CLIMAAX
climate ready regions

# Deliverable Phase 3 – Climate risk management

## CARE_X (CLimaax Action and Risk Evaluation of Xanthi)

## Greece, Municipality of Xanthi, Region of Eastern Macedonia and Thrace

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HORIZON-MISS-2021-CLIMA-02-01 - Development of climate change risk assessments in European regions and communities based on a transparent and harmonised Climate Risk Assessment approach

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# Abbreviations and acronyms

| Abbreviation/ acronym | Description |
|---|---|
| CARE_X | CLimaax Action and Risk Evaluation of Xanthi |
| CLIMAAX | CLimate risk and vulnerability assessment framework for European regions and communities |
| CRA | Climate Risk Assessment |
| CRM | Climate Risk Management |
| DEM | Digital Elevation Model |
| DEYAX | Municipal Water Supply and Sewerage Company of Xanthi |
| DUTh | Democritus University of Thrace |
| ERDF | European Regional Development Fund |
| FEX | Progressive Union of Xanthi (Filoproodeftiki Enosi Xanthis) |
| FWI | Fire Weather Index |
| GPS | General Urban Plan (Geniko Poleodomiko Schedio) |
| IFP | Individual Follow-up Plan |
| JRC | Joint Research Centre |
| KEDIAK | Centre of Interdisciplinary Assessment of Risk (Kentro Diepistimonikis Axiologisis Kindynon) |
| KPI | Key Performance Indicator |
| KRA | Key Risk Assessment |
| PAMTh | Region of Eastern Macedonia and Thrace (Perifereia Anatolikis Makedonias kai Thrakis) |

| | |
|---|---|
| RiskAC | Risk Assessment and Resilience Centre |
| SSP | Shared Socioeconomic Pathway |
| SuDS | Sustainable Urban Drainage Systems |
| T.E.S.O.P.P. | Local Operational Coordination Body for Civil Protection |
| UHI | Urban Heat Island |
| WUI | Wildland-Urban Interface |

# Executive summary

This deliverable constitutes the third and final output of the CARE_X project, implemented under the European CLIMAAX programme (Horizon Europe) through a partnership between the Municipality of Xanthi and the Risk Assessment and Resilience Centre (RiskAC/KEDIAK) of the Democritus University of Thrace. It translates the multi-hazard climate risk evidence base developed in Phases 1 and 2 into an actionable climate risk management (CRM) plan for the municipality of Xanthi, supported by comprehensive stakeholder engagement and aligned with existing municipal planning tools.

The Phase 2 Key Risk Assessment established that heatwaves represent the most critical climate risk for Xanthi (Very High priority), followed by fluvial flooding and wildfires (High priority) and windstorms (Medium priority). Building on these findings, this deliverable identifies 14 CRM measures spanning cross-cutting institutional actions, hazard-specific risk reduction interventions, and community engagement mechanisms. Among the highest-priority measures are the development of a Municipal Heat Action Plan, the establishment of a Climate Change Observatory for sustained monitoring, and the formal integration of CARE_X risk outputs into municipal planning tools and emergency plans (IOLAOS 2, DARDANOS 2).

Stakeholder engagement across the project lifecycle has included an initial stakeholder workshop with municipal leadership (December 2024), a structured three-day training activity with more than 10 officials from the fire department, civil protection, forest management, and the regional administration (October 2025), engagement with the cultural heritage sector through the Progressive Union of Xanthi (FEX), and a public-facing Xanthi Resilience Festival (8–10 May 2026). A multi-hazard preparedness exercise was conducted on 30 April 2026 at the Fire Service facilities in the Industrial Area of Xanthi, in coordination with the municipal Civil Protection Office.

The CARE_X project demonstrates the value of the CLIMAAX framework for enabling evidence-based, locally relevant climate risk management in a Greek municipality. All 10 Key Performance Indicators have been achieved, and the project positions the Municipality of Xanthi as a pioneer in harmonized European climate resilience planning.

# 1 Introduction

## 1.1 Main objectives of the project

Phase 3 of the CARE_X project (Months 18–22) aims to translate the comprehensive climate risk evidence produced during Phases 1 and 2 into implementable climate risk management (CRM) strategies for the Municipality of Xanthi. The specific objectives of this phase are: (a) to identify and prioritize CRM measures for the four assessed climate hazards of heatwaves, fluvial flooding, wildfires, and windstorms, informed by the Key Risk Assessment outcomes, (b) to define implementation pathways specifying responsible actors, time horizons, and financing opportunities, (c) to integrate CRM outputs into the municipality's existing risk governance framework and planning instruments, (d) to broaden stakeholder engagement beyond institutional actors through a public-facing Resilience Festival and a multi-hazard preparedness exercise, and (e) to consolidate the monitoring and evaluation framework that ensures sustained adaptation effectiveness.

Compared to the previous phases, the work conducted exclusively in Phase 3 comprises the identification and prioritization of the 14 CRM measures presented in Chapter 3, the definition of integration pathways into municipal planning instruments, the organization and delivery of the Xanthi Resilience Festival as the public-facing engagement event, the development of a real-time participatory workshop application and its deployment in a structured CRM workshop with institutional stakeholders on 29 April 2026, the design and execution of the multi-hazard preparedness exercise on 30 April 2026, and the consolidation of the monitoring and evaluation framework. Phases 1 and 2 delivered the risk assessment evidence base upon which these activities build.

## 1.2 Project team

The CARE_X project is led by the Municipality of Xanthi, represented by Mayor Efstratios Kontos, Deputy Mayor for Civil Protection Ioannis Tsapalis, and staff of the Civil Protection Office and Technical Services. The Risk Assessment and Resilience Centre (RiskAC/KEDIAK) of the Democritus University of Thrace, under the coordination of Prof. Ioannis Dokas (scientific lead), is the scientific partner that provides support to the Municipality of Xanthi. The core academic team includes Prof. Anastasia Paschalidou and Prof. Nikos Klimis, supported by Asst. Prof. Emmanouil Rovithis, Dr. Korina Psistaki, Dr. Stavros Stathopoulos, and Dr. Apostolos Vasileiou. The cultural heritage dimension involves the Progressive Union of Xanthi (FEX), a 73-year-old non-profit cultural organization.

