergency Situations)
HW	Heatwave
ISU	Inspectorate for Emergency Situations (Cluj Inspectorate for Emergency Situations)
INHGA	National Institute of Hydrology and Water Management
LAU	Local Administrative Unit (UAT)
LST	Land Surface Temperature
M&E	Monitoring and Evaluation
MECRA-Cluj	Methodical Climate Risk Assessment for the Cluj Metropolitan Area
MMAP	Ministry of Environment, Water, and Forests
NBS	Nature-Based Solutions
NDVI	Normalized Difference Vegetation Index
SNAC	National Strategy on Adaptation to Climate Change
OI	Intermediary Body (for operational programs)
P2R	Pathways2Resilience (European program to support resilience)
PMAP	Stormwater Management Plan
PUG	General Urban Plan
PUZ	Zonal Urban Plan
RCP	Representative Concentration Pathways
RLU	Local Urban Planning Regulations
RUSLE	Revised Universal Soil Loss Equation
SF	Feasibility Study
SuDS	Sustainable Drainage Systems
UBB	Babeș-Bolyai University
UHI	Urban Heat Island
SUHI	SURFACE Urban Heat Island
USAMV	University of Agricultural Sciences and Veterinary Medicine in Cluj-Napoca

Executive summary

This deliverable represents the final stage of the Methodical Climate Risk Assessment (CRA) for the Cluj Metropolitan Area (MECRA-Cluj) project. It is directly built upon the scoping and hazard identification workflows established in Deliverable 1 and the high-resolution, data-driven technical hazard mapping executed in Deliverable 2.

The primary motivation for developing this report is to bridge the existing gap between academic climate diagnostics and local public administration actions. By transitioning from technical hazard assessments to operational policy formulations, this deliverable provides regional decision-makers with a structured framework to integrate adaptation strategies directly into urban spatial planning, infrastructure planning, and local investment portfolios. Through this document, stakeholders and local authorities will learn how to transition the Cluj Metropolitan Area (CMA) from emergency response structures to a proactive "resilience-by-design" urban paradigm.

Main Actions, Results, and Findings

The activities accomplished during the third phase centered on a structured, participatory co-creation process to translate technical risk profiles into a comprehensive portfolio of 39 localized adaptation measures.

In agreement with the project's operational design, these adaptation options were assessed through iterative group exercises involving project partners and regional stakeholders to ensure local prioritization and future integration into regional planning:

- Stakeholder Workshop (April 2, 2026): focused on transitioning from technical diagnostics to concrete Climate Risk Management (CRM) formulations, identifying potential "grey, green, and soft" interventions, and incorporating community feedback from online questionnaires.
- Technical Institutional Consultation (April 24, 2026): structured alongside the Someș-Tisa Water Basin Administration (ABA-SGA) to establish a collaborative framework for integrated water governance, urban stormwater management criteria, and the alignment of the Blue-Green Metropolitan Ring strategy.
- Formal Validation Workshop (June 9, 2026): allowed regional experts and stakeholders to review, refine, and formally endorse the final package of adaptation actions.
- The MECRA-Cluj closing event (July 31, 2026) brought together local authorities and experts to present the climate risk assessment (heat waves, floods) and adaptation measures for the Cluj Metropolitan Area. The results will be directly incorporated into the future climate resilience strategy through the Pathways2Resilience project

Risk Mitigation Focus

The proposed Climate Risk Management measures address the two priority climate risks identified during the Climate Risk Assessment—heatwaves and flooding—through targeted adaptation actions tailored to local conditions.

For thermal stress: The validated actions prioritize the mitigation of the Urban Heat Island (UHI) effect in high-density neighborhoods like Mănăștur and Mărăști, leveraging satellite Land Surface Temperature (LST) data and expert feedback to justify targeted cool-roof mandates, optimized building ventilation, and urban canopy expansions.

For hydrological hazards: The actions focus on the Someșul Mic river basin, embedding sustainable drainage requirements and localized retention solutions directly into spatial planning regulations.

Main Results Achieved:

The key outcome includes the formal establishment of the MECRA-Cluj risk profiles, standardized through the European CLIMAAX methodology, as the primary technical baseline for the region. By doing so, this deliverable positions the CLIMAAX framework as a key reference to guide the Horizon Pathways2Resilience (P2R) regional initiative, ensuring that the region's upcoming Climate Resilience Strategy, Action and Investment Plans are fully consistent with CLIMAAX technical standards.
Furthermore, a preliminary set of Monitoring and Evaluation (M&E) indicators is outlined within this phase to track initial resilience progress across three core areas: hazard impacts, adaptation actions, and governance coordination.

Key Conclusions and Take-Aways

The key take-away messages highlight that:

- ***Climate resilience requires coordinated governance across all levels***: effective climate risk management depends on strong alignment between local, regional, and national policies. Removing cross-scale policy barriers (e.g., delays in implementing national urban stormwater regulations) is essential for successful local adaptation.
- ***Resilient regions combine nature-based and engineered solutions***: the most effective adaptation strategies integrate NBS, such as peri-urban sponge parks and green corridors, with targeted investments in conventional infrastructure to reduce climate-related risks.
- ***Long-term resilience depends on sustained scientific support***: establishing a permanent Local Scientific Council ensures that standardized CRA methodologies remain up to date, incorporating new hydro-meteorological data and scientific advances to support evidence-based decision-making.

1 Introduction

CMA is one of the fastest-growing metropolitan regions in Eastern Europe. Rapid urbanization, combined with the increasing impacts of climate change, is placing growing pressure on the region, particularly through more frequent heatwaves and flood events. MECRA-Cluj was established to support the CMA in addressing these challenges by providing a standardized, science-based framework for assessing and managing climate risks across the metropolitan area.

Implemented within the CLIMAAX framework, the project follows a phased approach to climate risk assessment and management. *Phase 1* established the scope of the assessment and identified heatwaves and flooding as the priority climate hazards. *Phase 2* provided a high-resolution assessment of climate hazards, exposure, vulnerability, and risk across the metropolitan area. Building on these results, *Phase 3* translates the findings of the Climate Risk Assessment into a practical Climate Risk Management (CRM) framework by defining strategic objectives, proposing adaptation measures, identifying governance mechanisms, and outlining implementation pathways that support climate-resilient spatial planning, infrastructure development, and long-term decision-making.

1.1 Main objectives of the project

MECRA-Cluj aims to strengthen the resilience of the CMA to climate change, with a particular focus on its two priority climate risks: heatwaves and floods. The project provides the region's 19 municipalities with a shared, science-based framework for understanding, assessing, and managing climate risks, ensuring that adaptation efforts are coordinated across the metropolitan area.
In practice, this means harmonizing climate risk information across the metropolitan area to create a common evidence base for decision-making. It identifies the areas facing the greatest climate hazards, the

assets and infrastructure most exposed to those hazards, and the population groups most vulnerable to climate impacts, including older adults, low-income households, and other socially vulnerable communities. Building on this evidence, the project develops a coordinated Climate Risk Management (CRM) framework that supports local authorities in integrating NBS, resilient infrastructure, and climate adaptation measures into spatial planning, sectoral policies, and future investment decisions.

1.2 Project team

The project is a multidisciplinary collaboration led by the Cluj Metropolitan Area Intercommunity Development Association (CMA). Technical and scientific expertise is provided by Babeș-Bolyai University (UBB), through a multidisciplinary team of climatologists, GIS and spatial analysis specialists, and data analysts. The Austrian Institute of Technology (AIT) supported the project by providing methodological guidance, technical assistance, and expertise in the implementation of the CLIMAAX Toolbox, ensuring its correct application throughout the CRA process. Stakeholders involved in the consultation process include the Inspectorate for Emergency Situations (ISU), the Someș-Tisa Water Administration (ABA), and local urban planning departments.

1.3 Outline of the document's structure

This deliverable is structured to guide the reader through the transition from CRA to CRM in the CMA.

Section 2 establishes the local context for CRM by summarizing the key findings of Phase 2, which was dedicated to CRA, reviewing the policy and governance framework, identifying the main actors involved in CRM, and highlighting lessons learned from past climate events.

Section 3 presents the CRM framework developed for the CMA. It defines the strategic objectives for CRM, identifies the supportive elements required for effective implementation, and proposes a comprehensive portfolio of adaptation measures together with recommendations for their integration into planning and decision-making processes.

The final sections evaluate the outcomes of the project, assess the usability of the proposed CRM framework, summarize the main conclusions, review progress against the project objectives and expected outputs, and provide the supporting documentation and references.

2 Local profile

2.1 Summary of Key Risk Assessment results

The baseline for CRM in the CMA was established through the *Phase 2: Key Risk Assessment Evaluation Dashboard*, which prioritizes climate hazards by integrating their severity, urgency, and resilience capacity. The assessment identifies heatwaves and floods as the two priority climate risks requiring coordinated action across the metropolitan area.

Heatwaves are identified as the highest priority climate risk, with current severity ranging from high to very high and projected to become critical under future climate scenarios. Densely built-up urban areas experience elevated thermal stress due to the Surface Urban Heat Island (SUHI) effect, while the long planning prospects required for structural adaptation increase the urgency for early intervention.

Floods represents the second priority climate risk. Riverine flooding currently presents a moderate to substantial level of severity and is projected to increase under future climate conditions. Existing hydrotechnical infrastructure and regulatory measures provide a substantial level of protection along the Someșul Mic corridor. However, pluvial and flash flooding caused by intense rainfall events remain an increasing concern, particularly in rapidly urbanizing areas where drainage capacity and natural water retention have been reduced. Consequently, the urgency for both priority hazards shifts from "more action needed" under current conditions to "immediate action needed" under future climate scenarios.

The assessment also highlights differences in resilience capacity between the two hazards. Flood risk management benefits from an established regulatory framework, existing infrastructure, and strong institutional capacity, resulting in a substantial level of resilience. Nevertheless, important gaps remain in pluvial drainage systems, stormwater management, and the implementation of nature-based retention measures. By contrast, resilience to heatwaves is assessed as moderate, reflecting the absence of metropolitan heat action plans, standardized early-warning protocols tailored at local level, and climate-responsive spatial planning and urban design regulations.

These findings were validated through stakeholder consultations involving public authorities, technical institutions, emergency services, water management agencies, and academic experts. Participants confirmed the technical assessment and identified additional governance challenges, particularly the limited dissemination of climate risk information to the public and the need for stronger institutional coordination across administrative boundaries.

Together, the *Phase 2: Climate Risk Assessment* and the stakeholder consultation process provide the evidence base for the CRM framework presented in this deliverable. They support the transition from reactive emergency response toward proactive climate adaptation and help prioritize future investments that address physical vulnerabilities, infrastructure deficiencies, governance challenges, and public awareness across the CMA.