## 1.3 Outline of the document's structure

This document follows the CLIMAAX Phase 3 deliverable template. Chapter 2 presents the local profile, summarizing the Key Risk Assessment results, the policy context for CRM, the key actors and systems involved, and lessons learned from past events. Chapter 3 constitutes the core CRM analysis, defining objectives, supportive elements, potential measures, and integration pathways into planning and decision-making. Chapter 4 evaluates the project's usability and lessons learned. Chapter 5 presents the Phase 3 conclusions. Chapter 6 reports on key performance indicators and milestones. Chapter 7 lists supporting documentation, and Chapter 8 provides references.

# 2 Local profile

## 2.1 Summary of Key Risk Assessment results

The Key Risk Assessment (KRA) conducted in Phase 2 evaluated the four priority climate hazards for Xanthi by jointly considering the severity of current and projected impacts, the urgency of action, and the resilience capacity of the local system. Table 2-1 presents the KRA results in the format of the CLIMAAX Evaluation Dashboard, reporting for each hazard the severity of current and future risk, the urgency of action, the resilience capacity, and the resulting priority ranking, as established in the Phase 2 deliverable. Table 2-2 complements the dashboard by characterizing the resilience capacity for each hazard and by documenting the stakeholders, experts, and priority groups involved in the assessment.

| *Hazard* | *Severity (current)* | *Severity (future)* | *Urgency* | *Resilience capacity* | *Priority* |
|---|---|---|---|---|---|
| **Heatwaves** | Substantial | Critical | Immediate action needed | Medium | **Very High** |
| **Fluvial flooding** | Substantial | Substantial to critical (extreme events) | More action needed | Medium | **High** |
| **Wildfires** | Substantial | Critical | More action needed | Substantial | **High** |
| **Windstorms** | Moderate | Moderate | Watching brief to more action needed | Medium | **Medium** |

*Table 2-1. Key Risk Assessment Evaluation Dashboard for the Municipality of Xanthi (Phase 2 Key Risk Assessment).*

| *Priority climate risk* | *Resilience capacity* | *Description of the resilience capacity* | *Stakeholders, experts and priority groups involved in the KRA* |
|---|---|---|---|
| **Heatwaves** (Very High) | Medium | No dedicated municipal heat action plan exists. The Vulnerable Citizens Registry provides a partial foundation for targeted outreach. The healthcare system has a baseline capacity but no heat-specific surge protocols. Urban Heat Island amplifies risk in central areas. Knowledge gap: locally calibrated heat-health thresholds are now available from Phase 2 but not yet operationalised. | Municipal Civil Protection, Social Services, public health authorities, RiskAC. Priority groups: older adults, outdoor workers, health-sensitive populations. |
| **Fluvial Flooding** (High) | Medium | DARDANOS 2 emergency plan operational. T.E.S.O.P.P. coordinates seasonal drainage maintenance. DEYAX manages the stormwater network. Gaps include undersized drainage capacity in identified hotspots, the absence of a | T.E.S.O.P.P. members, DEYAX, Technical Services, PAMTh. Priority groups: residents in northern Xanthi (Kosynthos River corridor). |

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| | | systematic flood early-warning system at the municipal scale, and the lack of integration of climate projections into existing plans. | |
| **Wildfires** (High) | Substantial | IOLAOS 2 plan operational. Organized Citizen Evacuation Plan developed (2024). Seasonal fire protection staffing (7 forest workers + equipment). Volunteer groups engaged. Drone surveillance deployed. Gaps include limited fuel management to publicly managed areas, the absence of climate-informed scenario planning, and the need to monitor changes in WUI exposure. | Fire Department, Forest Management Office, volunteer groups, PAMTh, RiskAC. Priority groups: communities in peri-urban/rural WUI zones, cultural heritage in Old Town. |
| **Windstorms** (Medium) | Medium | BOREAS 2 covers snow and frost, while no specific emergency plan exists for windstorms or strong wind events. The existence of a single meteorological station close to Xanthi disallows proper validation. Post-event documentation is informal and rare. Gaps include limited monitoring density and the absence of a systematic vulnerability inventory for wind-exposed structures. | Municipality Technical Services, utility operators, RiskAC. Priority groups: residents in older or structurally vulnerable buildings, which are mainly located in semi-urban areas. |

*Table 2-2. Resilience capacity and stakeholder involvement for the priority climate risks of the Municipality of Xanthi.*

Participants in the KRA included the RiskAC technical team, municipal civil protection and technical services personnel, and representatives from the fire department, forest management, and the regional administration, engaged through the structured three-day training activity (October 2025). Risk ownership was discussed with institutional actors, confirming the municipality as the primary local risk owner. The KRA methodology followed the CLIMAAX Handbook, combining quantified hazard and impact indicators with expert and stakeholder judgement on severity, urgency, and capacity (CLIMAAX Consortium, 2024a). The resilience capacity ratings in Tables 2-1 and 2-2 follow the four-level qualitative scale of the CLIMAAX Handbook. Wildfires are rated as Substantial because an operational emergency plan, an organized evacuation plan, seasonal staffing, volunteer coordination, and drone surveillance are already in place, whereas the remaining hazards are rated as Medium, reflecting operational response structures that are not yet complemented by hazard-specific adaptation planning, with the absence of a dedicated Heat Action Plan constituting the most significant capacity gap.

## 2.2 Key implementation mechanisms and policy context for CRM

**National framework:** Greece's National Adaptation Strategy (NAS) and National Climate Law (Law 4936/2022) establish the strategic framework for climate adaptation. The Ministry of Climate Crisis and Civil Protection coordinates national-level disaster risk reduction through General Plans including IOLAOS 2 (forest fires), DARDANOS 2 (floods), EGKELADOS (earthquakes), and BOREAS 2 (snow/frost). These plans define standardised procedures that are operationalised at the municipal

level. The Ministry has recently launched the MySafetyPlan[1] digital platform for citizen preparedness.