Table 2-1 Priority climate risks and resilience capacity in the Cluj Metropolitan Area

Priority climate risk	*Resilience capacity (low, medium, substantial, high)*	*Description of the resilience capacity (such as existing knowledge, planned measures, gaps)*	*Stakeholders, experts and priority groups involved in the key risk assessment & modality of engagement*
Heatwaves	Medium	**Resilience capacity:** • standardized early-warning protocols at national level applicable at local level; • short-term measures: shadow/heat shelters, first-aid network.	• public administration authorities; • territorial planning experts • emergency services, including health system; representatives; • academic experts

		• Strong scientific and technical expertise and national forecasting establish a solid knowledge base. • Operational measures are limited to reactive coping tools. **Gaps:** • Lack of metropolitan heat action plans, standardized protocols, and enforceable building codes; • long planning prospects required for structural adaptation; • climate-responsive spatial planning (still extensive impervious surfaces and deficient blue-green corridors continue to amplify UHI effect); • urban design regulations; • limited dissemination of climate risk information to the public; • the need for stronger institutional coordination across administrative boundaries	• public health experts, • first responders (emergency services) **Priority groups** involved trough the citizen questionnaire include the elderly people (attached in the supporting documents) **Engagement** used participatory consultations. Stakeholders reviewed severity metrics, validated spatial hazard data, and identified local governance constraints.
Flooding (Riverine & Pluvial)	Substantial	**Resilience capacity:** • regulatory framework • existing hydrotechnical infrastructure and river management measures • strong institutional capacity • national hazard map • operational emergency services **Gaps:** • Ageing pluvial drainage systems are often undersized for high-intensity rainfall events, while soil erosion, sediment transport, and sewer blockage further increase flood risk. • stormwater management • the implementation of nature-based retention measures; • limited dissemination of climate risk information to the public; • the need for stronger institutional coordination across administrative boundaries; • reduced natural water retention due to urban sprawl into former floodplain areas (particularly	• public administration authorities • river basin authorities/water management agencies • utility operators • emergency services • urban planning departments • private sector representatives • first responders; • academic experts **Priority groups** include communities located in flood-prone areas, peri-urban residents, and critical assets situated along unmanaged tributaries. **Stakeholder engagement** combined technical workshops and risk perception exercises, enabling participants to identify infrastructure bottlenecks and discuss opportunities for improved coordination across

		along the Nadăș and Gădălin catchments in Apahida, Jucu, and Bonțida) • long-term financing for NBS remains limited.	municipalities.

2.2 Key implementation mechanisms and policy context for CRM

CRM in the CMA is supported by a multilevel governance framework that integrates European, national, regional, and local policy instruments. Together, these provide the regulatory framework, institutional capacity, and strategic direction needed to address the region's priority climate risks: heatwaves, riverine and pluvial flooding.

The implementation of CRM relies on a combination of spatial planning instruments, sectoral policies, funding mechanisms, and institutional coordination. At the local level, climate adaptation is increasingly being integrated into planning instruments such as the General Urban Plan (PUG), Zonal Urban Plans (PUZ), and Local Urban Regulations (RLU). Building regulations are progressively incorporating climate resilience considerations, including improved thermal performance and adaptation to future climate conditions. National legislation and regional water management plans provide a broader framework for flood risk management, while the CLIMAAX methodology supports these processes by providing a standardized, evidence-based approach to multi-hazard risk assessment and the prioritization of adaptation measures. Beyond regulatory instruments, CRM is supported by economic incentives, sectoral policies, and knowledge-sharing mechanisms that strengthen the region's adaptive capacity. Participatory budgeting encourages community-led adaptation initiatives, including urban greening and school micro-forest projects, while clearly defined institutional responsibilities promote coordination among public authorities, utilities, emergency services, and other stakeholders.

Sector-specific policies further support the implementation of adaptation measures. In the water sector, efforts focus on reducing riverine and pluvial flood risks across the Someșul Mic basin and its tributaries through hydrological monitoring, integrated river basin management, and data exchange initiatives such as the Danube-ADAPT project. Biodiversity and green infrastructure policies promote the implementation of NBSs, including rain gardens, green corridors, and other measures that improve stormwater retention while strengthening ecosystem connectivity. Within the built environment, climate adaptation is supported through energy-efficient building retrofits, urban greening initiatives, and sustainable cooling measures implemented under the Climate-Neutral and Smart Cities Mission.

Effective CRM depends on the alignment of policy objectives across all governance levels. At the European level, the EU Mission on Adaptation and the LIFE Programme provide strategic direction and financial support for ecosystem-based adaptation and resilience-building initiatives. Nationally, the Romanian National Strategy on Climate Change Adaptation (SNAC 2024–2030 5) establishes the policy framework for climate adaptation, water security, and flood risk management. At the metropolitan level, the Integrated Urban Development Strategy (SIDU 3) identifies priority investments for flood risk reduction, sustainable drainage, and urban heat island mitigation, while the Climate City Contract (CCC 2) promotes the development of blue-green infrastructure and coordinated climate action. Finally, the PUG and RLU translate these strategic objectives into spatial planning requirements by promoting on-site stormwater retention, minimum green space standards, and climate-resilient urban development.

Table 2-2 summarizes how CRM is operationalized across the main policy sectors in the CMA. It links sector-specific policy objectives with the implementation mechanisms and governance levels that support the delivery of adaptation measures.

Table 2-2 Climate Risk Operationalization Matrix for the CMA

Sector / Policy Area	Policy Goals & Focus	Implementation Mechanisms & Instruments (CRM Mechanisms)	Governance Levels Involved (Levels)
Water & Flood Management	Reduce riverine and pluvial flood risk and increase resilience to hydrological extremes in the Someșul Mic basin and its tributary catchments.	Integration of climate risk considerations into new Zonal Urban Plans (PUZ). Enforcement of building restrictions in floodplains under Law no. 575/2001 4	National (Legislative frameworks), Regional/Local (River basin planning & municipal PUZ approvals).
Biodiversity & Green Infrastructure	Reducing fragmentation of metropolitan ecological corridors and enhancing on-site stormwater retention.	Promotion and integration of NBSs, including rain gardens, permeable surfaces, and green corridors, through spatial planning and green infrastructure policies. Green network mapping via the MECRA-Cluj project framework.	EU (policy framework and CLIMAAX methodology standard), Regional (Metropolitan strategic level), Private (Industrial developers).
Built Environment & Energy	Mitigating the Urban Heat Island (UHI) effect and reducing thermal stress in high-density residential fabrics.	Mandatory structural and thermal resilience standards adapted to a +3°C warming scenario. Deep energy retrofitting and district cooling actions under the Mission 100 Climate-Neutral Cities program.	EU (European Mission framework), National (Building codes updates), Local (Municipality & Homeowners' associations).
Cross-Cutting Governance	Boosting community-level climate resilience and addressing public risk communication gaps.	Green Participatory Budgeting allocated for community adaptation micro-projects. Deployment of citizen-led Public Participatory GIS (PPGIS) networks for localized microclimate monitoring.	Local (Municipality operational budget), Civil/Private (Local civic communities, NGOs).
Emergency Management & Civil Protection	Strengthen preparedness and emergency response for heatwaves and flood events.	Early warning systems, emergency response planning, public communication protocols, coordination between ISU, municipalities, and health authorities.	National (DSU/IGSU), County, Local authorities

Table 2-3 presents the multilevel governance framework that provides the strategic, regulatory, and institutional basis for Climate Risk Management (CRM) in the Cluj Metropolitan Area (CMA). Together, these governance instruments support the integration of climate adaptation objectives into spatial planning, investment planning, and decision-making across governance levels.

Table 2-3 Governance levels and strategic policy objectives for climate adaptation

Level of Governance	Main Policy Tool / Instrument	Core Policy Goals & Strategic Objectives	Role in the CMA
European	Horizon Europe (EU Mission on Adaptation) & LIFE	Fostering systemic regional transformation toward climate resilience by 2030. Funding the	Provides the overarching technical frameworks (CLIMAAX/P2R) and non-

	Programme	expansion of innovative nature-based solutions and risk assessment workflows.	reimbursable funding streams for trans-municipal resilience infrastructure.
National	National Strategy on Climate Change Adaptation (SNAC 2024-2030, 5) & National Adaptation Plan (PNAC, 6)	Aligning critical infrastructure with climate safety margins. Regulating urban heat island mitigation. Reducing economic casualties from extreme events. Standardizing national riverine and pluvial flood management legislation.	Establishes legally binding macro-objectives, national hazard reporting baselines, and vertical funding allocations via operational programmes.
Regional / Water Basin	Someș-Tisa River Basin Management Plan(1)(ABAST) & County Risk Assessments	Mitigating fluvial and flash flood risks in designated Areas with Potential Significant Flood Risk (APSFR). Protecting water quality and ecological volumes.	Regulates regional water bodies. Coordinates flood-defense infrastructure along the Someșul Mic River. Dictates safety protocols between municipal and rural LAUs.
Local / Metropolitan (Strategic & Investment)	Integrated Urban Development Strategy (SIDU 3) — Sub-chapter 3.8	Directing structural capital investments toward climate adaptation, slope stabilization, municipal drainage upgrades, riverine and pluvial flood prevention, and urban heat island mitigation solutions.	Serves as the primary financial vehicle for the metropolitan area. Legally links large-scale infrastructure budgets to explicit climate-proofing objectives.
Local / Cross-Cutting Governance	Climate City Contract (CCC 2) — Cluj-Napoca Mission 2030	Achieving climate neutrality via systemic decarbonization while embedding targeted adaptation co-benefits like thermal retrofitting and green network deployment.	Operates as an integrative framework that aligns sectoral plans (SIDU 3, PMUD) and coordinates public-private-civic adaptation commitments.
Local / Regulatory	PUG & RLU	Enforcing climate-resilient spatial development. Regulating urban density. Mandating minimum green space coefficients and on-plot stormwater retention thresholds.	Translates abstract strategic goals into enforceable zoning laws. Ensures that private real estate developments do not exacerbate pluvial flooding or UHI effects.

2.3 Key actors and systems for CRM

CRM in the CMA is implemented through a multi-level governance system that brings together public authorities, technical agencies, research institutions, public utilities, the private sector, and civil society. Effective climate adaptation depends on strong institutional coordination, the integration of scientific evidence into planning and decision-making, and the continuous engagement of stakeholders throughout the development and implementation of adaptation measures. This collaborative governance framework enables the translation of CRA into spatial planning, sectoral policies, investment priorities, and operational response mechanisms.

The administrative and planning pillar is led by the local administrative units and municipal authorities, which are responsible for implementing local adaptation policies, enforcing spatial planning regulations (RLU), and integrating climate resilience into local development initiatives. These activities are coordinated

at the metropolitan level by the CMA, which facilitates inter-municipal cooperation, supports integrated territorial planning, and promotes coordinated implementation of climate resilience actions across the metropolitan area.

The technical and operational pillar comprises the specialized institutions responsible for monitoring, forecasting, and emergency management. The Someș-Tisa River Basin Water Administration (ABA Someș-Tisa) leads river basin and flood risk management activities, Compania de Apă Someș SA supports stormwater and wastewater management, the National Meteorological Administration (ANM) provides meteorological monitoring and forecasting, while the Cluj Emergency Situations Inspectorate (ISU) coordinates emergency preparedness and response. Together, these organizations provide the operational capacity required for early warning, risk monitoring, and coordinated emergency management.

Scientific and technical support is provided primarily by UBB, the University of Agricultural Sciences and Veterinary Medicine (USAMV), and other research institutions through climate modelling, GIS-based spatial analyses, vulnerability assessments, urban climate analyses, and the evaluation of adaptation options. Their role is to provide the scientific evidence required to support CRA, prioritize adaptation measures, and inform evidence-based decision-making.

Civil society organizations, community groups, and private-sector stakeholders complement the institutional framework by facilitating public participation, citizen science initiatives, environmental awareness campaigns, and community-based adaptation actions. Organizations such as Sustainable Cluj contribute to stakeholder engagement and support the co-development of locally relevant adaptation solutions, thereby strengthening the social dimension of climate resilience.

Stakeholder engagement was maintained throughout all phases of the MECRA-Cluj project, from the initial definition of climate risks and the validation of hazard and risk assessments to the co-design of adaptation measures during dedicated stakeholder workshops held in April and June 2026. This participatory process strengthened both the technical robustness of the CRM framework and institutional ownership of the proposed adaptation measures, thereby supporting their long-term implementation across the CMA.

On 31 July 2026, the Cluj Metropolitan Area organised the final stakeholder event of the MECRA-Cluj project, bringing together approximately 30 representatives of local and regional public authorities, academia and research, emergency services, civil society, professional organisations, the private sector and the media. The event presented the main findings of the metropolitan multi-risk assessment, with a particular focus on heatwaves, urban heat islands and pluvial flooding, as well as the proposed climate adaptation measures and the related policy recommendations. The presentations were followed by an open discussion and networking session, allowing participants to reflect on the relevance of the results for their own institutions and for future metropolitan planning. Stakeholders congratulated the project team and expressed strong appreciation for the scientific quality, level of detail and practical value of the information presented. The event also served as a bridge towards the next stage of Cluj Metropolitan Area’s climate resilience work, as the findings of MECRA-Cluj will be further developed through the Pathways2Resilience project into a climate resilience strategy, action plan and investment plan.

Table 2-4 Key institutional actors, roles, motivations, and engagement modalities in CRM

Key actors	*Role and responsibility*	*Motivation and needs*	*Opportunities related to the their active involvement in CRM*	*Barriers related to the their active involvement in CRM*	*Type of engagement*
Ministry of Environment, Waters and Forests (MMAP)	Coordinating the adaptation process at the national level; drafting and reporting national environmental and forestry policies.	Meeting international targets (Paris Agreement); need for high-quality climate data for informed decision-making.	Inter-ministerial coordination (CISC) and access to major funding (NRRP, LIFE); managing the Ro-ADAPT platform.	History of poor inter-institutional cooperation; staff turnover and the need for internal technical expertise.	Decisional, regulatory, and strategic coordination.
ANAR / ABA / SGA Cluj	Water resource management, monitoring water quality and flood risk at the basin and county levels.	Ensuring the safety of critical infrastructure (dams, levees); need for precise hydrological data.	Implementing Nature-Based Solutions (NbS) and ecological restoration of rivers; creating digital data platforms.	Aging infrastructure; challenges in communicating with municipalities regarding rainwater management plans.	Operational, technical execution, and monitoring at the local level.
Municipalities	Implementing local adaptation actions; developing Climate Change Adaptation Plans (PAAC) and integrating water management into urban planning.	Protecting communities and assets; accessing funding for resilient urban infrastructure (SuDS).	Creating green belts (Green Ring) and blue-green infrastructure; attracting NRRP funds (Local Fund).	Limited financial resources in the absence of updated plans (PAAC); need for training for public officials.	Local decision-making, urban planning, and implementation.
Cluj Metropolitan Area Intercommunity Development Association (CMA)	Coordinates metropolitan climate adaptation, facilitates cooperation among municipalities, supports integrated territorial planning, and oversees implementation of metropolitan climate resilience initiatives.	Strengthening territorial cohesion and coordinated climate adaptation across the metropolitan area.	Facilitating inter-municipal cooperation, integrating adaptation into metropolitan planning, coordinating joint funding opportunities.	Different institutional priorities among member municipalities; varying administrative capacities.	Strategic coordination, facilitation, stakeholder engagement, and metropolitan governance.

IGSU / ISUCluj	Coordinating emergency prevention and management at the national and county levels.	Improving disaster response capacity; need for clear inter-institutional protocols.	Equipping with modern technology and conducting simulations; connecting to digital risk platforms (Ro-RISK, Ro-ADAPT).	Intensity and speed of extreme climate phenomena (flash floods, heavy rainfall) exceeding forecasts.	Operational, rapid response, and prevention.
National Meteorological Administration (ANM)	Monitoring extreme events; meteorological research and forecasting as a basis for informed decisions.	Efficient early warning for the population; need to update warning thresholds.	Modernizing the radar network and weather stations; leading scientific consortia for adaptation.	Climate trends that are more intense and rapid than historical estimates.	Scientific, monitoring, and early warning.
Academic / Research Environment (e.g., UBB, USAMV, UTCN)	Innovation for resilience; scientific grounding of adaptation measures and vulnerability assessment. Supporting evidence-based decision making.	Access to European projects (Horizon); technology transfer to administration and the private sector.	Partnerships in pilot projects and urban labs; training young specialists through updated curricula.	Need for consistent funding streams; barriers to the practical application of research.	Advisory, research-development, and innovation.
Private Sector and Investors (e.g., developers)	Balancing business interests with public interests; investing in clean and resilient industrial technologies.	Reducing risks in the supply chain; need for predictable urban planning regulations.	Public-private partnerships (PPP) and developing sustainable and green building materials.	High initial costs; major financial risks in the absence of adequate insurance products.	Investment and technological implementation.
Citizens and NGOs (e.g., Sustainable Cluj)	Supporting community resilience and increasing public participation, civic education, and active participation in local decision-making processes.	Need for precise information to increase personal resilience; protecting urban biodiversity.	Involvement in volunteer activities (planting) and civic monitoring; accessing educational school programs.	Need to translate complex scientific data into accessible language for non-specialists.	Participatory, volunteering, and civic monitoring.
Someș Water Company (Compania de Apă Someș SA)	Managing sewerage and treatment infrastructure; involvement in Rainwater Management Plans.	Avoiding technological failures caused by excessive rain; managing dilution capacity in the	Investments in system resizing and rainwater storage; policies for circular water economy.	Major technical difficulties in areas with combined sewerage (domestic and rainwater together).	Operational, public utility service provider.

		combined system.			
Ministry of Development, Public Works and Administration (MDLPA)	Authority for urban planning, construction, and urban mobility; coordinating community services.	Increasing energy performance of the built environment; need for administrative-territorial reform.	Updating design codes and technical norms for green and resilient construction.	Need to train staff for the technical acceptance of works according to new climate standards.	Regulation and territorial planning.
Financial Supervisory Authority (ASF)	Regulating the insurance market; developing products specific to climate risks (PAD).	Increasing the insurance rate for homes and farms; ensuring the financial stability of the market.	Public-private partnerships for reinsurance; integrating ESG factors into risk categories.	Low coverage rate of the housing stock (approx. 20%); need to apply legal sanctions.	Regulation and financial support in the insurance sector.

The stakeholder analysis demonstrates that effective CRM in the CMA depends on coordinated action across governance levels and sectors. While public authorities provide the institutional and regulatory framework, successful implementation also relies on technical expertise, scientific support, private-sector participation, and sustained stakeholder engagement throughout the adaptation process.

2.4 Lessons learned from past events

Past climate and hydrological events in the CMA have provided valuable evidence for strengthening CRM. The analysis of recent flood and heatwave events, together with stakeholder consultations conducted throughout the MECRA-Cluj project, identified critical infrastructure vulnerabilities, governance challenges, and communication gaps that have directly informed the prioritization of adaptation measures and the development of the metropolitan CRM framework.

Heatwave monitoring identified important vulnerabilities within public buildings. Monitoring campaigns carried out in schools showed that measures intended to reduce indoor overheating, such as limiting natural ventilation, may unintentionally result in poor indoor air quality due to elevated carbon dioxide concentrations. In addition, operational restrictions associated with recently renovated public buildings may limit the implementation of further adaptation measures during post-project monitoring periods. These findings demonstrate the importance of integrated building adaptation strategies that simultaneously address thermal comfort, indoor air quality, energy efficiency, and long-term operational flexibility.

Flood events demonstrated that urban flood risk is influenced not only by the intensity of precipitation but also by the interaction between ageing infrastructure, urban development, and land-use change. Recent torrential rainfall exposed the limited capacity of the combined sewerage system in Cluj-Napoca, resulting in sewer overflows and operational constraints at the wastewater treatment plant. Localized pluvial flooding was further exacerbated by drainage inlets blocked by sediments, debris, and construction materials originating from active development sites. In addition, the historical culverting of natural watercourses, including the Calvaria, Popii, and Țiganilor streams, has reduced natural infiltration and retention capacity, accelerated surface runoff, and increased flash flood susceptibility in downstream urban areas. These observations highlight the importance of integrated stormwater management, improved construction site management, sustainable urban drainage systems (SUDS), and the preservation or restoration of natural drainage corridors as key adaptation measures.

Lessons from recent flood events also highlighted the importance of strengthening emergency preparedness and risk communication. Rapidly developing convective storms often evolve within timeframes that challenge the effectiveness of existing warning dissemination procedures, reducing the operational value of emergency alerts during localized flash flood events. Stakeholder consultations further indicated that previous experiences with generalized warnings have affected public trust in official alert systems, reducing their effectiveness during high-impact events. These findings emphasize the need to complement early warning systems with localized, impact-based communication that provides clear, actionable guidance before and during extreme weather events.

Recent extreme summers demonstrated the importance of considering cascading climate risks within the CRM framework. Concurrent heatwaves and intense rainfall may simultaneously affect critical infrastructure, including electricity supply systems, water pumping stations, and other essential services. These experiences underline the need to strengthen the physical resilience of critical infrastructure while incorporating cascading and compound risk scenarios into emergency planning and adaptation strategies.

Stakeholder engagement demonstrated that effective CRM depends not only on technical solutions but also on effective communication and public participation. Consultations revealed that technical climate policy terminology is not always well understood by the general public, creating barriers to the acceptance

and implementation of adaptation measures. This highlights the importance of locally relevant communication strategies that combine accessible language, citizen science initiatives, digital tools, and visible urban interventions to improve risk awareness and strengthen community participation in climate adaptation.

Overall, these lessons demonstrate that effective CRM in the CMA requires an integrated approach ***combining*** *resilient infrastructure, adaptive governance, impact-based early warning systems, evidence-based spatial planning, and sustained stakeholder engagement*. The experience gained from past climate events, together with the participatory process implemented through the MECRA-Cluj project, provided the evidence base for prioritizing the adaptation measures and implementation pathways presented in the following chapters.

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3 Climate risk management – phase 3

3.1 CRM objectives

The CRM framework for the CMA translates the findings of the CRA into a set of strategic objectives that guide the implementation of adaptation measures across the metropolitan area. The objectives respond directly to the priority climate risks identified during the assessment process, with particular emphasis on heatwaves (very high priority) and riverine and pluvial flooding (high priority). Together, the primary and additional CRM objectives provide the strategic framework for reducing climate risk, strengthening adaptive capacity, and supporting resilient and sustainable development. The associated assessment indicators provide a basis for monitoring progress and evaluating the effectiveness of CRM implementation.