**Regional framework:** The Region of Eastern Macedonia and Thrace (PAMTh) maintains an independent Civil Protection Directorate. The regional plans for IOLAOS, DARDANOS, and EGKELADOS are updated regularly (most recently October 2024 and March 2024). The PAMTh coordinates with municipal T.E.S.O.P.P. bodies and provides resource support during emergencies.

**Municipal level:** The Municipality of Xanthi operates an independent Civil Protection Department under the Deputy Mayor (Ioannis Tsapalis). The T.E.S.O.P.P. coordinates all involved agencies. Key tools include the four hazard-specific emergency plans, a Vulnerable Citizens Registry, an Organized Citizen Evacuation Plan for forest fires (developed in 2024), and the Municipal Operational Programme which sets priorities for infrastructure investment and service delivery. Relevant spatial planning instruments include the General Urban Plan (GPS) and the zoning regulations governing the historic Old Town.

**EU level:** The EU Mission on Adaptation to Climate Change, the European Climate Law, the Floods Directive, and the Sendai Framework for Disaster Risk Reduction provide the strategic context. The CLIMAAX programme itself represents a Horizon Europe instrument for harmonizing climate risk assessment across European communities. Funding instruments include ERDF, the Cohesion Fund, the LIFE Programme, and the Recovery and Resilience Facility (RRF).

**Sectoral mandates:** Relevant sectors include public health, covering heat-related mortality surveillance and hospital surge capacity, water management, where DEYAX manages water supply, sewerage, and stormwater, forestry, where the Forest Management Office is responsible for fuel management in state forests, and cultural heritage, covering the protection of the UNESCO-tentative Old Town and broader cultural assets managed in collaboration with FEX.

## 2.3 Key actors and systems for CRM

| *Key actors* | *Role and responsibility* | *Motivation and needs* | *Opportunities* | *Barriers* | *Engagement type* |
|---|---|---|---|---|---|
| Municipality of Xanthi (Mayor, Deputy Mayor CP) | Primary local risk owner. Coordinates emergency plans, allocates budget, integrates CRM into municipal planning. | Legal obligation for civil protection. Protecting citizens and infrastructure. Accessing EU/national funding. | Updated evidence base from CARE_X. New funding pathways through CLIMAAX visibility. | Limited dedicated CRM staff. Budget constraints for capital investments. | Co-design partner throughout all phases (Scoping, KRA, CRM). |
| RiskAC / KEDIAK (DUTh) | Technical lead. Risk assessment, methodology, capacity building, | Research excellence. University spin-off development. Applied science impact. | Long-term partnership with municipality. Expanding to | Dependency on project funding cycles. | Lead institution for all phases and all CRA steps. |

[1] https://mysafetyplan.gov.gr/

| | | | | | |
|---|---|---|---|---|---|
| | monitoring support. | | regional applications. | | |
| Fire Department (Xanthi) | Wildfire response. Participates in T.E.S.O.P.P. and seasonal coordination. | Improved risk intelligence for operational planning. | Climate-informed scenario planning from CARE_X wildfire outputs. | Operational focus limits engagement in strategic planning. | Phase 2 training participant. KRA consultation. |
| Forest Management Office | Fuel management in state forests. Technical guidance on wildfire prevention. | Better spatial targeting of prevention activities. | CARE_X fuel mapping and FWI projections directly support operations. | Jurisdiction limited to public forest land. | Phase 2 training participant. |
| PAMTh (Regional CP) | Regional coordination. Resource allocation. Regional plan updates. | Regional-scale risk intelligence. Compliance with national framework. | Scale CARE_X approach to other municipalities in the region. | Competing priorities across region. | Phase 2 training participant. |
| DEYAX (Water Utility) | Stormwater drainage network. Flood-related infrastructure. | Asset protection. Service continuity during flood events. | Flood hotspot maps from CARE_X support targeted maintenance. | Investment capacity for major upgrades. | Institutional coordination (T.E.S.O.P.P.). |
| FEX (Cultural heritage) | Cultural asset preservation. Community engagement. Heritage sector advocacy. | Protect irreplaceable cultural heritage from climate hazards. | Cross-sector integration of cultural heritage into CRM. | Volunteer-based organization with limited technical capacity for risk assessment. | Phase 2 heritage engagement. Resilience Festival co-organizer. |
| Citizens / General public | Self-protection. Compliance with preparedness guidance. Community resilience. | Safety, awareness, empowerment. | Resilience Festival as participatory platform. | Sustained participation outside crisis periods. | Phase 3: Resilience Festival. |

*Table 2-3. Key actors for CRM in the Municipality of Xanthi.*

## 2.4 Lessons learned from past events

**Windstorm of November 2023:** A severe local windstorm event on 4 November 2023 caused documented damage to buildings, trees, and infrastructure in the Xanthi area. This event demonstrated that even hazards classified as moderate in baseline assessments can produce locally significant impacts. It also exposed the limited monitoring of wind events , which constrain post-event validation. The lesson reinforced the Phase 2 recommendation for denser wind monitoring networks and established systematic damage documentation protocols.

**Seasonal flood preparedness (recurring):** The municipality's regular T.E.S.O.P.P. sessions for winter flood preparedness (most recently in October 2025) have revealed recurring challenges: drainage inlet blockages from vegetation and sediment, insufficient capacity in certain stormwater segments, and the need for continuous inter-agency coordination between the municipality, DEYAX, and the regional authority. The Phase 2 high-resolution flood mapping now provides the spatial targeting to prioritize these maintenance activities.

**Storm ADEL (November 2025):** The municipality issued an emergency notification to citizens ahead of storm ADEL in November 2025, demonstrating active use of the early warning communication infrastructure. Lessons from the event highlighted the importance of pre-positioned resources and the value of the digital communication channels maintained by the Civil Protection Department.

**Fire season operations:** Annual fire prevention campaigns have demonstrated the effectiveness of seasonal staffing (7 forest workers recruited in 2025), volunteer coordination, and drone-assisted surveillance. However, fuel management remains limited to publicly managed areas, and the wildland-urban interface zones require more systematic preventive attention, as confirmed by the Phase 2 exposure analysis.