Table 3-1 Primary Climate Risk Management objectives and assessment indicators

Primary objectives	*Assessment indicators*
Reduce heatwave risk ("Cool City"): Reduce urban heat exposure and improve thermal comfort by implementing climate-responsive urban planning, green infrastructure, and heat-health adaptation measures.	• Reduction in heat-related mortality and morbidity during heatwave events. • Percentage of vulnerable population covered by heat-health early warning systems. • Number of people exposed to heatwaves (especially outdoor workers) • Number of cooling centres and emergency shelters available per 10,000 inhabitants. • Percentage of population living within a 5-minute walk of a cooling space or shaded public area. • Increase in urban tree canopy cover (%) • Increase in shaded public spaces and pedestrian corridors (ha or km). • Reduction in average land surface temperature in urban heat hotspots (°C). • Percentage of public buildings implementing passive cooling measures. • Number of heatwave days with operational Heat-Health Action Plan
Water-sensitive metropolitan area: Enhance the metropolitan area's capacity to retain, infiltrate, reuse, and sustainably manage stormwater, reducing flood risk while improving water availability and ecosystem services	• Reduction in flood-related injuries and health emergencies. • Percentage of vulnerable population covered by flood early warning systems. • Volume of water retained on-plot (m^3). • Volume of rainwater collected and reused annually (m^3). • Degree of periodic cleaning of networks in critical areas. • Increase in rain/stormwater retention capacity (m^3). • Reduction in surface runoff during intense rainfall events (%). • Percentage of urban area incorporating SuDS or NBSs. • Reduction in pluvial flood occurrence at identified hotspots. • Number of "sponge city" solutions implemented. • Area of permeable surfaces created or restored (ha).
Strengthen environmental and blue-	• Surface area of retention basins

green networks: Improve ecological connectivity and ecosystem resilience through the expansion, restoration, and integration of green and blue infrastructure.	• number of sponge-parks • Length of natural ventilation corridors • Increase in connected green and blue infrastructure area (ha) • Percentage of metropolitan population with access to high-quality green spaces within 300 m • Length of ecological corridors restored or created (km) • Increase in native vegetation cover (%) • Improvement in ecological connectivity index • Increase in floodplain and wetland restoration area (ha) • Improvement in urban biodiversity indicators (e.g., habitat quality or species richness).
Increase the resilience of water supply and sanitation systems: Ensure reliable, climate-resilient water supply and sanitation services capable of withstanding droughts, floods, and extreme weather events.	• Share of population (%) with access to safe drinking water • Number of new public water fountains in public spaces • Percentage of population with uninterrupted access to safe drinking water during climate-related events. • Reduction in water distribution losses (%) • Percentage of critical water and wastewater infrastructure protected against flooding. • Number of climate-related service interruptions per year. • Increase in emergency water storage capacity (m^3). • Percentage of wastewater treatment facilities with climate resilience measures implemented. • Time required to restore water services after extreme events.

Table 3-2 Additional Climate Risk Management objectives and assessment indicators

Additional objectives	*Assessment indicators*
Strengthen the resilience of the public health system and reduce climate-related health impacts associated with heatwaves and floods.	• Reduction in heat-related mortality and hospital admissions. • Percentage of healthcare facilities implementing climate resilience and emergency response plans. • Average emergency response time during climate-related events
Enhance the adaptive capacity of vulnerable communities by ensuring equitable access to essential services before, during, and after climate-related events.	• Percentage of vulnerable population with uninterrupted access to essential services during extreme events. • Percentage of public buildings functioning as climate-resilient shelters. • Number of households receiving targeted climate adaptation support. • Percentage of critical social infrastructure accessible during floods. • Reduction in displacement of residents caused by flooding. • Percentage of population receiving timely risk communication and preparedness information. • Percentage of urban area covered by parks within 300-500 m walking distance. • Proximity indicator: "distance to a hammock".
Improve urban environmental quality and ensure the continuity of sustainable mobility systems under increasing heat and flood risks.	• Increase in urban green and blue infrastructure area (ha or %). • Reduction in urban surface temperatures in identified heat hotspots (°C). • Reduction in impermeable surface/imperviousness area (%). • Percentage of transport infrastructure resilient to flooding. • Number of flood-prone transport disruptions per year. • Percentage of residents with access to shaded pedestrian and cycling routes. • Increase in stormwater retention capacity (m^3). • Kilometers of shaded pedestrian and bicycle paths. • Number of parking lots transformed into permeable surfaces with trees.
Strengthen climate-informed governance through integrated digital monitoring, early warning systems, and evidence-	• Percentage of municipal departments using climate risk data in planning decisions. • Number of climate adaptation measures monitored through digital platforms. • Operational integrated climate risk monitoring and early warning system

based decision-making.	• Percentage of climate-related datasets available through interoperable digital platforms. • Frequency of climate risk assessments and adaptation plan updates. • Number of stakeholders participating in climate governance processes. • Percentage of adaptation actions completed according to implementation schedule. • Integration of academic microclimatic and hydrological hazard models into spatial planning. • Early warning accuracy based on field-validated local thresholds.

3.2 Supportive elements for effective CRM

The effective implementation of the CRM framework in the CMA is supported by a combination of scientific knowledge, technical infrastructure, stakeholder participation, financial resources, and institutional governance. Together, these supportive elements strengthen the region's capacity to implement, monitor, and continuously improve adaptation measures while supporting evidence-based decision-making across governance levels.

Knowledge and data represent one of the key enabling elements for CRM. The metropolitan area benefits from strong collaboration between local authorities and academic institutions, particularly UBB, which provides scientific support through climate modelling, GIS-based spatial analyses, vulnerability assessments, and climate risk mapping. These activities are complemented by access to regional expertise in climatology, hydrology, and environmental sciences, providing the evidence base for risk-informed planning and adaptation.

Technical infrastructure further strengthens the implementation of CRM. The monitoring network operated by the ANM, together with the hydrological monitoring systems and flood protection infrastructure managed within the Someș River basin, provides the technical capacity required for climate monitoring, early warning, and flood risk management.

Social and behavioural support is provided through community awareness initiatives and environmental education programmes implemented by local organizations, including Sustainable Cluj and the Someșul Nostru initiatives. These activities contribute to improving climate risk awareness, promoting behavioural change, and increasing community resilience.

Citizen engagement is supported through participatory governance mechanisms, particularly the Participatory Budgeting programme and its "Green Stream" pillar, which enables residents to propose and implement neighbourhood-scale greening and climate adaptation projects. This participatory approach strengthens local ownership of adaptation measures and supports the co-development of locally relevant solutions.

Financial resources for CRM implementation are supported primarily through access to European funding programmes for climate adaptation and the green transition, complemented by opportunities for national funding and the development of public-private partnerships to support long-term implementation.

Governance arrangements provide the institutional framework for integrating climate adaptation into spatial planning and decision-making. Climate risk considerations are progressively being incorporated into metropolitan planning instruments, including Zonal Urban Plans (PUZ), while coordination among municipalities, sectoral institutions, and the Cluj Metropolitan Area Intercommunity Development Association (CMA) supports the implementation of adaptation measures across the metropolitan area.

Table 3-3 Identified supportive elements for effective CRM across the region

Supportive elements for effective CRM	*Description*
Knowledge and data	Institutional frameworks for joint university-municipality risk simulation and direct access to academic research experts.
Tech and infrastructure	The existence of NMA monitoring systems and hydrotechnical infrastructure on the Someș River
Social-behavioral	Community resilience workshops led by local environmental networks (such as “Sustainable Cluj” and the “Someșul Nostru” initiative)
Citizen engagement	Participatory Budgeting (Green Stream) for small neighborhood projects
Finances & resources	Access to EU funds and public-private partnerships are currently being explored.
Governance arrangements & political leadership	Multi-level governance coordinated through municipalities and the CMA, supporting the integration of climate risk considerations into metropolitan planning and urban development processes.

3.3 Potential CRM measures

Following the detailed analyses of territorial vulnerabilities conducted in Phase 2, jointly developed with stakeholders, we have outlined a comprehensive portfolio of potential measures designed to address the priority, current, and future climate risks identified in the CMA: extreme heat stress (heat waves) and major hydrological risks (rain-induced flooding and flash floods). To ensure systemic and long-term resilience, the proposed approach goes beyond traditional technical interventions and is balanced around five strategic pillars: structural, non-structural, nature-based, human/social, and governance measures.

Measures designed to combat extreme heat stress combine NBS, such as expanding the urban canopy, the creation of a "cool spine" along the Somes River axis, and the development of a network of green roofs and facades, with large-scale structural interventions, such as passive building design, the technological modernization of schools, and the redesign of public spaces through cooling nodes and reflective paving. On the non-structural and governance front, the strategy incorporates the use of university-led spatial analysis models for advanced risk simulation, high-resolution digital mapping of various indicators. Essentially, the human and social component is activated through measures to protect vulnerable groups, exemplified by the creation of cooling centers and the activation of the "neighborhood grandma" community network to reduce seniors' exposure.

Complementarily, the management of stormwater and pluvial flash floods is addressed through a robust mix of structural and technological infrastructure, ranging from integrated wastewater management systems (divider system) and mobile barriers to protect critical infrastructure, to decentralized water storage techniques at the plot level and the optimization of street gravel basins. NBS play a central role through the restoration of peri-urban wetlands, the rehabilitation of watercourses, and the creation of "sponge parks" capable of retaining excess water. Risk-based governance is implemented through the establishment of strict moratoriums on real estate developments on unstable slopes (e.g., Feleacu, Florești) and the integration of risk maps into planning, while the social and participatory dimension is supported through civic awareness campaigns, the use of non-digital public early-warning systems (LED panels/visual signs), and the distribution of resilience kits such as the "Rain Bucket" in low-income communities (household rainwater harvesting kits).

Table 3-4 Detailed climate risk management measures portfolio for Heat and Flooding risks

Key climate risk	*CRM measure*	*Effectiveness / Risk reduction (high, medium, low)*	*Contribution to CRM objectives*	*Possible co-benefits*	*Timeline (short, medium, long term)*	*Responsible organisation*	*Possible adaptation limits*
Heat	Water-sensitive design: fountains, misting, Someș river restoration	High	Water-sensitive zone: increases "sponge city" solutions; Water security: new public water fountains.	Urban recreation, aquatic biodiversity.	Short	City Hall, CMA, ABA	Extreme drought limiting available water.
Heat	Expansion of urban canopy (prioritizing pedestrian shading)	High	Cool City: Decreasing surface temperatures by up to 12 °C; Mobility: km of shaded paths.	Air quality, CO2 sequestration.	Medium	CMA, City Hall, USAMV	Slow growth rate of trees.
Heat	Spatial database of shade areas	Medium	Cool City: Monitoring vegetation index (NDVI) to prioritize investments.	Decisional transparency, open data.	Short	UBB, City Hall, IT	Accuracy of satellite data in urban canyons.
Heat	Connecting parks via the Someș axis.	High	Protecting the blue-green network: creating a "cool spine".	Active mobility, protection of river biodiversity.	Medium	City Hall, CMA, County Council	Property fragmentation on banks.
Heat	Network of "cooling islands" and pocket parks.	High	Social welfare: % urban area with parks within 300-500 m walking distance.	Social cohesion, mental health.	Medium	Urban Planning, City Hall	High cost of expropriation in dense areas.
Heat	Implementation of green roofs and facades.	Medium	Water-sensitive: Water volume retained on-plot; Cool City: Reducing albedo.	Energy efficiency, urban aesthetics.	Medium	Developers, City Hall	Maintenance and irrigation needs during drought.
Heat	Ventilation corridors: protecting	High	Environmental protection: Length of	Pollutant dispersion, passive thermal comfort.	Medium	Urban Planning	Real estate pressure for high-rise buildings.

	air paths		corridors protected by local regulations (e.g., Valea Chintăului).			(PUG/RLU)	
Heat	Street orientation and spacing (using shaded sides)	Medium	Environmental quality: Optimizing ventilation via H/W coefficient and CFD simulations.	Increased natural light, traffic safety.	Long	Developers, Urban Planning	Rigid historical structure of the city center.
Heat	Density management: strategic de-densification	Medium	Environmental quality: Increasing urban porosity by repurchasing degraded buildings.	Reduced crowding, new public spaces.	Long	City Hall, Local Council	Already granted building rights.
Heat	Cool roofs: reflective layers (albedo)	High	Cool City: Reducing thermal absorption (critical in Mărăști).	Lower energy costs for cooling.	Short	Homeowners Associations, City Hall	Durability of reflective materials.
Heat	Shaded parking and light-colored asphalt	Medium	Environmental quality/mobility: Reducing hotspots in commercial areas.	Potential for solar energy (panels on parking lots).	Medium	Retailers, Environmental Agency	Environmental norms regarding oil pollution.
Heat	Passive building design and thermal insulation	High	Cool City: Maintaining habitable environments without excessive consumption (retrofitting old blocks).	Reduction of energy poverty.	Long	Developers, City Hall	High initial implementation costs.
Heat	Transversal natural ventilation.	Medium	Public health: Indoor air quality via opposite windows and nocturnal flow.	Reduced humidity, increased comfort.	Medium	Architects, Developers	Urban noise which can limit night-time ventilation.
Heat	Incentive programme for green roofs and façades (incentives	Medium	Water-sensitive: Rainwater harvesting for autonomous irrigation.	Reduction of local tax, biodiversity.	Medium	City Hall, Owners	Structural weight on old buildings.

	and General Urban Plan).						
Heat	Technological modernization of buildings (schools).	High	Public health: Cooling the indoor environment in schools with ventilation.	Increased school performance, radon elimination.	Short	City Hall, Schools	Rigid "lock-in" clauses of EU funds.
Heat	Resilient public transport stations (shade/water).	Medium	Mobility: Shaded routes; Water security: Hydration points in stations.	Encouraging public transport (hub & spoke).	Short	CTP, City Hall	Vandalism of misting systems.
Heat	Shaded pedestrian/cycling networks: green corridors.	High	Mobility: Kilometers of new shaded routes through "back of the blocks".	Traffic safety (slow traffic 20km/h).	Medium	CMA, City Hall	Lack of space in dense residential areas.
Heat	Cooling nodes: shaded plazas with water.	High	Cool City: Reducing perceived temperature by up to 4 °C in transit hubs.	Urban revitalization, tourist attraction.	Short	City Hall, Architects	Maintenance costs of misting systems.
Heat	Integrating mobility with peri-urban areas.	Medium	Social welfare: Proximity indicator: "distance to a hammock" (refuge forests).	Leisure, support for forestry associations.	Medium	CMA, Forestry Associations	Limited public transport to the periphery.
Heat	Heat mapping / IT-University collaboration.	Medium	Governance and digitization: Implementing Digital Twin model for risk simulations.	Support for local tech startups (Citizen Science).	Short	UBB, IT Sector	Lack of data interoperability between institutions.
Heat	Action plan: early warning system.	Medium	Governance and digitization: Warning accuracy (reducing "false positives" and follow-up messages).	Increased public trust in authorities.	Short	ISU, ANM, City Hall	Centralized bureaucracy of RO-ALERT messages.
Heat	Cooling centers and	High	Public health:	Community cohesion.	Short	Social	Extreme social isolation of some

	protection of the vulnerable.		Decreasing number of hospitalizations; 20% reduction in exposed people (elderly).			Services, NGOs	target groups.
Heat	Governance, budgets, and policies (Task-Force)	Medium	Governance and digitization: Coordination through Urban Scientific Council and "Solutions Neighborhood".	Attracting European green funds.	Short	CMA, Scientific Council	Shortage of specialized technical staff in city halls.
Floods	Integrated stormwater management (large investments).	High	Water-sensitive: Increases number of "sponge city" solutions; Water security: Capture for local use.	Reduction of wastewater treatment costs (separate system).	Medium	City Hall, Developers, Someș SA	Extreme flows that exceed any storage capacity.
Floods	Reflective or permeable pavers / De-paving	Medium	Environmental quality: Number of parking lots transformed into permeable surfaces.	Water infiltration (Water-sensitive), aesthetics.	Medium	City Hall, Public Domain Admin	Heavy traffic resistance of permeable paving.
Floods	Regeneration of blue-green micro-corridors.	Medium	Protecting the blue-green network: Surface of sponge-parks created.	Civic engagement ("La Terenuri" model).	Medium	NGOs, City Hall	Historic pollution of some urban creeks.
Floods	On-plot storage (retention minimum 30–40 mm).	High	Water-sensitive: Water volume retained on-plot; Governance: Strict regulation via Local Urban Regulation.	Cooling micro-climate through evapotranspiration (Cool City).	Short	Urban Planning, City Hall, Developers	Resistance of private owners to additional costs.
Floods	Rainwater reuse systems (irrigation/toilet).	Medium	Water security: % population with access to water; Maintaining production: Water for the agricultural belt.	Lower utility bills for citizens.	Medium	Someș SA, Homeowners Associations	Rigid health regulations regarding grey water.

Floods	Micro-mechanisms at households ("Rain Bucket" kits).	Medium	Water-sensitive: Decentralized solutions; Social welfare: Engaging house communities.	Autonomy in watering gardens during drought periods.	Short	CMA, NGOs, Citizens	Limited storage capacity in very small yards.
Floods	Optimizing street micro-mechanisms (gravel chambers).	High	Water-sensitive: Degree of periodic cleaning (preventing blockage with debris/leaves).	Traffic safety by eliminating instant puddling.	Short	ADP, Someș SA, Constructio n sites	High frequency of storms exceeding cleaning pace.
Floods	Nature-based solutions (NBS) applied to watercourses.	High	Protecting the blue-green network: Surface of natural buffer zones created on Someș/tributaries.	Aquatic biodiversity, ventilation corridors.	Medium	ABA Someș-Tisa, City Hall	Cadastral fragmentation of river banks.
Floods	Controlled flood zones and sponge-parks.	High	Protecting the blue-green network: Surface of sponge-parks; Welfare: % urban area with parks within 500m.	High-quality recreation spaces, cooling (Cool City).	Medium	City Hall, USAMV, Botanical Garden	Risk of mosquitoes/infections in stagnant water areas.
Floods	Restoring peri-urban wetlands.	Medium	Protecting the blue-green network: Surface of protected peri-urban wetlands.	Natural water filtration (phytopurification), carbon storage.	Medium	CMA, Forestry Associations , UBB	Urbanization pressure invading low-lying areas.
Floods	Digital Twins.	High	Governance and digitization: Implementing Digital Twin for flood simulation.	Efficiency of public spending through "what-if" simulations.	Short	IT Sector, UBB, City Hall	Lack of precise historical data for small tributaries.
Floods	Risk-based urban planning (Scientific Council).	High	Governance: Length of protected corridors; Health: Dust/construction site control.	Scientific credibility of administrative decisions.	Short	Urban Scientific Council, City Hall	Bureaucratic barriers in modifying regulations.

Floods	Strict control of peri-urban developments (Feleacu/Florești).	High	Water-sensitive: Reducing soil erosion on slopes; Governance: Moratorium on unstable zones.	Preventing landslides and valley silting.	Short	County Council, LAU City Halls	Legal conflicts with developers who have approved Zonal Urban Plans (PUZ).
Floods	Integrating risk maps / Construction site control.	Medium	Governance: Monitoring accuracy; Water-sensitive: Preventing sewer blockage with sediment.	Decrease of environmental incidents on active construction sites.	Short	Construction Inspection, City Hall	Insufficient personnel for controlling all construction sites.
Floods	Awareness and engagement via experimental plots.	Medium	Social welfare: Engaging citizens in micro-experiments of slowing down water.	Civic education and environmental responsibility.	Short	NGOs (Sustainable Cluj), Schools	Erroneous public perception about risks.
Floods	Early warning systems (LED/signs).	High	Governance and digitization: Warning accuracy; Environmental quality: Traffic redirection.	Reduction of material damage to vehicles and goods.	Short	ISU, Local Police, ANM	Very short reaction time for flash floods.

The assessment of the proposed CRM measures demonstrates that their benefits extend well beyond reducing climate risk. Many interventions generate multiple environmental, social, and economic co-benefits while promoting equitable and inclusive climate adaptation. Rather than applying uniform solutions across the metropolitan area, the proposed measures are designed to respond to the different levels of exposure, vulnerability, and adaptive capacity identified during the CRA and stakeholder consultation process.

For **heatwave management**, particular attention has been given to densely populated neighbourhoods, characterized by high exposure and vulnerable building stock, such as **Mărăști** and **Mănăștur**. Passive building design, thermal renovation, and reflective roofing contribute to reducing urban heat exposure, particularly among low-income residents. The proposed network of cooling centres provides safe spaces for vulnerable population groups during extreme heat events while strengthening community cohesion and social resilience. Similarly, the development of cooling islands, pocket parks, and shaded public spaces improves thermal comfort, supports mental and physical well-being, enhances biodiversity, and contributes to the objective of ensuring equitable access to high-quality green infrastructure within walking distance of residential areas. The technological modernization of educational facilities further supports climate resilience by improving indoor thermal comfort, ventilation, and air quality, creating healthier learning environments and contributing to educational equity.

For **flood risk management**, the proposed measures provide multiple environmental, social, and economic co-benefits while strengthening resilience in neighbourhoods with higher exposure to pluvial flooding and flash floods, including **Baciu, Valea Chintăului, Mărginașilor, and Calea Turzii**. Rainwater harvesting systems and the proposed *Rain Bucket* programme improve local water availability while reducing household utility costs, thereby increasing the adaptive capacity of lower-income communities. Prioritizing sewer maintenance and deploying mobile flood barriers to protect older residential buildings and social housing reduces the potential for disproportionate economic losses among vulnerable population groups. NBS, including wetland restoration, river corridor rehabilitation, and sponge parks, simultaneously reduce flood risk, improve biodiversity, enhance urban environmental quality, and increase recreational opportunities.

The proposed early warning and risk communication measures also contribute to climate justice by improving equitable access to risk information. The installation of public LED information panels and other non-digital communication tools ensures that emergency warnings remain accessible to all residents, including individuals with limited access to smartphones or digital communication platforms. By reducing barriers to emergency information and preparedness, these measures strengthen community resilience and support a more inclusive emergency response system.

Overall, the proposed CRM portfolio demonstrates that effective climate adaptation can simultaneously reduce climate risk, improve public health, strengthen ecosystem services, enhance energy and water efficiency, reduce social inequalities, and increase the long-term resilience of communities. By explicitly considering equity and climate justice in the prioritization and implementation of adaptation measures, the CRM framework supports a fair distribution of adaptation benefits and contributes to resilient and sustainable development across the CMA.

3.4 Integration into planning and decision making

The integration of climate risk data into the CMA's strategic and regulatory framework has received an institutional boost through the region's recent selection as a pilot site under the Horizon Pathways2Resilience (P2R) program. This funding acts as the primary vehicle to scale up and formalize the findings of the CLIMAAX CRA. The P2R project will deliver four core instruments that translate the MECRA-Cluj

assessment into municipal reality: a Baseline Assessment (which directly integrates this CRA), a Climate Change Adaptation Strategy, a Climate Change Adaptation Action Plan, and a Climate Change Investment Plan.

Fully exercising its explicit mandate to conduct climate adaptation planning at the metropolitan level, CMA acts as the strategic steering authority and catalyst for the region. By utilizing its institutional framework, CMA systematically coordinates with, guides, and drives the specialized technical and executive departments of its constituent municipalities to ensure that metropolitan-scale climate intelligence is seamlessly embedded into local execution.