# 3 Climate risk management – phase 3

## 3.1 CRM objectives

Based on the KRA results and stakeholder input, and following the CLIMAAX guidance on climate risk management (CLIMAAX Consortium, 2024b), the CRM objectives for the Municipality of Xanthi are organized into primary objectives that directly address climate risks, and additional objectives that support broader resilience. Table 3-1 presents the primary CRM objectives with associated assessment indicators.

| *Primary objectives* | *Assessment indicators* |
|---|---|
| Reduce heat-related health risk for vulnerable populations | Heat Action Plan adopted (Y/N). Number of designated cooling centres. Trend in heat-related hospital admissions. Percentage of Vulnerable Citizens Registry members reached by early warning. |
| Reduce flood risk to the population and infrastructure | Number of people exposed in flood-prone zones (from risk maps). Drainage maintenance coverage in high-risk zones (%). Flood damage (EUR/event). Average flood response time. |
| Reduce wildfire risk in the wildland-urban interface | Area of preventive vegetation management WUI,(ha/year). Number of residents covered by the updated evacuation plan. Fire response time. Trend in fire incidents per season. |
| Improve windstorm preparedness and monitoring | Number of operational wind monitoring stations. Post-event damage reports compiled (count) for urban and agricultural/forest areas. Vulnerable structures identified and assessed (%). |
| Strengthening institutional capacity for multi-hazard CRM | Climate Change Observatory established (Y/N). Officials trained per year. Emergency plans updated with climate projections (count). Multi-hazard exercises conducted (count). |

*Table 3-1. Primary CRM objectives and assessment indicators.*

| *Additional objectives* | *Assessment indicators* |
|---|---|
| Public health | Decrease in heat-related hospitalizations during extreme events. Healthcare surge capacity protocols established. |
| Cultural heritage protection | Heritage buildings with fire risk assessments (count). Emergency protocols for heritage sites adopted (Y/N). |
| Social well-being and environmental quality | Urban green space area (m²/capita). Percentage of urban area with tree canopy. New walking/cycling paths (km). |
| Justice and equity | Vulnerable populations explicitly targeted in all CRM measures. Accessible formats for risk communication materials. Inclusive participation in public events. |

*Table 3-2. Additional CRM objectives and assessment indicators.*

## 3.2 Supportive elements for effective CRM

| *Supportive elements for effective CRM* | *Description* |
|---|---|
| Knowledge and data | CARE_X has produced a comprehensive, multi-hazard evidence base through the CLIMAAX framework, including regionalized risk maps for all four hazards, locally calibrated temperature-mortality relationships, high-resolution DEM-based flood mapping, scenario-based wildfire modelling, and a Key Risk Assessment with priority ranking. RiskAC provides sustained institutional capacity for risk assessment, with expertise in hazard analysis, remote sensing, and computational modelling. The CLIMAAX Toolbox (Jupyter notebook workflows) and associated GitHub repositories provide reproducible, updateable analysis pipelines. |
| Tech and infrastructure | The municipality operates a 24-hour emergency communication line, digital notification systems (as demonstrated during storm ADEL), and drone-assisted surveillance for fire monitoring. The DEYAX maintains the stormwater drainage network. Gaps include: limited number of local wind monitoring stations, no automated flood early warning at the municipal scale, and no dedicated urban heat monitoring network. The proposed Climate Change Observatory would centralize monitoring data and provide the infrastructure backbone for ongoing CRM. |
| Social-behavioural aspects | Public awareness of civil protection mechanisms exists through the municipal website, media releases, and seasonal preparedness campaigns. The Vulnerable Citizens Registry reflects willingness of at-risk populations to register for protection. Community norms around fire prevention are reinforced through annual volunteer coordination. Challenges include sustaining engagement outside crisis periods and reaching isolated or socially excluded populations. |
| Citizen engagement | Active volunteer groups coordinated through the Civil Protection Department for fire surveillance. The Xanthi Resilience Festival (8–10 May 2026) represents a new public engagement format combining awareness, education, participatory dialogue, and cultural activities. FEX provides a bridge to the cultural heritage community. The City's digital channels (website, social media, push notifications) support broad citizen reach. The participatory CRM workshop application developed in Phase 3, a mobile-friendly real-time tool for structured idea collection and prioritization, remains available to the municipality as a reusable instrument for future consultations. |
| Finances and resources | The municipality has demonstrated the capacity to allocate budget for seasonal fire protection staffing, civil protection equipment, and drainage maintenance. The JTI Foundation partnership (2024) shows potential for private-sector co-financing. EU funding instruments (ERDF, LIFE, Horizon Europe Mission on Adaptation, RRF) provide significant co-financing opportunities for capital investments. The SATA fund supports annual civil protection works. The CARE_X budget for Phase 3 includes €5,000 for public workshops and €8,500 for multi-hazard exercise equipment and provisions. |

| | |
|---|---|
| Governance arrangements and political leadership | Strong political commitment demonstrated through the Mayor's and Deputy Mayor's active participation in CARE_X activities. The T.E.S.O.P.P. provides an established coordination mechanism bringing together all relevant agencies. The dedicated Civil Protection Department reports directly to the Mayor. The municipal council has authority to adopt updated plans and allocate resources. The RiskAC–Municipality partnership, formalized through the CLIMAAX sub-grant agreement, provides a model for sustained technical–governance collaboration. |

*Table 3-3. Supportive elements for effective CRM in the Municipality of Xanthi.*

## 3.3 Potential CRM measures

Table 3-4 presents the identified CRM measures for the Municipality of Xanthi, organized by priority climate risk. A total of 14 measures are identified, substantially exceeding the KPI 6 target of at least 5. Each measure is characterized by its effectiveness, contribution to CRM objectives, co-benefits, timeline, responsible organization, and potential adaptation limits.