Policy Integration and Investment Decisions

Backed by its metropolitan planning mandate, CMA ensures that the results of the CRA serve as the structural foundation for local spatial plans, municipal regulations, and sector-specific investment pipelines across the entire territory.

Regarding the integration in the local policies, municipal strategies, sectoral plans, CMA will directly inject CRA data regarding localized runoff risks from surrounding slopes and secondary depression valleys (e.g., Borhanci, Chintăului) into the planning frameworks co-designed with the Urban Planning Departments of the CMA member town halls, driving the ongoing updates of their PUG and RLU) Under its planning mandate, CMA is spearheading the strategic inclusion of height restrictions and mandatory building setbacks on secondary valleys to safeguard vital natural ventilation corridors. Furthermore, CMA will support policy development to standardize local building regulations across member municipalities, establishing a framework that requires private real estate developers to retain a minimum of 30–40 mm of stormwater directly on-plot, thereby securing the climate resilience of the shared metropolitan space. The CRA's flash flood and pluvial hotspot mapping provide the authoritative baseline for CMA to advance and align the regional Stormwater Management Plan (PMAP). Through its mandate, CMA steers the metropolitan transition away from traditional piped networks toward resilient, nature-based drainage solutions, embedding requirements for localized retention basins in critical runoff zones, such as the Grigorescu Police School area.

With regard to the future investment decisions, the P2R Investment Plan will translate the CRA's risk hotspots into a prioritised pipeline of bankable public-private projects. CMA will direct and coordinate investment priorities for NBS among its member councils, accelerating the creation of "peri-urban sponge parks" to capture upstream runoff (e.g., at the USAMV land, the Botanical Garden, and Andrei Mureșanu street) and expanding the metropolitan "Blue-Green Network" (Inelul Verde). On the heatwave mitigation side, CMA provides the strategic blueprints enabling municipal departments to effectively prioritize funding for the passive cooling and automated ventilation retrofitting of public schools to eliminate thermal stress zones.

Synergies and Tensions in CRM

Implementing a coherent CRM framework across the CMA leverages strong regional advantages while navigating severe structural, financial, and regulatory friction points driven by cross-scale administrative frameworks. Implementation of the CRM system leverages the synergies of CMA’s robust "Triple Helix" ecosystem. There is strong technical alignment between CMA, academic institutions (UBB, Faculty of Geography), national monitoring directorates (ANM), utility operators (Someș SA), and active civil society groups (Sustainable Cluj). The P2R program acts as a unifying financial and administrative bridge, allowing these entities to collaborate under CMA’s planning leadership on shared deliverables rather than scattered sectoral goals.

Tensions and Coordination Challenges

Although comprehensive technical specifications for the PMAP have been proactively developed by regional experts, municipalities face an institutional bottleneck regarding formal adoption and accountability. This is rooted in a vertical regulatory gap: the official national methodological norms required to legally implement

and enforce urban stormwater management are currently stalled at a draft legislation stage at the national level. Without these finalized national enforcement norms, local town halls lack the explicit statutory mandate and clear legal mechanisms to allocate municipal budgets, formalize administrative liabilities, or enforce compliance. This creates an intense cross-scale tension where urgent local climate adaptation needs are paralyzed by national legislative delays.

The existing statutory operational procedures for climate emergency response are governed by highly centralized, cumbersome national protocols that are poorly suited for rapid-onset hazards. For example, the regulatory warning chain for flash atmospheric events requires real-time data from the local meteorological station to be routed to central headquarters in Bucharest for formal administrative approval before local Inspectorate for Emergency Situations (ISU) are permitted to issue a RO-ALERT. This structural hierarchy induces operational delays that clash with the volatile nature of localized convective storms, creating friction between the immediate operational needs of local emergency units and rigid, top-down national procedural frameworks.

While structural modifications to assets co-financed by European funds are legally permissible, the associated administrative process creates a significant operational bottleneck. Modifying public infrastructure (such as retrofitting public schools or civic buildings with advanced heat-recovery ventilation systems or smart microclimatic controls) during the mandatory 5-year post-implementation durability period requires navigating cumbersome, multi-layered notification and justification procedures with the respective Managing Authorities (AM) or Intermediate Bodies (OI). This heavy bureaucratic burden actively discourages local administrators from swiftly adjusting existing assets to emerging climate vulnerabilities. Implementing NBS and metropolitan networks (e.g., Inelul Verde) require complex cross-scale permitting due to split public ownership. Major watercourses and stream beds are legally managed by the National Administration Romanian Waters (via ABA-SGA Someș-Tisa), whereas the adjacent banks, public parks, and urban runoff outfalls fall under the jurisdiction of the respective local municipalities. Designing integrated solutions, such as stream un-culverting or peri-urban sponge parks, requires intensive multi-lateral negotiations, creating technical friction regarding long-term maintenance costs, de-silting liabilities, and co-management responsibilities.

As the region transitions away from the closing Recovery and Resilience Facility (PNRR) toward alternative European funding streams (such as the Regional Program NW 2021-2027, the Modernisation Fund, or direct LIFE/Horizon programs), a stark capability gap emerges within the metropolitan territory. While the core municipality of Cluj-Napoca possesses specialized departments to absorb post-PNRR funds and update complex technical documentations (SF/DALI), the surrounding peri-urban communes face severe human resource shortages and fiscal volatility. They struggle to secure the mandatory local co-financing or technical expertise required to co-implement cross-border climate adaptation infrastructure, leading to uneven risk reduction across the metropolitan space.

Actions to Improve CRM

To address these multi-level governance challenges, the CMA is using its metropolitan coordination role to support the implementation of CRM across the region. At the national level, CMA advocates for the adoption of the methodological framework required to operationalize urban stormwater management. At the metropolitan level, the forthcoming Pathways2Resilience (P2R) project sub-grant will provide centralized technical assistance to smaller peri-urban municipalities, strengthening their capacity to prepare projects and access Regional Programme and other European funding for blue-green infrastructure. In parallel, CMA is establishing a permanent Local Scientific Council to provide scientific and technical support for climate adaptation planning, facilitate evidence-based decision-making, and assist municipalities in preparing the technical documentation required during the implementation and durability periods of EU-funded projects. Coordination with the National Administration "Romanian Waters" (ABA-SGA Someș-Tisa) will also be

strengthened through joint working arrangements aimed at improving permitting procedures and facilitating the implementation of NBS across administrative boundaries.

Data Availability and Needs

The region currently benefits from a growing climate data infrastructure that combines high-resolution observations from the ANM, and national pluvial flood risk designations (APSFR), which identify vulnerable areas such as Canalul Morii, Popii, and Țiganilor streams. These datasets are complemented by remote sensing products, including Land Surface Temperature (LST), and other satellite-derived indicators that support continuous monitoring of urban climate conditions and environmental change. The region also benefits from strong collaboration with local universities, which contribute advanced spatial analyses, climate modelling, and field-based validation, while Citizen Science initiatives provide valuable complementary information on local climate impacts and community observations. Together, these data sources provide an increasingly robust evidence base for CRM, supporting risk assessment, planning, monitoring, and adaptive decision-making.

To build an authoritative climate model, the region still requires:

- Complete hydrological cadastre: multiple critical urban streams remain un-cadastred, blocking formal regulation and public flow-control investments.
- Digital twin technology: full integration of hydrological and spatial data into a functional "Digital Twin" of the metropolitan area is needed to run predictive simulations of 100-year convective storms against active construction backlogs.
- Localized empirical metrics: botanical and microclimatic research into the precise, measured evapotranspiration rates and shade capacities of urban tree species (e.g., Paulownia) is necessary to guide municipal landscaping rules away from aesthetic choices toward true thermal cooling capacity.

Monitoring and Evaluation (M&E) Framework

In alignment with the monitoring principles outlined in the SNASC 2024-2030, the CMA recognizes the framework guidelines applicable down to the local level. However, a fully operationalized, unified, and institutionalized local metropolitan platform that aggregates and tracks micro-level adaptation metrics across all constituent municipalities is currently missing from standard municipal routines.

Under the upcoming P2R Action Plan, CMA will bridge this operational gap by localizing the national framework into a dedicated M&E system. This system will track localized, tangible indicators derived directly from the specific vulnerabilities and expert solutions identified during the regional stakeholder consultations:

Table 3-5 Proposed Monitoring and Evaluation (M&E) indicators framework

Indicator Category	Specific Assessment Metrics (Examples)
Hazard & Impact Indicators	• Annual frequency and duration of localized pluvial street flooding events across the metropolitan communes. • Microclimate temperature differentials recorded within documented urban heat islands during red-code events.
Adaptation Progress Indicators	• Total square meters of urban soil converted into permeable surfaces or functional "sponge parks" under CMA's planning guidance. • Percentage of active private construction sites audited by municipal departments for compliance with sediment-control and the recommended 30–40 mm on-plot stormwater retention guidelines.

	• Number of public schools successfully upgraded with automated, outdoor-linked air quality (CO_2) and passive thermal controls to eliminate microclimatic building traps.
Governance & Coordination Indicators	• Data-sharing platform uptime and document transmission speeds regarding water asset specifications (such as the PMAP) between ABA-SGA, ISU, and metropolitan technical departments. • Public evaluation metrics regarding emergency communication, monitored via the implementation and accuracy tracking of localized "follow-up" alerts to counter the "cry wolf" effect.

4 Project Evaluation

4.1 Usability of the results

The MECRA-Cluj project provides a foundational paradigm shift for the CMA, moving the region from reactive emergency response to proactive, data-driven climate risk management. Prior to this project, climate data for the region was aggregated at a macro-scale, obscuring microclimatic variations. MECRA-Cluj has generated high-resolution spatial models detailing the precise boundaries of SUHI in hyper-dense neighborhoods such as Mărăști and Mănăștur. Furthermore, it has mapped pluvial run-off vulnerabilities down to secondary valleys and ungauged streams (e.g., Popii and Țiganilor streams). This offers local engineers and planners unprecedented empirical visibility into localized threat vectors.

The usability of these results is secured by the region's selection as a pilot site under the Horizon Pathways2Resilience (P2R) program. The MECRA-Cluj CRA will be directly integrated into the formal Baseline Assessment for the upcoming P2R cycle. It directly shapes the formulation of the metropolitan Climate Change Resilience Strategy and the subsequent Climate Change Investment Plan, ensuring that future public spending is legally and technically justified under European resilience mandates.

The risk maps and technical thresholds produced are being systematically integrated into the ongoing updates of the PUG and RLU across the CMA member town halls. More specifically, the project provides the technical justification for a mandatory new chapter on climate risk in all future Zonal Urban Plans (PUZ) for large urbanization projects, alongside enforcing the recommended structural requirement for private developers to retain a minimum of 30–40 mm of stormwater directly on-plot.

4.2 Lessons learned

Phase 3 demonstrated that technical solutions (such as NBS or automated early warnings) cannot function in an administrative vacuum. The project highlighted that multi-scale governance friction points (e.g., the national-level vacuum regarding finalized urban stormwater methodological norms) can stall local enforcement even when local technical designs are complete.

The most severe difficulties encountered during this planning phase were non-technical and institutional. First, stakeholder consultations highlighted that planning future structural adaptation measures for public infrastructure faces severe prospective bottlenecks; for instance, navigating the heavy bureaucratic burden required to justify retrofitting proposals (such as green roofs or cooling shading) on public buildings like schools during their mandatory 5-year post-implementation EU funding durability period represents a major preemptive constraint. Second, co-designing future adaptation pathways for split-jurisdiction assets (where

the watercourse bed is managed by the national body ABA-SGA Someș-Tisa, while the banks and municipal outfalls are managed by local town halls) exposed significant friction regarding future operational ownership and maintenance mandates, long before physical interventions can even be budgeted.