The effectiveness ratings in Table 3-4 are based on the quantitative evidence produced in Phase 2. For heatwaves, the locally calibrated exposure and response relationship established that the relative risk of cardiovascular mortality in Xanthi increases by 6.2 % for each °C above the local threshold of 20.3 °C, based on data covering the period 1999 to 2018. This relationship provides a direct quantitative basis for the expected health benefit of the Municipal Heat Action Plan (HW-1), since each avoided degree of effective heat exposure for the vulnerable population, whether through early warning activation, cooling centre access, or urban heat island mitigation (HW-2), translates into a measurable reduction of mortality risk. The heat-health surveillance measure (HW-3) operationalizes the same relationship as a monitoring instrument, allowing the effectiveness of HW-1 and HW-2 to be evaluated against observed outcomes.

For fluvial flooding, the Phase 2 downscaling of the JRC flood hazard maps to a 5-meter spatial resolution using the local digital elevation model identified specific inundation hotspots within the urban fabric and along the Kosynthos River corridor. These hotspots define the spatial targeting of the drainage maintenance and upgrade measure (FL-1) and of the river corridor management measure (FL-2). It is recalled that the downscaled maps do not account for existing flood defences, which means that the mapped exposure represents an upper bound for the areas protected by such works and that measure FL-2 should incorporate a verification of defence conditions. The risk communication measure (FL-3) draws on the same maps to deliver spatially explicit preparedness information to residents of the identified zones.

For wildfires, the Phase 2 combined risk assessment, integrating the Fire Weather Index projections, fuel availability, and exposure at the wildland-urban interface, identified the WUI zones with the highest combined risk. Measure WF-1 targets preventive fuel management and early detection precisely in these zones, while WF-2 incorporates the projected worsening of fire weather under the SSP2-4.5 and SSP5-8.5 scenarios into the operational planning of IOLAOS 2. The cultural heritage protection measure (WF-3) responds to the exposure of the Old Town and heritage assets identified during the Phase 2 heritage sector engagement.

For windstorms, the Phase 2 analysis indicated that the principal climate change signal for the region is the projected northward shift of storm tracks rather than a systematic increase in wind speeds, and applied vulnerability adjustments only to the most vulnerable building categories. This

evidence justifies the emphasis of measures WS-1 and WS-2 on strengthening the observational and inventory basis and on the structural resilience of the identified vulnerable asset classes, rather than on large-scale infrastructural interventions that the current evidence would not support.

The identification and validation of the measures was further supported by a structured participatory CRM workshop held on 29 April 2026, shortly before the Xanthi Resilience Festival, using a purpose-built real-time web application developed by the CARE_X team. Ten officials from the municipal Civil Protection Department, the Technical Services, the Forest Management Office of Xanthi, the regional civil protection authority, and the Fire Service contributed, for each of the four hazards, structured responses on existing measures, identified gaps, and required inter-agency cooperation, following the CLIMAAX approach of identifying adaptation options before prioritizing them. The exercise produced approximately seventy documented contributions. The findings corroborate the measure inventory of Table 3-4. Participants highlighted, among others, the shortage of air-conditioned public spaces and urban green areas, supporting measures HW-1 and HW-2, the need for water level telemetry, early warning protocols, and continuous drain maintenance staffing, supporting measures FL-1 and FL-3, the demand for continuous patrolling capacity and water tanker vehicles at the wildland-urban interface, supporting measure WF-1, and the absence of a local meteorological station for wind monitoring, directly confirming measure WS-1. The full dataset, including author, organization, and timestamp per contribution, is available as supporting documentation.

Regarding financing opportunities, the implementation pathway of each measure is matched to the funding instruments identified in Section 2.2. The cross-cutting institutional measures (CC-1 to CC-3) and the monitoring measures (HW-3, WS-1) are suitable for Horizon Europe and LIFE Programme instruments as well as for continued engagement with the EU Mission on Adaptation, building on the visibility gained through CLIMAAX. The infrastructural measures (HW-2, FL-1, FL-2, WS-2) align with ERDF and Recovery and Resilience Facility priorities for climate-proof infrastructure and can be included in the next programming submissions of the municipality and the Region of Eastern Macedonia and Thrace. The preparedness and communication measures (HW-1, FL-3, WF-1, WF-2, WF-3) can be supported through national civil protection funding lines and municipal budget allocations, for which the demonstrated capacity of the municipality to fund seasonal fire protection staffing provides a precedent, complemented by private sector co-financing following the model of the JTI Foundation partnership.

| *Key climate risk* | *CRM measure* | *Effectiveness* | *Contribution to CRM objectives* | *Possible co-benefits* | *Time line* | *Responsible organisation* | *Possible adaptation limits* |
|---|---|---|---|---|---|---|---|
| All hazards | CC-1: Climate Change Observatory | High | Enables sustained monitoring and iterative assessment updates across all hazards | Research infrastructure, improved evidence for funding applications | Short | Municipality and RiskAC | Requires sustained institutional commitment and funding beyond project cycle |
| All hazards | CC-2: Integration of CRM into | High | Embeds climate risk evidence in | Improved urban planning, | Short | Municipality (Technic | Depends on political continuity and |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | municipal planning instruments | | land-use, infrastructure, and budget decisions | resource allocation efficiency | | al Serv., CP) | administrative capacity |
| All hazards | CC-3: Continuous capacity building and training | High | Builds human capital for CRM across all hazards | Institutional knowledge, inter-agency networking | Ongoing | RiskAC and Municipality | Staff turnover may erode capacity gains |
| Heatwaves | HW-1: Municipal Heat Action Plan | High | Directly reduces heat-related mortality and morbidity for vulnerable groups | Public health improvement, reduced healthcare costs | Short | Municipality (CP, Social Services) | Extreme heat beyond physiological limits and the energy costs of cooling infrastructure |
| Heatwaves | HW-2: Urban green and blue infrastructure for UHI mitigation | Medium | Reduces urban temperatures in heat hotspots | Biodiversity, air quality, recreational value, property values | Medium | Municipality (Environment, Technical) | Space constraints in dense urban areas and water availability for irrigation |
| Heatwaves | HW-3: Heat-health surveillance and monitoring | Medium | Provides evidence for real-time response and measure evaluation | Health data for research and policy evaluation | Short - medium | Municipality + Public Health | Data sharing agreements with health sector |
| Flooding | FL-1: Drainage infrastructure maintenance and upgrade | High | Reduces flooding in identified hotspots | Improved urban sanitation, reduced property damage | Short - medium | Municipality (Technical), DEYAX | Insufficient for extreme future discharge scenarios without major capital works |
| Flooding | FL-2: Kosynthos River flood risk management | High | Reduces fluvial flood exposure for northern Xanthi | Ecosystem services from riparian vegetation, water quality | Medium | Municipality, PAMTh, water authorities | Requires multi-agency coordination, while upstream management lies beyond municipal control |
| Flooding | FL-3: Flood risk communication and | High | Enhances community resilience and | Empowerment, social capital, informed | Short | Municipality (CP) | None identified |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | preparedness | | reduces casualties | citizen participation | | | |
| Wildfires | WF-1: Enhanced WUI fire prevention | High | Reduces fuel loads and improves early detection in highest-risk zones | Forest health, biodiversity, air quality | Short (annual) | Municipality (CP), Forest Mgmt, Fire Dept | Private land management outside municipal authority |
| Wildfires | WF-2: Update IOLAOS 2 with climate scenarios | High | Improves preparedness for worsening fire weather | Inter-agency coordination, exercise-based learning | Short | Municipality (CP), Fire Service | Plan updates require national-level coordination |
| Wildfires | WF-3: Cultural heritage fire protection | Medium | Protects irreplaceable cultural assets in Old Town and heritage sites | Cultural identity preservation, tourism asset protection | Medium | Municipality, FEX, Fire Service | Heritage building constraints limit structural modifications |
| Windstorms | WS-1: Wind monitoring expansion and post-event documentation | Medium | Strengthens evidence base for future risk updates | Research data, improved hazard model validation | Short | RiskAC, Municipality | Monitoring alone does not reduce risk without action on findings |
| Windstorms | WS-2: Structural resilience for wind-vulnerable assets | Medium | Reduces damage to vulnerable structures and critical infrastructure | Building quality, infrastructure reliability | Medium-long | Municipality (Technical) | High cost for retrofitting older building stock |

*Table 3-4. Overview of potential CRM measures for the Municipality of Xanthi.*

## 3.4 Integration into planning and decision making

The CARE_X project outputs provide the evidence base for integrating climate risk management into multiple planning instruments and decision-making processes of the Municipality of Xanthi:

**Municipal Operational Programme:** The CRM priorities identified in this deliverable should inform the next revision of the Municipal Operational Programme, ensuring that infrastructure investments, service delivery priorities, and human resource allocation reflect the climate risk evidence. Specifically, heat mitigation measures (green infrastructure, cooling centres) and drainage upgrades should be prioritized in the investment programme.

**Civil Protection Plans:** The existing emergency plans (IOLAOS 2, DARDANOS 2, BOREAS 2) should be updated to incorporate the climate change projections produced in Phase 2. The CARE_X risk maps enable spatial targeting of preparedness measures and evacuation planning. The

development of a new Heat Action Plan addresses the most significant gap in the current plan portfolio.

**General Urban Plan (GPS):** The flood and wildfire risk maps produced by CARE_X should be consulted during any revision of zoning regulations, building codes implementation, and land-use decisions, particularly for the Kosynthos River corridor and the wildland-urban interface zones.

**Synergies and tensions:** The multi-agency coordination required for effective CRM creates both opportunities and challenges. The T.E.S.O.P.P. provides an established platform for inter-agency dialogue, but operational mandates sometimes create tensions between rapid response priorities and longer-term adaptation planning. The CARE_X project has helped bridge this gap by producing decision-relevant outputs that serve both operational and strategic purposes. Cross-scale tensions exist between the municipality's local implementation capacity and the national/regional level at which some hazard management responsibilities reside (e.g., upstream watershed management for flood risk, national fire service coordination).

**Data and monitoring needs:** The Phase 2 risk assessment has produced significant new data for the Municipality of Xanthi, including the first locally calibrated heat-health (exposure-response) relationship, the first high-resolution municipal flood mapping, and the first scenario-based wildfire exposure analysis. However, sustained effectiveness requires: denser wind monitoring, systematic post-event impact documentation, improved inventories of critical assets and vulnerable groups, and harmonized municipal-scale socio-economic projections. The proposed Climate Change Observatory would provide the institutional basis for addressing these needs.

**Monitoring and evaluation:** The assessment indicators defined in Tables 3-1 and 3-2 constitute the monitoring framework for tracking CRM progress. The Climate Change Observatory, once established, would be the institutional mechanism for data collection, indicator tracking, and reporting. The monitoring cycle should follow the CLIMAAX iterative approach, with full reassessment recommended every 5 years and intermediate indicator reviews annually. The municipality should designate a responsible unit (Civil Protection Department) for coordinating indicator data collection across departments.

Beyond the project horizon, the transition from the CRM measures identified in this deliverable towards a comprehensive regional resilience strategy can be supported by the Pathways2Resilience (P2R) programme, the sister initiative of CLIMAAX under the EU Mission on Adaptation to Climate Change (CLIMAAX Consortium, 2024b). The P2R Regional Resilience Journey offers a structured continuation for the Municipality of Xanthi, in which the CARE_X risk evidence and the prioritized measure inventory constitute the entry point for vision building and adaptation pathway design. Engagement with P2R is therefore recommended as the natural next step for sustaining and scaling the results of this project.

# 4 Project Evaluation

## 4.1 Usability of the results

The CARE_X project has generated substantial new knowledge and practical outputs for the Municipality of Xanthi:

**Risk maps and spatial products:** The risk maps for all four hazards provide the first spatially explicit, scenario-based climate risk information at the municipal scale in Xanthi. These products can directly inform land-use decisions, infrastructure investment prioritization, and emergency preparedness targeting. The maps are produced in formats compatible with municipal GIS systems.

**Heat-health evidence:** The locally calibrated temperature-mortality relationship represents entirely new knowledge for Xanthi and the broader region. It provides the scientific foundation for evidence-based heat-health policy, including the proposed Heat Action Plan and heat-health surveillance system.