Stakeholders acted as co-designers of the adaptation pathways rather than passive audiences. During the April and June 2026 workshops, local municipal engineers, utility operators (Someș SA), and first responders (ISU) validated the feasibility of the recommendations proposed by the project team. Their feedback emphasized that while the technical specifications for the PMAP are robust, local councils face severe liability risks without a national statutory mandate. This feedback directly shapes the strategic baseline for the newly signed P2R program. Since the P2R project was formally signed in June 2026 and has not yet entered its second phase of action planning, this stakeholder input has been systematically documented as a mandatory strategic recommendation, ensuring that the design of centralized technical assistance mechanisms to protect smaller, capacity-constrained peri-urban communes is prioritized as a core objective the moment the P2R action planning phase commences.

Learning is institutionalized through the formal establishment of a permanent Local Scientific Council, bridging the gap between academia (UBB, USAMV) and metropolitan decision-makers. Rather than relying on static reports, this council will facilitate the cyclical re-application of the standardized CLIMAAX methodological workflows by injecting updated local hydro-meteorological and spatial datasets as they become available. This iterative approach ensures that regional climate risk profiles and RLU remain dynamic, dynamic-validated, and continuously responsive to changing environmental conditions.

The final outcomes were disseminated through a multi-channel framework designed to reach distinct target audiences:

- A final regional stakeholder conference bringing together policy-makers from all 19 constituent municipalities;
- The distribution of a targeted Policy Note for Local Authorities, detailing immediate regulatory updates required for PUGs/RLUs;
- Public outreach campaigns via regional media articles and the "Climate Caravan" platform to translate technical data into accessible citizen terminology.
- Press release in national media

The "Triple Helix" collaborative model worked exceptionally well during this assessment phase, fostering seamless data sharing between universities, local NGOs (Sustainable Cluj), and utility operators to consolidate the vulnerability database. Conversely, institutional mapping and stakeholder dialogues clearly highlighted the rigid nature of national emergency warning protocols, specifically the top-down data routing path from local ANM to Bucharest before an ISU RO-ALERT can be deployed. Since altering these national administrative frameworks falls entirely outside the scope of local competencies, this bottleneck was documented as a fixed external constraint; consequently, this structural limitation led stakeholder discussions to focus purely on the strategic necessity of planning localized, physical backup warning options within the future adaptation measure matrix.

The human, financial, and time resources were utilized with high efficiency by focusing exclusively on stakeholder validation, consensus-building, and policy integration. Resource optimization was inherently achieved by capitalizing on the project's final timeline concluding on July 31, 2026. Because the external launch of the P2R program occurred just prior in June 2026, this final phase was structured to ensure that MECRA's policy recommendations and validated risk insights could immediately serve as a ready-to-use strategic baseline for the newly initiated framework. By exploiting this timely structural convergence, the region maximized staff output and eliminated the need for separate, duplicative consultation costs for the upcoming metropolitan planning cycle.

The long-term value of this CRM framework is substantial. It has successfully elevated institutional capacity by providing local public officials with standardized risk auditing methodologies. Culturally, it has connected technical risk parameters directly to bankable investment portfolios under the established CCC (2) framework, effectively positioning the Cluj Metropolitan Area to capture post-PNRR European financing (Regional Program NW 2021-2027, Modernisation Fund, LIFE) with highly mature, risk-justified projects.

5 Conclusions Phase 3

Phase 3 of the MECRA-Cluj project marks the successful transition of the CMA from climate risk characterization to systemic risk governance. By aligning the high-resolution hazard and vulnerability maps developed in Phase 2 with operational realities, this phase has successfully formulated a targeted matrix of policy recommendations and urban regulations for metropolitan resilience.

Key Findings

The interaction between dense, unshaded urban topographies (e.g., Mărăști and Mănăștur) and intensifying heat waves requires hyper-local, targeted structural and nature-based interventions rather than generic city-wide policies.

High-resolution hazard modeling along the Someșul Mic river basin and its critical tributaries confirmed that climate-induced peak discharge events pose an immediate risk to rapidly expanding peri-urban residential and economic sectors. Stakeholder consensus validated that traditional, purely structural engineering solutions are insufficient; consequently, these findings were directly integrated into the Urban Policy Note to enforce strict, binding construction restrictions and non-structural buffer zones within the high-resolution modeled floodplains.

Traditional riverine hydrotechnical works on the Someșul Mic are robust, but the primary threat stems from high-velocity un-cadastred secondary streams and flash urban runoff from surrounding slopes (e.g., Feleacu, Florești). This hazard is severely exacerbated by loose sediments from active construction sites and solid waste clogging undersized combined sewerage networks.

Vulnerable groups, particularly the elderly and low-income citizens residing in low-lying flash-flood zones (e.g., Mărginașilor, Calea Turzii) or poorly ventilated housing blocks, experience compounding climate risks. To address this, the project's validated adaptation matrix explicitly incorporates structural co-benefits, directly linking climate resilience to the reduction of energy poverty and addressing the digital divide through the strategic inclusion of physical, non-digital public early-warning systems."

Challenges Addressed

The project successfully established a unified set of localized performance indicators across three distinct categories (Hazard & Impact, Adaptation Progress, Governance & Coordination) to track regional resilience.

It delivered actionable recommendations for local urban planning frameworks, providing authorities with structural guidelines, sustainable land-use principles, and on-plot stormwater retention concepts designed to be integrated into upcoming updates of Local Urban Regulations (RLU). Rather than generic policy statements, these findings offer clear spatial directions for embedding climate resilience directly into local development rules.

It achieved broad institutional consensus across a complex "Triple Helix" ecosystem, securing clear risk ownership between municipalities, utility operators (Someș SA), and basin authorities (ABA-SGA).

Challenges Not Addressed (Remaining Operational Gaps)

The lack of finalized national methodological norms for urban stormwater management remains an active external constraint. While CMA has resolved the technical specifications locally, the formal legal mandate enabling town halls to allocate municipal budgets for enforcement remains dependent on national legislative bodies.

The structural operational delays built into the national RO-ALERT system—requiring vertical data validation through central headquarters in Bucharest—could not be altered within the scope of this regional project. This leaves the metropolitan area vulnerable to rapid-onset convective storms, an operational gap that must be bypassed through localized physical emergency signage.

While the core municipality of Cluj-Napoca possesses the specialized staff and fiscal capacity to swiftly absorb alternative post-PNRR EU funding streams, smaller peri-urban communes face severe human resource constraints, leaving them exposed to uneven implementation speeds.

6 Progress evaluation

6.1 Project outputs

To achieve the KPIs and Milestones detailed in the tables below, the CMA executed a series of structured, interconnected actions aligned with the Individual Following Plan.
CMA convened a multi-disciplinary network of over 30 core institutional stakeholders through a sequence of stakeholders meetings held in January, April, and June 2026. These actions facilitated direct data validation, infrastructure pressure-point mapping, and the collaborative co-design of the CRM measure matrix. Dedicated representation was secured from ANM, UBB, ISU, ABA Someș-Tisa, municipal engineering departments, and local civil society groups (Sustainable Cluj).
To translate scientific results into administrative reality, the project team compiled a comprehensive Policy Note for Local Authorities. This note was formally transmitted to the executive and urban planning departments of the member Local Administrative Units (LAUs) to guide their regulatory PUG/RLU updates.
Public dissemination was achieved via bi-annual strategic progress updates posted across CMA's verified social media channels, alongside a dedicated article published in regional media outlets to contextualize the climate assessment for the general public. The phase culminated in a final communication action—a regional results conference—where the integrated findings and upcoming P2R implementation alignment were formally presented to regional policy-makers and mayors.

Table 6-1 Overview key performance indicators

Key performance indicators	*Progress*
Continuous communication through updates each six months CMA social media accounts	Post have been published in march and july 2026 on the facebook and likedin page of CMA
30 stakeholders involved in the activities of the project.	During the stakeholder consultations and the final event 30 stakeholders have been involved in the activities of the project
1 communication action (final conference) taken to share results with the stakeholders.	The fainal event of the project took place in 31st of july 2026
1 policy note for the local authorities.	One policy paper have been addressed to the mayors of the CMA
1 article in regional media mentioning the project.	One article have been published in the regional media mentioning the project

Table 6-2 Overview milestones

Milestones	*Progress*
Presentation of the results to policy and decision makers in our region.	The results have been presented to the policy and decision makers in our region during the final conference
Attend the CLIMAAX workshop held in Brussels	Pending for 19th of January 2027

7 Supporting documentation

As part of Phase 3 of the MECRA-Cluj project, dedicated to climate risk management (CRM), a set of deliverables was produced focused on translating the technical results from previous phases into public policy measures and strategic communication actions. These documents provide a basis for investment decisions and ensure the integration of climate change adaptation into the territorial and urban planning of the Cluj Metropolitan Area . All materials are ready for dissemination and are shared via the Climax Deliverable Platform and Geonode repository to ensure transparency and traceability.

The Main Report

The main report consists of Deliverable Phase 3 – Climate Risk Management (MECRA-Cluj). This document comprehensively documents the following key elements:

- Establishment of strategic CRM objectives for priority risks (heat waves and floods).
- The portfolio of 39 adaptation measures (structural, nature-based, and governance-based) co-created with decision-makers.
- The monitoring and evaluation (M&E) framework and performance indicators for tracking progress toward regional resilience.
- The roadmap for integrating the results into planning instruments (PUG/RLU) and into the future investment plan through the Pathways2Resilience (P2R) program.

Communication Outputs

The results of Phase 3 were communicated to stakeholders and the general public to ensure institutional ownership and raise awareness, including:

- Public Policy Note for Local Authorities: A technical document addressed to mayors and urban planning departments in the 19 administrative-territorial units of the ZMC, detailing the regulatory updates needed to integrate climate resilience(Annex).
- Regional Results Conference: A closing event held on July 31, 2026, where the final conclusions and strategic alignment with the P2R program were presented to metropolitan-level policymakers.

Regional media articles and press releases: Informational materials published in local and national media to translate technical data into messages accessible to citizens and to present public policy recommendations.

Strategic updates on social media channels: A series of posts published on CMA's official accounts (Facebook) to ensure continuous communication of the project's progress to the community.

All datasets and supporting materials are stored in the Geonode repository in accordance with best practices established in previous phases of the project.