**Policy recommendations:** The 14 CRM measures, with specified responsible actors, timelines, and indicators, provide an implementable action plan that can be incorporated into municipal council decisions and the Municipal Operational Programme revision.

**Capacity building:** The three-day training activity and the Resilience Festival have built institutional capacity across the civil protection ecosystem. Trained personnel can now interpret CLIMAAX workflow outputs and translate them into operational planning actions. This human capital investment extends the project's impact beyond its formal timeline.

**Reproducible methodology:** The CLIMAAX Toolbox workflows used in CARE_X are documented and reproducible, enabling future assessment updates as new climate scenarios and data become available. This positions the municipality of Xanthi for iterative adaptation planning rather than a one-off exercise.

**Digital engagement tool**: The participatory CRM workshop application developed for the 29 April 2026 session provides the municipality with a permanent, low-cost instrument for structured stakeholder consultation, complete with digital attendance records and exportable, analyzable outputs.

## 4.2 Lessons learned

**Stakeholder engagement timing:** Engaging institutional stakeholders (civil protection, fire department, forest management) during Phase 2 through the training activity proved highly effective, as their feedback directly shaped the Key Risk Assessment and CRM measure prioritization. Earlier engagement in Phase 1 was more limited in scope (focused on municipal leadership), and broader public engagement is addressed in Phase 3 through the Resilience Festival. For future projects, initiating cross-sectoral engagement earlier would strengthen the scoping phase.

**Data availability challenges:** The most significant difficulty encountered was the uneven availability of local data across hazards. Wind monitoring is particularly sparse, limiting robust spatialization of windstorm risk. For heat, collaboration with health authorities required careful data sharing arrangements. Flood modelling benefited from the availability of a high-resolution DEM but lacked harmonized municipal-scale socio-economic projections. These constraints were managed through transparent reporting of assumptions and limitations.

**Stakeholder feedback on CRM:** Participants in the training activities emphasized the importance of decision-oriented outputs (telling them where to act first), consistent interpretation of uncertainty across hazards, and explicit attention to priority groups. This feedback was directly incorporated into the KRA methodology and the measure prioritization in this deliverable.

**Communication of outcomes:** Results have been communicated through: the Phase 1 and Phase 2 deliverables submitted to CLIMAAX, a press release at project launch, the FEX/Municipality/KEDIAK framework presentation at ICOM Dubai 2025, participation in the CLIMAAX Barcelona workshop (May 2025), the  The Xanthi Resilience Festival was covered by a radio interview and article on the Municipal Radio of Xanthi (radio899.gr, 27 April 2026), streamed live on YouTube with sign language interpretation, and disseminated through short-form videos on social media.Xanthi Resilience Festival (May 2026), and the municipal website. The bilingual approach (Greek for local stakeholders, English for CLIMAAX deliverables) has worked well but required additional effort. A novel societal aspect of communicating CLIMAAX outcomes during the Xanthi Resilience Festival was the live streaming of the event in sign language.

**Resource efficiency:** The project has been implemented within budget and largely within timeline. The sub-grant model, with the municipality as principal and RiskAC as subcontracted technical partner, provided flexibility while maintaining clear accountability. The allocation of 2.5 academic work-months, 3 postdoc work-months, and 5 graduate student work-months for Phase 3 proved appropriate for the scope of work.

**Impact assessment:** The project has demonstrably improved institutional understanding of climate risks in Xanthi. Municipal leadership now has quantified, spatially explicit risk information for all four priority hazards. The training activities have built capacity for ongoing risk interpretation. The project has generated visibility for Xanthi within the CLIMAAX community of practice, creating opportunities for continued European collaboration.

# 5 Conclusions Phase 3

Phase 3 of the CARE_X project has successfully translated the multi-hazard climate risk evidence base from Phases 1 and 2 into an actionable Climate Risk Management plan for the Municipality of Xanthi. The principal conclusions are:

**1.** Heatwaves represent the most urgent and escalating climate risk for Xanthi, requiring immediate action through the development and adoption of a Municipal Heat Action Plan. This is the single highest-priority CRM measure identified by the project.

**2.** The existing municipal civil protection framework provides a solid foundation for CRM, with operational emergency plans, an active T.E.S.O.P.P. coordination mechanism, and demonstrated capacity for seasonal preparedness. However, these tools are not yet climate-informed and do not cover heatwaves specifically.

**3.** A total of 14 CRM measures have been identified and prioritized, addressing all four hazards through a combination of institutional strengthening, hazard-specific risk reduction, and community engagement interventions. Implementation is feasible within existing governance structures, with external funding required for capital-intensive measures.

**4.** The establishment of a Climate Change Observatory is recommended as the institutional mechanism for sustained monitoring, data integration, and iterative assessment, ensuring that the CRM cycle remains active beyond the project timeline.

**5.** Stakeholder engagement has been comprehensive and effective, reaching institutional actors across multiple sectors, the cultural heritage community, and (through the Resilience Festival) the general public. The structured training activity in Phase 2 was particularly impactful for building operational capacity.

Challenges not fully addressed within the project scope include: the formal adoption of updated emergency plans by the municipal council (which requires a separate administrative process), the deployment of additional wind monitoring infrastructure, and the development of harmonized municipal-scale socio-economic projections for consistent cross-hazard coupling. These represent priorities for the post-project period.

The CARE_X project positions the Municipality of Xanthi as one of the first Greek municipalities to complete a full CLIMAAX Climate Risk Assessment cycle, from scoping through risk analysis to climate risk management planning. The partnership between the Municipality and RiskAC/KEDIAK provides a sustainable model for continued climate resilience development.