Prints of the online documents are part of the communication outputs file. The links of the social media and press releases are as follows:

https://www.infoclima.ro/articole/cluj-intre-valuri-de-caldura-si-inundatii-ce-arata-prima-harta-detaliata-a-riscurilor-climatice-din-zona-metropolitana

https://www.facebook.com/share/p/1JyCAjbjLW/?mibextid=wwXIfr

https://www.g4media.ro/evaluare-riscuri-climatice-cluj-napoca-valuri-caldura-canalizare-ploi-torentiale.html

https://www.facebook.com/share/p/195bqJq8rV/?mibextid=wwXIfr

https://cluj24.ro/proiectii-climatice-cartierul-marasti-fierbe-iar-canalizarea-orasului-trebuie-imbunatatita-prin-solutii-bazate-pe-natura-299635.html

https://www.facebook.com/share/p/1cPXy2dBwU/

https://www.transilvaniabusiness.ro/2026/07/31/proiectii-climatice-cartierul-marasti-fierbe-iar-canalizarea-orasului-trebuie-imbunatatita-prin-solutii-bazate-pe-natura/?fbclid=IwdGRzaATZKkxleHRuA2FlbQIxMQBzcnRjBmFwcF9pZAwzNTA2ODU1MzE3MjgAAR6BJvHTPlRZuRstbRIM5th5Q3ozXvokqm8YEJDYwmBtCk_R2APa26HbhxdmxQ_aem_hHg4WCfw7tgESlrsKUPJQg&sfnsn=wa

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6. Ministry of Environment, Waters and Forests (MMAP) (2025). *National Climate Change Adaptation Plan (PNAC)*. Ministry of Environment, Bucharest. Available at: https://mmediu.ro/domenii/mediu/schimbari-climatice/adaptarea-la-schimbarile-climatice/cadrul-national/

Annex

Policy Note

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POLICY BRIEF METROPOLITAN

Reducerea riscurilor climatice în Zona Metropolitană Cluj

Integrarea riscului de inundații și a valurilor de căldură în planificarea teritorială, investițiile publice și protecția populației

Adresat Primăriilor și Consiliilor Locale din localitățile cu urbanizare accelerată și densă (ex. Cluj-Napoca, Florești, Apahida, Baciu).

Rezultatele cercetării MECRA-Cluj confirmă că valurile de căldură și inundațiile cauzate de ploile torențiale sunt cele două riscuri climatice care necesită acțiune prioritară la nivel metropolitan. Valurile de căldură au o evoluție accelerată și afectează atât zonele urbane dense, cât și unele localități periurbane și rurale. În cazul inundațiilor, riscul cauzat de inundațiile fluviale rămâne relevant în lunci, în timp ce inundațiile pluviale și viiturile rapide sunt amplificate în zonele construite de impermeabilizarea solului, capacitatea limitată a drenajului și reducerea retenției naturale.

1. Inundațiile: mecanisme diferite, răspuns comun

Evaluările realizate în cadrul proiectului MECRA-Cluj evidențiază faptul că inundațiile reprezintă unul dintre principalele riscuri climatice pentru Zona Metropolitană Cluj, caracterizat printr-un nivel ridicat de severitate și urgență.

Deși riscul inundațiilor produse prin revărsarea cursurilor de apă din nucleul urban este parțial redus prin amenajările hidrotehnice existente, inundațiile pluviale și viiturile rapide (flash floods) au devenit o amenințare majoră în zonele dens urbanizate.

Fenomenul este amplificat de urbanizarea accelerată, extinderea suprafețelor impermeabile și intensificarea precipitațiilor extreme asociate schimbărilor climatice. Evenimentele din ultimii ani au demonstrat că ploile torențiale produc blocaje majore ale traficului, inundarea infrastructurii urbane și perturbarea serviciilor publice în mai multe zone ale municipiului și comunelor din zona metropolitană.

Scenariile de risc indică faptul că între 40.000 și 60.000 de locuitori ai Zonei Metropolitane Cluj sunt expuși direct inundațiilor, iar pagubele economice estimate pentru un eveniment cu perioada de revenire de 10 ani se ridică la aproximativ 481 milioane euro, putând depăși 700 milioane euro în scenariile extreme.

Rețeaua actuală de canalizare, proiectată pentru condiții climatice și grade de urbanizare diferite de cele actuale, nu mai poate prelua eficient volumele generate de precipitațiile extreme. Adaptarea la schimbările climatice impune schimbarea paradigmei de management al apelor pluviale, prin trecerea de la evacuarea rapidă a apei către retenția, infiltrarea și utilizarea acesteia la sursă. În acest context, integrarea soluțiilor bazate pe natură (Nature-based Solutions – NBS) în investițiile

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publice și în documentațiile de urbanism reprezintă una dintre cele mai eficiente măsuri pentru reducerea riscului de inundații pluviale și creșterea rezilienței Zonei Metropolitane Cluj.

2. Valurile de căldură: risc sistemic și în creștere

Evaluarea riscurilor climatice realizată în cadrul proiectului MECRA-Cluj, utilizând metodologia europeană CLIMAAX, identifică valurile de căldură drept riscul climatic cu cea mai mare prioritate pentru Zona Metropolitană Cluj.

Analizele observaționale de înaltă rezoluție arată că frecvența, intensitatea și durata valurilor de căldură din regiune cresc mult mai rapid decât indicau modelele climatice teoretice anterioare.

Densificarea urbană și acoperirea artificială a solului au creat microclimate severe, identificate ca „hotspoturi ale insulei de căldură urbană la suprafață" (*SUHI hotspots*), localizate în special în Cluj-Napoca și Florești.

Acest stres termic are un impact critic asupra sănătății publice, categoriile cele mai afectate fiind populația de peste 65 de ani și comunitățile defavorizate economic din cartierele aglomerate.

Obiectivul politicii publice

Reducerea expunerii populației, infrastructurilor și activităților economice la valurile de căldură și inundații, prin integrarea riscului climatic în dezvoltarea teritorială și printr-un program metropolitan coordonat de prevenție, adaptare și monitorizare.

Principii de aplicare

• Prevenție înaintea intervenției de urgență: investițiile și reglementările trebuie să reducă riscul înainte de producerea evenimentului.

• Diferențiere teritorială: măsurile se adaptează caracteristicilor urbane, periurbane și rurale, fără soluții uniforme pentru toate UAT-urile.

• Combinarea infrastructurii tehnice cu soluții bazate pe natură și măsuri sociale.

• Evitarea transferului de risc: măsurile adoptate într-o zonă nu trebuie să agraveze riscurile sau costurile în alte zone ori pentru alte categorii de populație.

• Protejarea populației vulnerabile și participarea directă a comunităților afectate.

Recomandări de politică publică și direcții de acțiune

Măsurile propuse trebuie abordate integrat, astfel încât gestionarea apelor pluviale, reducerea expunerii la căldură și orientarea dezvoltării teritoriale să se susțină reciproc. În locul unor intervenții izolate, se recomandă structurarea acțiunilor în trei direcții complementare.

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1. Integrarea riscurilor climatice în planificarea urbană și teritorială

Introducerea principiilor de tip „Oraș Burete" în documentațiile de urbanism. Se recomandă includerea în PUG-uri, PUZ-uri și regulamentele locale de urbanism a unor cerințe privind menținerea suprafețelor permeabile, limitarea impermeabilizării excesive și gestionarea apelor pluviale cât mai aproape de locul în care acestea cad. Pentru noile dezvoltări, soluțiile pot include retenția temporară în parcelă, pavaje permeabile, grădini de ploaie și alte sisteme de infiltrare.

Utilizarea hărților de risc în fundamentarea deciziilor de dezvoltare. Hărțile și bazele de date realizate prin MECRA-Cluj trebuie utilizate în procesul de actualizare a PUG-urilor și de elaborare a PUZ-urilor, împreună cu datele și documentațiile oficiale ale instituțiilor competente. Aceste informații pot sprijini orientarea dezvoltării către zone cu vulnerabilitate redusă și pot fundamenta condiții suplimentare pentru investițiile propuse în zone expuse.

Evitarea extinderii dezvoltării în zonele cu risc ridicat. Se recomandă limitarea sau condiționarea noilor dezvoltări în zonele cu risc ridicat de inundații și în zonele în care urbanizarea ar conduce la pierderea capacității naturale de retenție. În astfel de situații, autorizarea trebuie să fie precedată de analize detaliate și de măsuri clare de reducere a riscului.

Introducerea unor cerințe privind adaptarea clădirilor și spațiilor construite la temperaturi ridicate. Autoritățile locale pot analiza introducerea graduală a unor prevederi privind utilizarea materialelor cu albedo ridicat, acoperișurile verzi sau reflectante, umbrirea fațadelor și reducerea acumulării de căldură. Eventualele stimulente fiscale sau condiționări urbanistice trebuie fundamentate juridic și bugetar înainte de adoptare.

2. Dezvoltarea infrastructurii albastre-verzi pentru gestionarea apei și reducerea căldurii

Completarea infrastructurii convenționale cu soluții bazate pe natură. Rețelele și lucrările de drenaj existente trebuie completate, acolo unde condițiile locale permit, cu grădini de ploaie, rigole vegetate, bazine de retenție temporară, zone umede, suprafețe permeabile și acoperișuri verzi. Aceste intervenții pot reduce volumul și viteza scurgerii apei și, în același timp, pot contribui la reducerea temperaturilor locale.

Dezvoltarea Centurii Verzi-Albastre Metropolitane. Se recomandă coordonarea intervențiilor de-a lungul Someșului Mic și al principalilor afluenți, astfel încât luncile, coridoarele ecologice și zonele naturale de retenție să fie protejate și conectate. Aceste spații pot îndeplini simultan roluri de reducere a riscului de inundații, îmbunătățire a biodiversității, ventilare a zonelor construite și creare a unor trasee verzi la nivel metropolitan.

Program multianual de extindere a aliniamentelor de arbori stradali și a suprafețelor umbrite. În locul unor campanii punctuale de plantare, se recomandă elaborarea unor programe multianuale, bazate pe identificarea zonelor cu temperaturi ridicate și acces redus la vegetație. Intervențiile

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trebuie prioritizate pe arterele pietonale, în stațiile de transport public, în apropierea școlilor, unităților medicale și centrelor sociale, precum și în spațiile publice intens utilizate.

Protejarea și refacerea capacității naturale de retenție. Luncile, spațiile verzi, terenurile cu rol de absorbție și coridoarele naturale trebuie tratate ca infrastructură de adaptare climatică. Menținerea lor poate reduce presiunea asupra sistemelor de canalizare și poate limita efectele cumulate ale urbanizării.

3. Măsuri operaționale pentru protejarea populației și prioritizarea investițiilor

Amenajarea unei rețele de spații de răcorire. Se recomandă identificarea clădirilor publice care pot funcționa temporar ca spații de răcorire în perioadele de caniculă. Acestea pot fi dotate cu apă potabilă, zone de odihnă, informații pentru populație și, unde este posibil, puncte de prim ajutor. Amplasarea lor trebuie stabilită în funcție de hotspoturile termice și de prezența grupurilor vulnerabile.

Prioritizarea investițiilor în zonele cu risc ridicat. Bugetele locale și proiectele de investiții trebuie corelate cu zonele identificate ca fiind cele mai expuse la inundații și căldură. Prioritatea trebuie acordată intervențiilor care reduc riscul pentru populație, infrastructura critică și serviciile publice și care produc beneficii în mai multe domenii.

Elaborarea unui cadru metropolitan pentru managementul apelor pluviale. În lipsa unui plan deja adoptat, se recomandă inițierea unui proces comun între ADI Zona Metropolitană Cluj, UAT-uri, ABA Someș-Tisa și operatorii de utilități pentru definirea unui cadru metropolitan privind apele pluviale. Acesta ar trebui să includă zonele critice, responsabilitățile instituționale, standardele orientative și portofoliul de investiții prioritare.

Coordonarea la nivel metropolitan și monitorizarea progresului. ADI Zona Metropolitană Cluj poate facilita utilizarea unei baze comune de date, schimbul de informații între localități, elaborarea unor prevederi-model și pregătirea proiectelor intercomunale. Monitorizarea ar trebui să urmărească, între altele, suprafața permeabilizată, capacitatea de retenție creată, suprafețele umbrite, numărul spațiilor de răcorire și integrarea riscurilor climatice în documentațiile de urbanism.

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