# 6 Progress evaluation

## 6.1 Project outputs

The Key Performance Indicators (KPIs) and Milestones reported below follow the Individual Follow-up Plan.

| *Key performance indicators* | *Progress* |
|---|---|
| KPI 1: Complete risk assessments for 2 identified hazards | Achieved and exceeded. Risk assessments completed for four hazards: heatwaves, fluvial flooding, wildfires, and windstorms. |
| KPI 2: Conduct at least 3 stakeholder workshops throughout the project lifecycle | Achieved. (1) Initial stakeholder workshop, December 2024. (2) Structured three-day training activity, October 2025. (3) Xanthi Resilience Festival, 8–10 May 2026. (4) Participatory CRM workshop, 29 April 2026. |
| KPI 3: Engage a minimum of 10 local stakeholders from different sectors | Achieved. Stakeholders engaged from: Municipal leadership, PAMTh, Fire Department, Military, Forest Management Office, Civil Protection Office, DUTh, FEX. |
| KPI 4: Integrate at least 4 local datasets into the risk assessment | Achieved. Local wind observations, high-resolution DEM, updated GDP per capita, health-risk data, Sentinel-based fuel mapping. |
| KPI 5: Produce at least 1 comprehensive risk map for each assessed hazard | Achieved. Risk maps produced for all four hazards. |
| KPI 6: Identify at least 5 potential adaptation measures or policy recommendations | Achieved and exceeded. 14 CRM measures identified and prioritized (Table 3-4). |
| KPI 7: Train at least 10 local officials or stakeholders | Achieved. Three-day training activity, >10 participants from multiple sectors. The participatory CRM workshop of 29 April 2026 engaged ten officials from the municipal Civil Protection Department, Technical Services, the Forest Management Office, the regional civil protection authority, and the Fire Service, with digital attendance records. |
| KPI 8: Organize at least 1 public event to present results to the wider community | Achieved. Xanthi Resilience Festival, 8–10 May 2026, Old Town Hall of Xanthi. |
| KPI 9: Achieve at least 3 local media mentions or press releases | Achieved and exceeded. Press release at project launch, two confirmed local media mentions on radio899.gr (April 2026) covering the project and the Xanthi Resilience Festival, a dedicated radio interview of the Deputy Mayor for Civil Protection and the scientific lead on the Municipal Radio of Xanthi with an accompanying article (27 April 2026), the official live streaming of the Festival on YouTube, short-form video coverage on social media, and further publicity through FEX and ICOM dissemination channels. Links are provided in the Supporting Documentation chapter. |
| KPI 10: Implement all 5 steps of the CLIMAAX framework | Achieved. Scoping, Risk Exploration, Risk Analysis, Key Risk Assessment, and Monitoring & Evaluation completed. |

*Table 6-1. Overview key performance indicators.*

| Milestones | Progress |
|---|---|
| M1: Initial stakeholder workshop (Phase 1) | Achieved. December 2024. |
| M2: Workflows for all relevant hazards established (Phase 1) | Achieved. Four hazard workflows completed. |
| M3: Refined risk analysis for each hazard (Phase 2) | Achieved. Documented in Phase 2 deliverable. |
| M4: Knowledge transfer sessions (Phase 2) | Achieved. Three-day training, October 2025. |
| M5: Existing risk management plans updated (Phase 3) | Addressed. This deliverable provides evidence and recommendations for updating IOLAOS 2, DARDANOS 2, and developing a Heat Action Plan. Formal adoption follows municipal processes. |
| M6: Multi-hazard climate event preparedness exercise (Phase 3) | Achieved. Tabletop preparedness exercise conducted on 30 April 2026 at the Fire Service facilities in the Industrial Area of Xanthi, based on a compound wildfire scenario at the wildland-urban interface adjacent to the Old Town (Samakov area) under extreme conditions of drought, fire danger index 4, and 30 km/h winds in pine-dominated vegetation. The exercise covered fire sector definition and time-phased episodes of fire perimeter evolution, testing inter-agency coordination in line with IOLAOS 2. |
| M7: Attend CLIMAAX workshop in Barcelona (May 2025) | Achieved. Prof. Ioannis Dokas participated. |
| M8: Attend CLIMAAX workshop in Brussels (Dec 2026) | Planned. |

*Table 6-2. Overview milestones.*

# 7 Supporting documentation

The following outputs have been produced during Phase 3 and will be shared in the Zenodo repository:

1. Communication Output 3/3: Xanthi Resilience Festival programme and documentation and photographic documentation (8–10 May 2026)

2. Multi-hazard preparedness exercise (30 April 2026, Fire Service facilities, Industrial Area of Xanthi): scenario materials, fire sector and perimeter evolution maps, session photographs

3. Participatory CRM workshop dataset (29 April 2026): structured contributions per hazard with author, organization, and timestamp, exported from the workshop application (CSV) and technical description of the CARE_X participatory CRM workshop web application (real-time, mobile-friendly, single-file React application with Firebase synchronization, deployed as a static site

4. Media coverage and public dissemination of the Xanthi Resilience Festival

# 8 References

CLIMAAX Consortium: CLIMAAX Handbook for Climate Risk Assessment, Deliverable D1.4, Horizon Europe Grant Agreement No. 101093864, 2024a.

CLIMAAX Consortium: Guidelines for Climate Risk Management, Deliverable D2.4, Horizon Europe Grant Agreement No. 101093864, 2024b.

Municipality of Xanthi: General Plan for Emergency Response to Forest Fires (IOLAOS 2), published via Diavgeia, 2024.

Municipality of Xanthi: General Plan for Emergency Response to Flooding (DARDANOS 2), published via Diavgeia, 2024.

Municipality of Xanthi: General Plan for Emergency Response to Earthquakes (EGKELADOS), published via Diavgeia, 2020.

Municipality of Xanthi: General Plan for Emergency Response to Snow and Frost (BOREAS 2), published via Diavgeia, 2024.

Hellenic Republic, Law 4936/2022: National Climate Law – Transition to Climate Neutrality and Adaptation to Climate Change, Government Gazette A' 105/27.5.2022.

CARE_X Project Team: Phase 1 Deliverable – Implementation of the CLIMAAX common methodology for multi-risk assessment and analysis of the results in the City of Xanthi, Month 6, 2024.

CARE_X Project Team: Phase 2 Deliverable – Refined Risk Assessment Report with Data Integration for the City of Xanthi, Month 16, 2025.